Book of Abstracts

XVI AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

XVI AGRICULTURAL SCIENCE CONGRESS 2023

ICAR

सी एम एफ आर आइ
CMFRI

XVI AGRICULTURAL SCIENCE CONGRESS 2023

Sponsors

सत्यमेव जयते

भाकृअनुप
ICAR

सी एम एफ आर आइ
CMFRI

PRADHAN MANTRI MATSYA SAMPADA YOJANA
PMMSY

NFDB

NABARD

SBI
The banker to every Indian

Yashaswi
Surimi Marine
Freshness Frozen

BAYER

mahyco
grow

SEAFOOD EXPORTERS ASSOCIATION OF INDIA


Nansen
Scientific
Society

PPVFRA

INCOIS

Book of Abstracts
ISBN : 978-93-82263-61-6

XVI AGRICULTURAL SCIENCE CONGRESS 2023

Transformation of Agri-Food Systems for Achieving Sustainable Development Goals

10-13 October 2023 I Kochi, Kerala, India

XVI Agricultural Science Congress 2023
Book of Abstracts

Printed and published by
Dr. A. Gopalakrishnan
Organising Secretary, XVI ASC 2023 & Director, ICAR-CMFRI, Kochi

Editors
Sobhana, K. S., Shoba Joe Kizhakudan, Grinson George, Sandhya Sukumaran, Krupesha Sharma, S. R., Shoji J. Edison, Muktha, M., Bindu, J., Kajal Chakraborty, Jayasankar, J., Shinoj, P., Rekha J. Nair, Lakshmi S. Pillai, Boby Ignatius, Kathirvel Pandian, A., Vinod, K., Krishna Sukumaran, Suresh Babu, P. P., Sumithra T. G., Reshma Gills, Ratheesh Kumar, R., Rathi Bhuvaneswari, G., Subal Kumar Roul, Linga Prabu, D., Parvathy, U. and Tejpal, C. S.

Technical Assistance
Manjeesh R.
Arun Surendran
Abhilash P. R.
Uma, E. K.
Vandana, V.

Secretarial Assistance
A. R. Reshma

Design
Graficreations, Kochi

Printed at
Anaswara offset Private Ltd. Kochi

ISBN : 978-93-82263-61-6

Citation example:
Gotyal, B.S., Choudhary, J.S., Joshi, S., Ramya, R.S., Lekhana, N. and Shivakumara, K.T. 2023. Garden pea *Pisum sativum* L. as a new host for pineapple mealybug, *Dysmicoccus brevipes* Cockerell (Hemiptera: Pseudococcidae). In: Book of Abstracts, XVI Agricultural Science Congress and ASC Expo, Transformation of Agri-food systems for achieving sustainable development goals. National Academy of Agricultural Sciences, New Delhi and ICAR-Central Marine Fisheries Research Institute, Kochi, 10-13 October 2023, Kochi, India, 720 p.

Preface

The XVI Agricultural Science Congress being jointly organized by the National Academy of Agricultural Sciences (NAAS) and the Indian Council of Agricultural Research (ICAR) during 10-13 October 2023, at hotel Le Meridien, Kochi, is a mega event echoing the theme "Transformation of Agri-Food Systems for achieving Sustainable Development Goals". ICAR-Central Marine Fisheries Research Institute takes great pride in hosting the XVI ASC, which will be the perfect point of convergence of academicians, researchers, students, farmers, fishers, traders, entrepreneurs, and other stakeholders involved in agri-production systems that ensure food and nutritional security for a burgeoning population.

With impeding challenges like growing urbanization, increasing unemployment, growing population, increasing food demands, degradation of natural resources through human interference, climate change impacts and natural calamities, the challenges ahead for India to achieve the Sustainable Development Goals (SDGs) set out by the United Nations are many. The XVI ASC will provide an interface for dissemination of useful information across all sectors of stakeholders invested in developing India's agri-food systems, not only to meet the SDGs, but also to ensure a stable structure on par with agri-food systems around the world.

It is an honour to present this Book of Abstracts which is a compilation of a total of 668 abstracts that convey the results of R&D programs being done in India. The abstracts have been categorized under 10 major Themes – 1. Ensuring Food & Nutritional Security: Production, Consumption and Value addition; 2. Climate Action for Sustainable Agri-Food Systems; 3. Frontier Science and emerging Genetic Technologies: Genome, Breeding, Gene Editing; 4. Livestock-based Transformation of Food Systems; 5. Horticulture-based Transformation of Food Systems; 6. Aquaculture & Fisheries-based Transformation of Food Systems; 7. Nature-based Solutions for Sustainable Agri-Food Systems; 8. Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems; 9. Policies and Institutions for Transforming Agri-Food Systems; 10. International Partnership for Research, Education and Development.

This Book of Abstracts sets the stage for the mega event itself, which will see a flow of knowledge emanating from a zeal to transform and push India's Agri-Food Systems to perform par excellence and achieve not only the SDGs of the UN but also to rise as a world leader in the sector. I thank and congratulate all the participants who have submitted abstracts for this mega event, and I also applaud the team that has strived hard to publish this Book of Abstracts ahead of the event. I wish all the delegates and participants a very vibrant and memorable time at the XVI ASC.

Jai Hind

Dr. A. Gopalakrishnan
Organising Secretary, XVI ASC 2023 & Director, ICAR-CMFRI, Kochi

Contents

Invited Talks

- Rethinking food crisis responses ... 3
- Contributions of gene editing towards achieving the SDGs ... 4
- Dietary guidelines for Indians and what Indians eat ... 5
- Food processing to combat malnutrition in India ... 6
- Nutraceuticals in food and health ... 7
- Addressing dual burden of malnutrition: Role of food systems ... 8
- Pharmaceutical approach and food fortification for combating micronutrient deficiencies ... 9
- Food based approaches and the role of women in alleviating malnutrition ... 10
- Biofortification to combat hidden hunger ... 11
- Nutrition communication in India: From rhetoric to reality ... 12
- Demand for and supply of agri-food commodities in India ... 13
- Resource efficient and environment friendly production of pulses ... 14
- Impact of climatic changes on food safety and nutrition ... 15
- Nutraceutical functions of milk and milk products: Prospects and challenges ... 16
- Extension strategies for mitigation and adaptation of climate change in Eastern Himalayan regions of India ... 18
- Opportunities in Big Data Analytics and ICTs to accelerate climate adaptation ... 19
- Genome editing and the remarkable lives of plant pathogenic bacteria ... 20
- Generating gene edited resources for basic science in chickpea ... 21
- Genome editing for improving stress tolerance in rice ... 22
- Reshaping the rice genome to meet the emerging challenges ... 23
- Genome editing for an ideal low-seed, high-leaf glucosinolate oilseed mustard ... 24
- An international perspective on trade in gene-edited crops: Issues and current status ... 25
- New seed technologies: Socioeconomic considerations ... 26
- Scope of genome edited livestock for India ... 27
- Preparedness of Indian dairy sector for food security ... 28
- Transforming the animal feed sector for food and environmental security ... 30
- Meat sector visioning and action agenda for continued food security ... 31
- Dairy value chain for food and income security ... 32
- Sex sorted semen for higher production and income security: Perspective and prospective ... 33
- Fast track breeding approaches in fruit crops for targeted genotype development ... 34

- Targeted breeding in vegetable crops for safe production 35
- Sensors, new molecules and smart packaging in PHM of horticultural crops 36
- Horticultural Crops: Potential for developing Functional foods and nutraceuticals 37
- Integrating climate change into fisheries management: Opportunities for sustainable and resilient fisheries 38
- Better exploitation of fish/shellfish leftover *via* the conversion to functional ingredients and food additives 39
- Innovations in Fish Processing Technology for Increasing Efficiency and Reducing Wastage 40
- Quality certification standards in fish product processing for consumer food safety – An Indian perspective 41
- Gender in Fisheries and Aquaculture: A research agenda for driving transformational change for food Systems 42
- Assessment and improvement of water productivity in rainfed and irrigated Districts of India: A pathway for transforming Agri-food Systems 43
- Nature-based solutions can support a healthy climate, economy and planet 44
- Innovations in rainwater harvesting technologies and their utilisation 45
- Managing poor quality water for Sustainable Agri-foods Systems 46
- Soil health enhancement for sustainable agriculture production 47
- Agroforestry: A nature-based solution for mitigation and adaptation to climate change 48
- Carbon farming opportunities and action plan towards achieving SDGs in India 49
- Microbiome-based approaches for sustainable agriculture 50
- Addressing nutritional security through natural resource management 51
- Nature-based soultions for climate resilient agriculture: Embracing the 5A approach 52
- Criticality of soil and water in one health approach 53
- *AIIA* (Assimilate, Interpret, Innovate and Adapt) Model in *Smart Agriculture* *54*
- Digital agriculture for agri-food systems disruption in India- Prospects and problems 55
- Artificial Intelligence systems for agriculture 56
- Artificial Intelligence: Case studies in Indian agriculture 57
- Opportunities and challenges in application of AI in building innovative climate smart digital agriculture solutions 58
- Biofortified food commodities for achieving sustainable development goals (SDGs) 59
- Sowing sustainability: G20's vision of Agri-food Transformation for One Earth, One Family, One Future 60
- Economic analysis of diversification of food diets through social safety net programs 61
- Transforming food systems in marginal environments: Strategies and implications 62
- Changing pattern of demand for agri-processed commodities in India 63
- Marketing channels and market prices: Evidence from high-value crop producers in India 64
- Role of FPOs and contract farming in agri-food system transformation: Evidence and policy issues 65
- Current systems of higher education in agriculture and its transformation to food security 66
- Kulagar traditional framing system for sustainability, soil quality and soil carbon sequestration in the Konkan region: A survey 67
- Reframing Indian coastal aquaculture and fisheries: An IPCC risk assessment perspective 68

- Impact of climate change and mitigation strategies for sustainable livestock production in coastal Regions.....69
- Natural farming for systemic transformation of coastal agriculture.....70
- Agro-eco tourism for livelihood diversification and scaling of entrepreneurship among rural youth.....71
- Repurposing agricultural subsidies for higher and sustainable agricultural development.....72
- From farm to fork: Role of FPOs and Agri-startups in India.....73
- Creating a start up ecosystem to empower youth and women in Amrit Kaal.....74
- Bridging gender inequity in agriculture through innovation and technology.....75

Poster Sessions

Ensuring Food & Nutritional Security: Production, Consumption and Value Addition

- Addressing malnutrition in North-east India: Strategies and solutions for a healthier future.....78
- COVID-19 pandemic impact on fish consumption paradigms across Kerala.....79
- Clam (*Tegillarca granosa*) blood exudate powder–Recommended as a micronutrient-rich supplement to address hidden hunger.....80
- Empowering fisherfolk communities for sustainable health practices and consumption: A path to food and nutritional security.....81
- ICAR-CIAE process technologies for entrepreneurship of women through processing and value addition of millets.....82
- Pre-breeding for biofortification in wheat (*Triticum aestivum* L.).....83
- Spatiotemporal analysis of marine fish valuation in India – Insights and perspectives.....84
- Contributions of agricultural interventions to food security–A comprehensive review.....85
- Enhancing food and nutritional security of tribal farmers–A successful model under the Farmer FIRST Programme.....86
- Phenolic antioxidant-linked health-promoting properties of tree bean (*Parkia roxburghii*) plant parts.....87
- Journey of Indian wheat and roadmap for improvement.....88
- Identification of high-yielding biofortified wheat genotypes in advanced breeding lines.....89
- Landraces and wild species to widen the genetic pool for crop improvement.....90
- Growth and yield of quinoa as influenced by different dates of sowing, crop geometry and nitrogen levels under sodic wasteland condition.....91
- Resistance prevalence and antioxidant enzyme alterations in *Tribolium castaneum* (Herbst) against phosphine toxicity.....92
- Add-ons to coastal livelihoods: Does it bring home the bacon? Collations from Gujarat, India.....93
- Curvularia leaf spot, re-emerging disease of maize: Status and perceptions.....94
- Screening of potential biocontrol agents against important seed-borne plant pathogens of field crops.....95
- New diseases in sugarcane germplasm at Kannur.....96
- Nutribars from nutricereals: A holistic approach to address malnutrition and promote sustainable nutrition.....97
- Barley: A potent harbinger of good health.....98

- Double emulsion encapsulated *Emblica officinalis* extract reduces the high fructose diet-induced metabolic dysfunctions in rats 99
- Nutri-SMART Village by KVKs – A pathway for nutrition security in Central India 100
- Utilizing natural genetic diversity for micronutrient enhancement in nutri-cereal pearl millet 101
- Exploring the economic viability of fishing crafts and gears: Essaying reflections from marine fisheries harvest from the south-east coast of India 102
- Impact of supplementation of an antioxidant-rich extract of seaweed *Eucheuma denticulatum* on feed efficiency, serum antioxidant status, immune response, gut pathogen count, and expression of intestinal and hepatic genes in broiler chickens 103
- Development of a core set from a large diverse rice (*Oryza sativa L.*) landraces population panel using agronomic data 104
- Evaluation of BNI introgressed lines and trait incorporation in Indian wheats 105
- Assessing peroxide levels and oxidative stress induced by fish oil supplements: Implications for product quality and cellular health 106
- Hybrid wheat development: Progress and challenges 107
- Influence of foliar application of 'PGR's and nutrients for enhancing the productivity of soybean under rainfed condition 108
- Optimum soil moisture regime during different phenological growth stages of Thompson Seedless (*Vitis vinifera*) grape 109
- Mass seed production and rearing of small indigenous fish mola carplet (*Amblypharyngodon mola*) to promote nutrition-sensitive aquaculture 110
- Induced breeding and mass seed production of pool barb (*Puntius sophore*) – A nutrient-dense small indigenous fish species in Assam 111
- Elucidating the genetic variability for grain zinc and iron content among indigenous wheat germplasm 112
- Tropical Chlorophytan seaweeds as potential storehouse of nutritional and bioactive properties 113
- Climate resilient sugarcane production for sustaining food and energy security in India: Future road map and policies 114
- Development and quality assessment of millet-legume based vermicelli 115
- Comparative advantage of zero tillage over conventional tillage for potato in rice-potato cropping system 116
- Comparative advantage of soil test based NPK applications over their recommended doses in potato under rice-potato cropping system 117
- Augmenting production potential and profitability of pulses through cluster frontline demonstrations in North-east Region, India 118
- Single and multi-nutrient deficiencies of sulphur and micronutrients in soils of India 119
- Host preference of shoot fly on different minor millets: A way for management through crop diversification 120
- Maize as ethanol feedstock: Prospects and strategies in India 121
- Nutri cookies and cakes sweetened with sugarcane raw sugar (jaggery) 122
- Effect of biofertilizers and levels of lime on linseed (*Linum usitatissimum L.*) under custard apple (*Annona squamosa L.*) based agri-horti system on Vindhyan soil 123
- Response of liquid biofertilizer and their mode of application on yield and economics of finger millet (*Eleusine coracana L.*) 124

- Enhancing chickpea productivity through post-emergence herbicides for comprehensive weed management....125
- Integrated farming system approaches for sustainable intensification, livelihood security and diversification of coastal agriculture....126
- Technological developments in sugarcane for value addition and product diversification....127
- Antimicrobial effects of chitosan-henna leaf extract on selected plant pathogens....128
- Millet, a potential crop of organic farming for climate resilience and nutritional security in Himalayan Ecosystem....129
- From Nuisance to Nutrition: Unmasking the seed-specific genes contributing to Raffinose Family Oligosaccharides accumulation in peanuts (*Arachis hypogaea* L.) via transcriptomic-based approach....130
- Insecticidal and repellent activities of essential oil from the leaves of *Callistemon lanceolatus* to control pulse beetle, *Callasobruchus chinensis*....131
- Bioefficacy of essential oil extracted from wild turmeric (*Curcuma aromatica* Salisb) leaves waste against a major secondary storage pest, *Tribolium castaneum*....132
- Effect of polyhalite application on maize yield, nutrient use efficiency and soil properties in semiarid Alfisols....133
- Flavoured RTS Beverage from coconut haustorium....134
- Chemical composition and insecticidal activities of essential oil of *Alpinia calcarata* (Haw.) Roscoe rhizome against Red flour beetle, *Tribolium castaneum*....135
- Molecular mapping of nutritional traits in synthetic hexaploid wheat (*Triticum aestivum L.*) population using a high-density SNP-based linkage map....136
- Low protein and high lipid diet: Effect on nitrogenous waste production of GIFT fingerlings reared in recirculatory aquaculture system....137
- Integrated Farming System: Way for nutritional and economic security of small farmers....138
- Preliminary assessment of yield and nutritional properties of coconut cabbage (heart of palm) in selected coconut (*Cocos nucifera* l.) accessions....139
- Technological interventions for enhancing farmers' income and productivity: A case study in Bihar....140
- Blending millets and legumes with wheat for food products with enhanced nutritional potential....141
- Banana biodiversity for food and nutritional security....142
- Soil test based balanced nutrient application in little millet (*Panicum sumatrense*) for lateritic soils of Tamil Nadu....143
- Evaluation of various insecticides against mustard aphid, *Lipaphis erysimi* (Kaltenbach) in mustard crop....144
- Cold anaesthetization of *Penaeus vannamei* for waterless transportation....145
- Deciphering the regulation of nutritive value and drought stress response in *Moringa oleifera* through genomic approach....146

Climate Action for Sustainable Agri-food Systems

- Impact of climate change on food and nutrition security: Evidence and research gaps....148
- Integrated Multi-Trophic Aquaculture (IMTA): Economic prosperity and environmental sustainability through the integration of cage fish farming and seaweed mariculture....149
- Low-salinity induced alterations in transcriptome of Indian white shrimp (*Penaeus indicus*)....150
- Utilisation of forecasts for enhanced preparedness and suitable crop planning....151

- Mapping the climate change-induced physical hazards along the coastal districts of India 152
- Harnessing *Asparagopsis taxiformis*: A promising red macroalga for methane mitigation and its prospects for seaweed farming to reduce dairy farm carbon footprints 153
- *In vitro* characterization and functional validation of plant-growth-promoting and stress-tolerant soil bacteria to improve the yield and salt resistance of rice 154
- Resilience index of Vembanad Lake fishery 155
- Effects of high water temperature stress on physiological profiles of *Labeo rohita, Labeo calbasu* and *Labeo bata* in context of global warming 156
- Can fishing holidays be part of just transition in marine fisheries? An exploratory study across coastal states in India 157
- Impacts of ENSO events on ocean-atmospheric parameters and selected marine fish resources along the Gujarat coast 158
- Breeding durable root and stem rot (*Macrophomina phaseolina*) resistant sesame genotypes 159
- Phenotypic evaluation of traditional rice landraces for root traits 160
- Weather based technological interventions in integrated farming system for reducing cost of cultivation and climate risk 161
- Symbiotic associations in diatoms and dinoflagellates in oligotrophic waters along the inshore waters off Kochi and Dakshina Kannada, South-west coast of India 162
- Soil microbial community and potential methane production under various vegetations of coastal area of Gujarat 163
- Climate smart technologies to enhance water productivity in wheat at farm level 164
- Effect of *in-situ* rice residue management practices on wheat productivity, profitability and soil health at graded N levels in North-west India 165
- Bloom occurrence of a rare and harmful dinoflagellate, *Scripsiella trochoidea* in the coastal waters off Kochi during the late summer monsoon of 2021 and its impact on the phytoplankton community structure 166
- Identification of stable short duration genotypes for introducing finger millet in summer season in Bihar 167
- Projecting the spatial distribution of major marine fishery resources along the west coast of India under varying climate change scenarios 168
- Influence of major environmental drivers on selected marine fishery resources of the south-eastern region of India 169
- Impact of cyclones on marine fisheries in the Arabian Sea: A comparative study between Ockhi and Tauktae 170
- Unveiling the natures' alchemy: Estimation of blue carbon sequestration potential of mangroves in Kerala 171
- Integrated assessment of fishing and environmental drivers on the sustainability of threadfin breams (*Nemipterus* spp.) in the South- eastern Arabian Sea 172
- Species distribution modelling for evaluating the habitat suitability of patagonian toothfish in the Southern ocean 173
- Unveiling climate-resilient coral conservation zones in India:Fostering fisheries sustainability 174
- Invasion of Corallimorpharians: Assessing competitive success over corals in Lakshadweep's shallow reefs 175
- Analyzing vegetation changes in Kerala forests: Effects of temperature and rainfall using Google Earth Engine 176
- Opportunities in big data analytics and ICTs to accelerate climate adaptation 177
- Index-based insurance–A step to strengthen resilience of fishing sector in the Bay of Bengal, amidst climate shifts 178

- Temperature and moisture dependent virulence of the entomopathogenic nematodes against larval and pupal stages of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) 179
- Waterlogging tolerance in cassava: Morphological traits, yield, proline content and catalase activity 180
- Variety x Landrace derived recombinant inbred line population reveal high genetic variability and transgressive segregants for grain yield and attributing traits in rice 181
- A novel coupled approach (AquaCrop-Economic Model) to explore future climate response to food security 182
- Biochemical analysis and antioxidant activity of shrubs under hot arid condition 183
- Climate smart technologies in the rice based farming system of Kumarakom 184
- Development of drought tolerant mulberry genotypes for rainfed sericulture 185
- Effect of zinc nanoparticle on physiology of finger millet [*Eleusine coracana* (*L.*)] under saline condition 186
- Transcriptome dynamics under waterlogging stress in tropical maize (*Zea mays L.*) 187
- Climate resilience: Plant breeding perspective 188
- Multiple indices-based selection of functional traits and elite mustard genotypes for cultivating salt affected soils 189
- Mapping land availability and potential bioenergy feedstocks for India 190
- How does incorporating atmospheric CO_2 concentration into FAO penman-monteith equation change reference evapotranspiration for future climate conditions projected over India? 191
- Yield and yield attributes of various foxtail millet (*Setaria italica L.*) cultivars under western Zone of Tamil Nadu 192
- Development of a common multi-parental population as genetic resource for mitigating heat and drought stress in wheat 193
- Evaluation of *Yr*-gene introgressed wheat lines for morpho-physiological and yield traits 194
- Trends in surface weather parameters of coastal India and implications for brackishwater aquaculture 195
- Vermicomposting with poultry litter and its effect on crop yield – Wealth out of waste 196
- A comparative analysis of energy use, carbon footprint and related environmental burdens of different fishing systems through Life Cycle Assessment approach 197
- Effect of improved staking method with plastic mulching for tomato cultivation in kharif season 198
- Present status of sesame diseases and their integrated management using indigenous practices 199
- Quantifying dry spell dynamics for sustainable rainfed agricultural production systems 200
- Assessment of *in-situ* residue management on carbon mineralisation and soil physico-chemical properties in rice-wheat system 201

Frontier Science and Emerging Genetic Technologies: Genome Breeding, Gene Editing

- *OsPSTOL* gene-driven adaptive alterations: Comparative transcriptomic study of Pusa44 and its *Pup1* introgressed NIL 204
- Identification of novel putative alleles conferring resistance to wheat rusts using genome-wide association study 205
- Identification of inbreds possessing favourable alleles for genetic improvement of grain yield and yield components in maize (*Zea mays* l.) 206
- Comparison of genomic prediction models in genomic selection for leaf, stem and yellow rust resistance at seedling and adult plant stage in bread wheat (*Triticum aestivum* L.) 207
- sRNAseq identifies known and novel miRNAs in drought tolerance in Black pepper (*Piper nigrum* L.) 208

- Genome-assisted breeding for the integration of triple rust-resistant genes to fast-track improvement for disease resistance in Bread wheat (*Triticum aestivum* L.) 209
- A comparative study on sugar-related transcripts in sugarcane hybrid, Co 11015, and progenitor species *S. officinarum* and *S. spontaneum*. *210*
- Validation of KASP markers associated with foliar blast resistance in Pearl millet delineated through GWAS and biparental mapping approaches. 211
- Genome-wide SNP discovery and annotation in the Gir breed of cattle 212
- Artificial Intelligence for CRISPR/Cas9 off-target prediction in crop plants 213
- CRISPR/Cas9-RNP-Mediated MSTN gene editing in buffalo fibroblasts: Unlocking growth potential for enhanced meat production. 214
- Genetic analysis of pre-weaning growth rate and efficiency-related traits in inter-cross sheep 215
- Molecular cytogenetic analysis to unravel the genome architecture of modern sugarcane cultivars 216
- CRISPR Cas9-based starch modifications in cassava paving way to futuristic-based industries 217
- CRISPR/Cas9-mediated lignin modification in sugarcane towards improved lignocellulosic biofuel production 218
- Delineating the molecular pathway of pretermination of sex in buffalo using CRISPR/Cas9 219
- TALEs are virulence factors of pomegranate bacterial blight 220
- Unraveling the genetic gain trends in Basmati rice over 37 Years: Insights from historical data for grain yield and quality. 221
- Patents, technology licensing and inclusive innovation for access and commercialization of technology: The case of CRISPR Cas9 222

Livestock-based Transformation of Food Systems

- Genetic analysis of variability and associations of fertility and production traits in crossbred cattle of Kerala using multi-trait models 224
- Genetic evaluation of Frieswal cattle under marginal production system. 225
- Field progeny testing of Frieswal bulls–An important tool for genetic improvement of cattle in the existing scenario 226
- Whole genome sequencing and analysis of Vechur cattle 227
- Rumen fermentation profile and faecal microbiota altered in response to electrohydrodynamically encapsulated probiotics in indigenous cattle calves 228
- Genetic evaluation of Gir bulls for first lactation milk yield through associated herd progeny testing programme. 229
- Fostering a livestock production sector transformation in India: An analysis of credit empowerment and innovations in value chain dynamics 230
- Bovine population dynamics and milk production in India: A household and district level analysis 231
- Changing breed preference among dairy farmers in Andhra Pradesh: Patterns and determinants. 232
- Institutional credit to dairy farming in Kerala for sustainable income: An economic analysis. 233
- On-farm assessment of different total mixed rations (TMRs) for dairy cows towards enhanced milk production in Ernakulam District. 234
- CRISPR and SCNT technology for production of β-lactoglobulin (BLG) gene knockout blastocyst stage buffalo embryos. 235

- Convergence policy strategies to conserve and propagate Nili-Ravi buffalo for higher returns in its breeding tract....236
- Extent of adoption of scientific dairy farming practices by tribal dairy farmers of Wayanad District in Kerala, south India....237
- Transcriptional profiling of GDF9 and it's signaling receptors in caprine granulosa and theca cells....238
- Performance evaluation of crossbred pigs reared in coastal ecosystem....239
- Ecological impact of pig production systems in India through lifecycle assessment....240
- Comparative expression analysis of microRNAs targeting the PTEN gene in testes of indigenous, crossbred and exotic pigs....241
- Assessment of water and energy usage in poultry slaughter and meat processing plant: A case study....242
- Green extraction of collagen hydrolysates through valorization of poultry skin: Physicochemical, functional and microstructural properties....243
- Floor space management in intensive duck production for growth and egg production....244
- Study to determine optimum level of protein requirement for White Pekin ducks during layer stage....245
- Adaptive capability of slow growing poultry as indicated by physiological and molecular responses in hot and humid climate and measures for acquired thermotolerance....246
- Harnessing drone technology for advancing animal agriculture....247
- Identification of suitable food-fodder production systems for enhancing fodder productivity in arid region....248
- Nutritive value of cultivated grasses and *Cenchrus* tri-specific hybrid *vis-a-vis* their silage fermentation characteristics....249
- Utilization of inter subspecies heterosis for enhanced green and dry biomass of maize fodder....250
- Coarse wool based eco-friendly sapling bags for organic horticulture plant growth....251
- Omega-3 fortified mozzarella cheese: A nutraceutical approach for enhancing food and nutrition security....252
- Microbial smart Time-Temperature Indicator (TTI) for determining thermal abuse of packaged *Paneer*....253
- Molecular epidemiology and pathology of lumpy skin disease outbreaks in Karnataka, India....254
- Lumpy skin disease: Virus isolation and molecular characterization from cattle including antibody detection in buffaloes....255
- Reproductive disorders in female dromedary camels of India....256
- Comparative efficacy of inorganic and nano forms of trace minerals (Cu, Zn and Mn) supplementation on recovery of subclinical mastitis in lactating dairy cows....257
- Evaluation of prevalence, biofilm forming ability of *Escherichia coli* isolated from buffalo mastitis and its association with antibiotic resistance....258
- Detection of *Coxiella burnetii* infection in goats and animal handlers in Chhattisgarh and Odisha using real-time PCR through One Health approach....259
- Detection of *Mycobacterium bovis* infection in goats and animal handlers in Chhattisgarh and Odisha using real-time PCR....260
- Challenges in Foot and Mouth Disease elimination in India and the way forward....261
- Evaluation of infectious bursal disease-Immunecomplex (IBD-Icx) vaccine induced response in chicken with IBD specific maternal antibodies....262
- Isolation, characterisation and adaptation of indigenous Infectious Bursal Disease Virus (IBDV) in cell culture....263

- Co-circulation of multiple serotypes of Foot and Mouth Disease virus among susceptible animal population in India during 2021-2022 264
- Foot and Mouth Disease in mithun, yak, cattle-yak hybrids and cattle in the north-eastern states of India during 2021-2022 265
- Assessment of antimicrobial activity of calves-origin lactic acid bacteria against predominant diarrhoea-causing pathogens and clustering to develop a multi-strain probiotics adjunct 266
- Testicular perfusion analysis using digital pulse wave Doppler ultrasonography in Shweta Kapila breed of indigenous cattle reared in their native tract under western coastal climate 267
- Expression patterns of genes related to intramuscular fat and fatty acid metabolism in Nellore and Deccani sheep breeds of deccan plateau region 268
- Pregnancy detection in ruminants using urinary metabolites 269
- Nutritional composition of mithun (*Bos frontalis*) milk reared under semi-intensive system 270

Horticulture-based Transformation of Food Systems

- Diversity of jackfruit (*Artocarpus heterophyllus*) accessions of Goa 272
- Novel lncRNA from stone apple (*Aegle marmelos L.*) regulate the gene expression profile under stress 273
- Factors influencing hyperhydricity associated with *in vitro* regeneration of coconut 274
- Pre-harvest bagging of litchi bunches enhances fruit quality 275
- Virome analysis of nursery plants of two Indian grapevine cultivars employing high throughput sequencing 276
- Invasion of exotic whiteflies (Hemiptera: Aleyrodidae) in India: Biosecurity, challenges and biocontrol strategies 277
- Litchi stink bug (*Tessarotoma javanica*): An invasive pest of litchi 278
- Transmission and real time detection of viruses (ApMV and ApNMV) associated with mosaic disease of apple (*Malus domestica*) 279
- Tachinid research in india: Miles to go? A status report 280
- Physiological approaches for improved post-harvest quality of fruits and vegetables under varied environments 281
- Price spread of coconut in Kozhikode District of Kerala, south India 282
- Impact of balanced and customized nutrient solution through enhanced efficiency fertilizers (EEF) on productivity, quality, soil health and climatic resilience in horticultural crops 283
- Bottom-up effect (HPR) on plant-insect interaction in underutilized horticultural crops for sustainable production 284
- Smart food production: Future of Indian horticulture 285
- Effect of growth regulators on dormancy breaking and yield in elephant foot yam *Amorphophallus paeoniifolius* (Dennst.) Nicolson 286
- Garden pea *Pisum sativum L.* as a new host for pineapple mealybug, *Dysmicoccus brevipes* Cockerell (Hemiptera: Pseudococcidae) 287
- Detection, identification and chemo-sensitivity of seed borne pathogens in vegetable crop seeds 288
- Advance heat tolerant potato hybrids evaluation for yield and quality parameters for West-Central India 289
- Source and sink manipulation effects on physiological characters and yield of cucumber (*Cucumis sativus L.*) grown under polyhouse condition 290
- Insights into ogura cytoplasmic male sterility system expediting breeding of Indian cauliflower 291

- Seed village programme for quality planting material production in Chinese potato 292
- Superiority of F_1 hybrids over parents for fruit yield and its component traits in okra *Abelmoschus esculentus (L.)* Moench 293
- Screening of brinjal (*Solanum melongena L.*) genotypes for tolerance to brinjal fruit and shoot borer 294
- Influence of plant density and deblossoming on zombi pea (*Vigna vexillata*): An underutilized nutritious vegetable 295
- Farmer participatory demonstration on site specific nutrient management in chinese potato cultivation in Tamil Nadu 296
- Performance of improved varieties of cassava in two agro-ecological units of Kerala, south India 297
- Protected agriculture for enhancing farmers' income in coastal region 298
- Horticultural Crops: Potential for developing functional foods and nutraceuticals 299
- Intercropping of seed spices with pomegranate (*Punica granatum*) 300
- Constraint analysis of seed spice farmer in Rajasthan 301
- Insecticidal activities of *Lantana camara L.* leaf essential oil against cigarette beetle *Lasioderma serricorne* *302*
- Nutritional and phytochemical profiling of potential edible flowers with scope for value addition 303
- Studies on drying characteristics and quality evaluation of cloves (*Syzigium aromaticum*) 304
- Ornamental flowers: Potential for future food and health, an investigation 305
- Unveiling the genetic integrity of *in vitro* induced micro rhizomes and their progenies in ginger: Implication for sustainable cultivation 306
- Commercial farming of African marigold in Ernakulam District: Towards enhancing farmer's income during Onam festival 307
- Optimization of process parameters for spray dried ginger-lime juice powder using RSM and physicochemical evaluation of the dried powder 308
- IISR-DNA fingerprinting facility: Crafting the genetic score of spice symphony 309
- Valorisation of leaf waste of *Curcuma angustifolia* as a bio-insecticide against cigarette beetle *Lasioderma serricorne* *310*
- Future of Indian cardamom, farmers, and farming in the cardamom hill reserves (CHR), Kerala, India 311
- Biochemical diversity of leaves and fruits from *Garcinia* species 312
- Orchids of India: Time to start claiming its legitimate place, ICAR-NRC for Orchid's perspective 313
- Enhancing vase life of *Dendrobium* cut flowers through carbendazim-mediated metabolic inhibition 314
- Orchid elegance in a bottle: Exploring *in vitro* flowering 315
- Biodiversity informatics and global knowledge inclusiveness: Windows of web-accessible interfaces on orchid biodiversity and conservation 316
- Chemoprofiling of essential oils and curcuminoids of three *Curcuma* species 317
- Propagation of two wild edible ferns of Sikkim Himalayas for conservation and sustainability 318
- Response surface methodology and genetic algorithm guided ultrasonication based resin assisted purification of anthocyanin 319
- In-depth study of floral bio-active constituents and antioxidant potential of *Papilionanthe teres* (Roxb.)– An endangered and endemic orchid species 320

- Extraction and characterization of bioactive constituents from seeds and peel of ten pomegranate varieties grown in arid region....321
- Orchids in nutraceuticals, cosmeceuticals and fast-moving consumer goods (FMCGs): Panorama on world trade and a prospective outlook of sustainable development goals 322
- Development of technology for preservation of tender coconut water....323

Aquaculture & Fisheries-based Transformation of Food Systems

- Growth, survival and production of nutrition sensitive small indigenous species (SIS) mola carplet (*Amblypharyngodon mola)* in carp-SIS poly-culture system 326
- Breeding of small freshwater indigenous prawn *Macrobrachium dayanum* under captivity....327
- Biofloc technology (BFT) based maturation and breeding of Indian white shrimp, *Penaeus indicus* along with eyestalk ablation in captive conditions....328
- Commercial scale seed production of pearlspot (*Etroplus suratensis):* A Farmer Participatory approach....329
- Breeding and seed production of *Oryzias setnai* (Kulkarni, 1940) in marine captive conditions....330
- Optimisation of seed production of fanged seabream, *Sparidentex jamalensis* Amir, Siddiqui & Masroor, 2014 in captivity 331
- Captive induced spawning and larval rearing of goldlined seabream *Rhabdosargus sarba*....*332*
- Production of hybrids of clown fishes and observations of the F1 progeny....333
- Production of hybrid marine ornamental clownfish *Amphiprion occularis* through interspecific hybridization between female *Amphiprion ocellaris* and male *Amphiprion percula* *334*
- Embryonic development in induced-bred *Siganus vermiculatus* and effect of environmental conditions on fertilised eggs....335
- Embryonic and early larval development of brackishwater ornamental fish *Monodactylus argenteus* (Linnaeus, 1758)....336
- Evaluation of ideal stocking density for rearing spawn to fry during nursery phase of *Labeo rohita* (Hamilton, 1822) in biofloc system....337
- Larval rearing of striped murrel, *Channa striata* in different refuge systems 338
- Effect of substrate on growth and survival of fry of *Clarias dussumieri* (Valenciennes, 1840), an endemic food fish from Peninsular India 339
- Growth performance of *Labeo rohita* (Hamilton, 1822) juveniles reared at varying salinity levels using inland saline groundwater....340
- A study on off season fish fingerling production in Nayagarh district of Odisha 341
- Effect of stocking density during nursery rearing on the growth, survival, and compensatory growth of speckled shrimp, *Metapenaeus monoceros* *342*
- Effect of varied salinities on breeding performance and larval development of orange chromide, *Etroplus maculatus*....*343*
- Standardized larval rearing protocol of vermiculated spinefoot, *Siganus vermiculatus* for mass scale seed production. 344
- Early inroads into larviculture and standardization of feeding in John's snapper, *Lutjanus johnii* (Bloch, 1792)–a promising mariculture species for India....345
- Nursery rearing of vermiculated spinefoot, *Siganus vermiculatus* in indoor *FRP* tanks....346
- Studies on growth responses of black clam, *Villorita cyprinoides,* (Gray, 1825) in different environments....347

- Feasibility and growth studies of hatchery produced *Crassostrea madrasensis* (Preston, 1916) spat in Palghar district of Maharashtra 348
- High density nursery and grow-out farming of *Penaeus vannamei* using copefloc technology 349
- Grow out production systems for mud crab, *Scylla serrata* *350*
- Optimal dosing of human chorionic gonadotropin (hCG) via sustainable-release hormonal implants improves gonad maturation, reproductive performance, and larval vitality of striped murrel, *Channa striata* reared under indoor condition 351
- Effect of different dietary n-3/n-6 polyunsaturated fatty acid levels on the captive maturation of *Anabas testudenius* reared in biofloc culture system 352
- Biochar enhances the growth parameters, haematological parameters and enzymatic activities of Genetically Improved Farm Tilapia (GIFT) reared in inland saline water 353
- Exploring the impact of fish waste hydrolysate on growth enhancement in *Penaeus vannamei* during nursery phase 354
- Frozen Tubifex – an effective way of feeding ornamental fishes 355
- Feeding techniques in the nursery rearing of bigfin reef squid, *Sepioteuthis lessoniana*. *356*
- Use of copepods as live feed for marine ornamental fish larval rearing 357
- Marine microalgae, *Isochrysis galbana* culture in Photobioreactor: Effect of CO_2 supply on enhanced growth and productivity 358
- Commercial scale cultivation of marine microalgae in open raceway ponds for algae meal production– Technical evaluation 359
- Biochemical effect Of microplastic ingestion on tilapia *(Oreochromis niloticus)* *360*
- Assessment of Condition Factor in *Pangasianodon hypophthalmus* reared under different Aquaculture Systems .. 361
- An investigation on the behavioral responses of spiny lobster, *Panulirus homarus* (Linnaeus, 1758) to salinity shifts with perspectives for coastal aquaculture practices 362
- Effect of thermal acclimation on the tolerance of silver pompano, *Trachinotus blochii*: A species for climate-resilient mariculture 363
- Does the lunar periodicity affect the spawning rhythm in captivebred marine ornamental fishes under controlled environment? 364
- Innovative approaches on procurement, transportation and development of captive broodstock of Asian seabass *Lates calcarifer* (Bloch) 365
- Degradation kinetics of potassium permanganate in tropical aquaculture environments 366
- Water budgeting and cutback approach in coastal shrimp culture 367
- Comparison of total carbon budgets for *Penaeus vannamei* in earthen and polyethylene lined culture systems .. 368
- Sustainable development of open sea cage farming in Indian mariculture: Insights from water quality analysis using Generalized Additive Modeling (GAM) 369
- Impact of extremely heavy rainfall on water quality in shrimp aquaculture areas of Godavari river basin of Andhra Pradesh 370
- Biodiversity and social impact of shrimp farming in coastal regions of Andhra Pradesh 371
- A metabolomic snapshot through NMR revealed differences in phase transition during induction of reproduction in *Ulva ohnoi* (Chlorophyta) 372
- Effective temperature shock and photoperiod for seed production of edible green seaweed *Ulva lactuca* *373*
- High-Density Polyethylene (HDPE) raft-based tube-net farming: a novel seaweed culture technique in open sea .. 374

- Feasibility studies on floating raft culture of *Gracilaria edulis* from coastal waters of Vellapatti, southeast coast of India. 375
- Success story on species, site and method suitability of seaweed farming in Ratnagiri coast, Maharashtra 376
- Good Management Practices in seaweed farming 377
- Aquaponics: Reshaping bio-integration based circular economy as a sustainable strategy for income diversification and climate resilience in agri-aquaculture food system 378
- Design and Development of 'Aquaculture Automation Technology' for Sustainable Shrimp Farming 379
- Development of super intensive marine finfish RAS 380
- Modified pen design for fish farming: A new venture for aquaculture in shallow coastal waters 381
- Technology for coastal pond farming of Indian Pompano (*Trichinous mookalee Cuvier, 1832)* – new options in coastal aquaculture 382
- Unleashing prosperity: Cage culture empowers SC communities in Ernakulam district 383
- Coastal resource management and economic performance of mud spiny lobster mariculture in tropical sea cages, north-eastern Arabian sea, India: An empirical study 384
- Brackishwater cage farming of Asian seabass *Lates calcarifer* as an additional income generation activity by fisher women SHG's 385
- The significance of small-scale cage farming in the livelihood transformation of coastal Karnataka's fishers 386
- Nurturing pearlspot seed production technology: A thriving enterprise in the fisheries sector. 387
- Fisher-women of Chilika empowered through mud crab fattening in HDPE boxes: An alternative livelihood support intervention under SCSP 388
- Participatory approach in marine ornamental aquaculture for livelihood and conservation 389
- Aquaculture of soft corals (Octocorallia:Alcyonacea) as a step towards their conservation in coral reef ecosystems 390
- Growth and asexual propagation of magnificent tentacle anemone, *Heteractis* sp. and bubble tip anemone *Entamacea quadricolor* for promoting sea anemone aquaculture and its sustainable aquarium trade . . . 391
- Indigenous ornamental fishes of the Western Ghats: Development of captive breeding for conservation. 392
- Successful mass production of *Clarias dussumieri* a near-threatened endemic catfish of the Western Ghats through captive breeding 393
- Captive breeding makes a way for the recovery of an endangered catfish *Horabagrus nigricollaris* endemic to River Chalakudy 394
- Prioritization of Watersheds for Fisheries Development in North-western Himalayas 395
- A review and projections on watershed management to improve fish production in Uttarakhand, India 396
- Brackish water aquaculture sector post-tsunami and the utilization of submerged land for aquaculture in South Andaman Island 397
- Scope, opportunities and challenges in mariculture entrepreneurship development in Gujarat 398
- Development of mariculture technology parks in India: A SWOT-based evaluation adds a new dimension to the mariculture sectorlandscape 399
- Delineation of aquaculture development zones in coastal India using geospatial techniques 400
- Prospect and management of wetland fisheries: A case study of Kasaraiya Dhar Maun in Bihar 401
- Fish and fishery of Idukki Reservoir, Kerala 402
- Fishery of black clam, *Villorita cyprinoides* (Gray, 1825) from Vembanad Lake 403

- Ashtamudi clam fishery-catch trend and status 404
- Status of blood clam fishery of Kakinada Bay, Bay of Bengal 405
- Fishery and stock assessment of *Babylonia spirata* (Linnaeus, 1758) (Neogastropoda: Buccinidae) along south-west coast of India..... 406
- Non-penaeid shrimp fishery along Maharashtra coast-catch trend and status 407
- Regime shift dynamics of oil sardine fishery in Kerala 408
- Status of marine fisheries of Odisha: An Overview..... 409
- Live bait resources of Lakshadweep–Imperative need for sustainable utilization and conservation..... 410
- Characterization of low-valued bycatch in the bottom trawlers of Gujarat 411
- Sustained food security from unconventional fishery resources: market oriented lucrative fishery of pufferfishes in Tamil Nadu, India..... 412
- Fishery, biology, and stock status of Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816) from the north-eastern Arabian Sea of Maharashtra coast..... 413
- Fishery of catfishes along north Tamil Nadu coast..... 414
- Present status of elasmobranch fishery, conservation and management in Odisha..... 415
- An integrative approach of fish identification for fishery management of Sarasakumri, a small river of Sundarban mangroves..... 416
- A taxonomic study on ornamental fishes under Cypriniformes from the Tansa River, Maharashtra..... 417
- Integrated taxonomic tools for the identification of selected loaches from India..... 418
- Taxonomic Studies and Phylogenetic Analysis of Genus *Osteobrama* Heckle, 1842 in India..... 419
- Mitochondrial-based molecular signatures for cone snails from Kollam and Thoothukudi waters..... 420
- Integrative taxonomy of needlefishes (Beloniformes: Belonidae) from Indian waters 421
- Mitochondrial marker-based integrated taxonomy reveals distributional range extension of *Gymnocranius obesus* beyond the Coral Triangle to the Indian Ocean..... 422
- Statolith-based age and growth of the Bobtail squid *Euprymna hyllebergi* Nateewathana, 1997 (Cephalopod: Sepiolidae) from the southeastern Arabian Sea 423
- Length-weight relationship and morphometrics of portunid crab *Monomia gladiator* (Fabricius, 1798) from southeastern Arabian sea 424
- Reproductive biology of green tiger shrimp *Penaeus semisulcatus* (De Haan,1844) in Palk Bay ecosystem, southern peninsular India 425
- Spawning seasons of commercially important demersal finfishes along the south-east coast of India 426
- Comparative ovarian development and spawning behavior in landlocked and migratory female *Tenualosa ilisha*: Insights from a Tropical Shad 427
- Assessment of different maturity stages and milt characteristics of Goldlined seabream, *Rhabdosargus sarba*... *428*
- Gonadal assessment of Fanged Seabream, *Sparidentex jamalensis*: a potential aquaculture candidate for Indian waters 429
- Length-weight relationship and reproductive biology of *Sillago malabarica* from the Malabar region, India 430
- Phenology of the *Indian mackerel Rastrelliger kanagurta* (Cuvier, 1816) from the northern Kerala coast..... 431
- Biology of the widenose guitarfish, *Glaucostegus obtusus* (Müller & Henle, 1841) (Rhinopristiformes: Glaucostegidae), from the eastern Arabian Sea 432

- Food and feeding ecology of green tiger shrimp *Penaeus semisulcatus* (De Haan,1844) in Palk Bay, southeastern coast of India 433
- Studies on ecomorphology of some food fishes 434
- Length-weight relationship and the feeding biology of fanged seabream, *Sparidentex jamalensis* from Korapuzha estuary, Calicut, Kerala, India 435
- Predator-prey interactions and its implications in the emergence of red-toothed triggerfish *Odonus niger* in the fishery along the coast of Kerala 436
- Feeding strategy of Indo-Pacific blue marlin, *Makaira nigricans* Lacepede, 1802 caught from the Eastern Arabian Sea 437
- Insights into feeding habits of little tuna, *Euthynnus affinis* (Cantor 1849) from Visakhapatnam Andhra Pradesh 438
- Unveiling population structure of Curmuca barb, *Hypselobarbus curmuca* (Hamilton 1807) in Karnataka rivers 439
- Redefining population structure of migratory hilsa shad in Hooghly-Bhagirathi River using variation in otolith shape 440
- Stock structuring of Unicorn leatherjacket, *Aluterus monoceros* (Linnaeus, 1758) from Indian Exclusive Economic Zones (EEZ) 441
- Seasonal dynamics of optical classes and small pelagic abundance off the South Eastern Arabian Sea 442
- Trophic interactions of major fishery functional groups along the marine ecosystem of Gujarat: An Ecopath model approach 443
- Exploring the dynamics of marine fish landings in Karnataka through Principal Component Analysis 444
- Assessing habitat suitability for endemic Mahanadi Rita, *Rita chrysea,* in Mahanadi River Basin, India 445
- Mapping of surface water dynamics and persistent pools in the Banas River Basin, Rajasthan: a geospatial approach for conservation planning 446
- Navigating the blue: spatial insights into tuna gillnet fisheries along northwest coast of India for advancing oceanic resource-led blue economy 447
- Spatio-temporal distribution of croakers along the Gujarat coast of India 448
- Insights into the reproductive areas of the critically endangered guitarfishes recorded from the Chavakkad coast, Kerala, India 449
- Insight into the fish seed availability and resource mapping along the coastal stretch of the Gulf of Mannar 450
- Spatio-temporal analysis of ichthyoplankton abundance and its relation to environmental factors in Visakhapatnam waters, Andhra Pradesh 451
- Studies on trawl codends with T0 and T90 meshes along Kochi, Kerala 452
- The promising role of V-Form Double-Slotted Otter Boards 453
- Comparative analysis of catch in experimental trials of the CIFT-Turtle Excluder Device 454
- Testing the efficiency of TED, using dive evaluation along the Kerala coast 455
- Candidate species research on sea urchins from the Gulf of Mannar and the Palk Bay for the echiniculture opportunities 456
- Gooseneck barnacles: overlooked and lesser known crustacean in India 457
- Obscurity to opportunity: optimizing the utilisation of Congrid Eel fish resources in India 458
- Productivity estimates of Chaliyar River in Kerala, India 459
- Loss of indigenous fish diversity from a flood plain wetland of Muzaffarpur, Bihar-A case study 460

- Assessing the invasive potential of Alligator Gar in the Indian Subcontinent 461
- Opisthobranchs of Karnataka, India 462
- Diversity indices and biomass variation of macrofoulers on test panels between fish farm site and the reference site at Karwar, west coast of India 463
- Seasonal variation in gastropod abundance in relation to seaweed density along the rocky intertidal area of Thikkodi, south west coast of India 464
- Rare occurrence of gastropod pearls from *Turbinella pyrum* and *Chicoreus ramosus* 465
- Mangrove associated avian fauna of Korapuzha Estuary, Calicut, Kerala 466
- Microplastics: A growing concern for marine ecosystem and Biodiversity 467
- Impact of fishing harbour activities on the coastal water quality of Tuticorin, south east coast of India 468
- Assessing benthic marine debris: A case study from RK Beach, Visakhapatnam 469
- Microplastics from abandoned Fibre glass reinforced plastics (FRP) fishing boats: Emerging concern for the marine environment 470
- Unveiling hidden plastic: Investigating the footprint of microplastics in India's cave waters and its implications for heritage sites 471
- Comparative life cycle assessment of small scale FRP and FRP sheathed fishing boats of Kerala 472
- Comparative life cycle assessment of *Litopenaeus vannamei* farming: Evaluating environmental sustainability 473
- Unlocking new horizons: Exploring in-situ growth studies of limited mobility crustaceans through 'Marine Citizen Science' data integration–A case study of *Solenocera choprai* in the Southeastern Arabian Sea 474
- Self-governance of brown mussel *Perna indica* resource along southwest coast of India 475
- Co-creation of solutions to challenges in small scale fisheries through community engagement 476
- Fisheries-based Aqua Tourism–an emerging entrepreneurship opportunity in Odisha, India 477
- Ecological characteristics of the newly established "Dugong Conservation Reserve" in Palk Bay, Tamil Nadu 478
- Nesting of Olive Ridley Sea turtle (*Lepidochelys olivacea*) in Car Nicobar Island, Andaman and Nicobar Islands 479
- Marine mammal-fishery interaction and indigenous mitigation measures followed by fishers along the west coast of India 480
- Indian Seas' Spinners: Studying *Stenella longirostris* distribution and habitat 481
- Evaluating the distribution and habitat suitability of the Humpback Dolphins, *Sousa plumbea* and *Sousa chinensis*, in Indian waters 482
- Sperm Whales in Indian Waters: habitat and distribution analysis 483
- Exploring ecological attributes and optimal fishing scenarios for the multispecies fisheries of Gayatri Reservoir, India 484
- National Repository of Fish cell lines: An integrated cell bank for *in vitro* applications and cellular agriculture 485
- Gene Expression Atlas: A comprehensive gene expression resource for brackishwater aquaculture 486
- Identification and characterization of LmO2 (Rhombotin-2) gene for its role in cellular growth in *Clarias magur* *487*
- Isolation and characterization of heterotrophic sulfur-oxidizing bacteria: An unexplored resource for improving soil fertility 488
- Variations in global gene expression profiles of *Catla catla* kidney tissues induced by low temperature 489
- Whole Mitogenomes reveal high genetic structure and evidences of purifying selection in *Lates calcarifer* populations in India 490

- Shrimp Nutrient Metabolic Pathway Database (SNMPdb): A repository of genes related to nutrient metabolism in shrimp 491
- From the depths to genes: Mitogenomic blueprint of the Japanese blunt-horn lobster *Palinustus waguensis* sheds light on its evolution 492
- Comparative transcriptomic analysis of acute salinity and temperature stresses in *Penaeus indicus* *493*
- Development of Polymorphic Microsatellite marker for stock identification of Green chromide, *Etroplus suratensis* using Next Generation Sequencing Technology. 494
- Development of novel microsatellite primers for genetic characterization of endangered and endemic yellow catfish, *Horabagrus brachysoma* and *Nilgiri mystus*, *Hemibagrus punctatus* (Bagridae) 495
- Metagenomics analysis unveils comparative haloarchaeal diversity of two solar salterns in Tamil Nadu, south-east coast of India 496
- Exploring MicroRNA expression in *Channa striata:* Insights into habitat manipulation and spawning mechanisms 497
- Deciphering the functional role of opsin gene in vision, growth and reproduction of Penaeid shrimp *Fenneropenaeus indicus* *498*
- Meta-analysis to unravel core transcriptomic responses in *Penaeus vannamei* exposed to biotic and abiotic stresses 499
- Heritability estimates of random regression coefficients for the growth trajectories of *Clarias magur* *500*
- Non-additive genetic effects in enhancing stress tolerance in *Macrobrachium rosenbergii* *501*
- Comparative RNASeq studies on common carp cultured in low saline environments 502
- An *In Vitro* Protein Expression Profile of cultured muscle cells developed from *Labeo rohita* *503*
- Differential expression of steroidogenic enzymes genes and gonadotropin receptors during ovarian development of grey mullet *Mugil cephalus* *504*
- Evolutionary rescue by local adaptation could confer climatic resilience on Indian oil sardine, *Sardinella longiceps*– Clues from genome scans 505
- Comparative cell cycle analysis of two novel humpback grouper (*Cromileptes altivelis*) fin cell lines by flow cytometry 506
- Muscle cell culture system from *Lates calcarifer* (Asian seabass) for cultivated seafood development 507
- Thiamine deficiency in fishes- a symptom of dysfunctional aquatic ecosystems 508
- Effect on hemato-biochemical indices of *Labeo catla* reared in different culture systems. 509
- Mitigating effects of dietary Zinc nanoparticles on arsenic, ammonia, and temperature Induced Stress in fish using molecular signatures 510
- Physio-immunological response of *Nelumbo nucifera* leaf extract-fed *Oncorhynchus mykiss* challenged with pathogenic *Aeromonas hydrophila* *511*
- Effect of varying sources of arachidonic acid on the growth performance of whiteleg shrimp, *Penaeus vannamei* reared at three different water salinities. 512
- Effect of inulin on the growth and disease resistance status of Pacific white shrimp, *Penaeus vannamei* *513*
- Prototype development of marine black pearl through biomineralization of *in-vitro* cultured mantle epithelial cells of black lip pearl oyster *Pinctada margaritifera* *514*
- Biomineralization of cryopreserved *in-vitro* cultured mantle epithelial cells of black lip pearl oyster, *Pinctada margaritifera* *515*

- In-vitro analyses reveal Shewanella algae as a treasure for eicosapentaenoic acid: A prospective candidate for application in marine larviculture 516
- Pilot scale Solid State Fermentation: A key advancement in bioprocess development 517
- Antagonistic properties and biocompatibility of host-gut-derived marine bacteria for the development of potential probiotic consortia in Indian pompano mariculture 518
- The impact of dietary microalgal oil on fatty acid composition and the expression of genes associated with fatty acid metabolism in silver pompano (*Trachinotus blochii*) 519
- Protective mechanisms of *Schizochytrium* oil against hyperlipidemia: evidence from a zebrafish model 520
- Soybean meal-induced intestinal inflammation is associated with developmental defects and behavioral aberrations in zebrafish 521
- Bioconversion of poultry feather waste for the formulation of keratin derivatives supplemented feed: measures towards sustainable marine ornamental aquaculture 522
- Fishmeal replacement using a sustainable, low carbon footprint algal meal in the diet of snubnose pompano, *Trachinotus blochii* *523*
- Mixed insect meal as a sustainable fishmeal replacer in the diet of juvenile snubnose pompano, *Trachinotus blochii*. *524*
- Dietary selenium influences the growth, antioxidant enzyme activity and gene expression of Pacific white leg shrimp *Penaeus vannamei* *525*
- Synthesis of *Padina tetrastromatica* capped copper nanoparticles and its effect on growth, blood biochemical profiles and immune response of the Cobia (*Rachycentron canadum*) 526
- Aqueous leaf extract of *Psidium guajava* improves growth and health parameters in the Pearl Spot, *Etroplus suratensis* *527*
- Growth, reproductive performance, body composition and egg quality of orange chromide, *Etroplus maculatus* (Bloch, 1795) fed with broodstock diets containing different levels of protein and lipid 528
- *Aurantiochytrium*: a potential replacer of fish oil in Shrimp 529
- Future-proofing rainbow trout aquaculture with functional feeds 530
- Effect of partial replacement of fish meal with guar meal (*Cyamopsis tetragonoloba*) in the diet of pearl spot, *Etroplus suratensis* juveniles 531
- Deciphering the dietary influence on the fatty acid profile of fishes of varying feeding guilds of the Vembanad Lake, southwest coast of India 532
- Study on the co-infection of *Vibrio alginolyticus* with parasites in Indian Mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) from Karwar, West Coast, Uttara Kannada, Karnataka 533
- Pathological anomalies in vital organs of Indian mackerel, *Rastrelliger kanagurta* in relation to water quality and parasitic infestation 534
- Silencing shrimp STAT gene by administering dsRNA *in vitro* and *in vivo* to control of white spot syndrome virus infection 535
- TMT- based proteome analysis of rohu gut infected with *Edwardsiella tarda* *536*
- Assessment of antibiotic use and antimicrobial resistance pattern in freshwater aquaculture in Odisha and Andhra Pradesh: A preliminary report 537
- Present status of disease occurrence and economic loss in freshwater aquaculture in Odisha and Andhra Pradesh 538
- Investigations on the phenotypic and genetic patterns of oxolinic acid resistance among marine aquaculture pathogens 539

- Prevalence of shrimp microsporidian, *Enterocytozoon hepatopenaei* (EHP) in farmed tiger shrimp, *Penaeus monodon* in India 540
- Comprehensive sequence analysis of interleukin-10 in snubnose pompano (*Trachinotus blochii)* (Lacepede, 1801) 541
- *In-vitro* characterizations and *in-silico* analyses revealed an antineoplastic drug with clinically compatible features from a marine crab haemolymph-associated bacterial symbiont *Comamonas testosteroni* *542*
- Microbiome profiling of *Trachinotus blochii* unveiled the transient microbiome in the early life stages to become stable during ontogenetic progression 543
- Unravelling the whole microbiome profiles of cobia (*Rachycentron canadum*) before and after metamorphosis by PacBio Single-Molecule Real-Time Sequencing 544
- Dynamics of antioxidant biomarkers during ontogenetic progression in *Trachinotus blochii* larvae 545
- Prevalence and characterization of *Vibrio parahaemolyticus* isolated from the black clam, *Villorita cyprinoides* from the southwest coast of India 546
- Antibacterial, cytotoxicity and anti-inflammatory evaluation of N-Chlorotaurine (NCT) for possible application in aquaculture 547
- Computational aided identification of immune-epitopes and insilco development of multi-epitope-based peptide vaccine against Cyprinid herpesvirus-2 548
- Taxonomy of two new species of myxosporeans infecting the *Abudefduf vaigiensis* from the southwest coast of India 549
- Comparative analysis of proinflammatory and humoral immune gene expression in Cyprinid herpesvirus 2 infected and vaccinated goldfish (*Carassius auratus*) 550
- A new species of myxosporean, *Myxobolus vembanadensis* n. sp (Myxosporea: Myxobolidae) infecting *Planiliza macrolepis* (Smith,1846) from Cochin backwaters, Kerala 551
- Pathogenic and genomic characterization of *Vibrio harveyi* *552*
- Antibacterial activity of alcoholic extract of *Decalepis hamiltonii* (DH) root against the fish pathogen (*Aeromonas* sp.) 553
- Comparative evaluation of different chromatographic techniques for the purification of fish serum immunoglobulin 554
- Investigations into disease outbreaks have revealed the endemic presence of infectious spleen and kidney necrosis virus in cultured Oscar fish (*Astronotus ocellatus*) in Kerala, India 555
- Genomic characterization of a novel lytic *Autographiviridae* bacteriophage PhPV1.2 specific to *Vibrio parahaemolyticus* *556*
- Protective immune response against viral nervous necrosis (VNN) in silver pompano *(Trachinotus blochii)* against inactivated, recombinant and DNA vaccines by various delivery methods (intramuscular, intraperitoneal, and oral) 557
- Rapid detection of *Red Sea Bream Iridovirus* disease (RSIVD) by Recombinase Polymerase Amplification Assay (RPA) 558
- Construction of a recombinant bacterial clone for assisting the PCR-based molecular surveillance of *Infectious hypodermal* and *hematopoietic necrosis* virus infections 559
- Prevalence of White Spot Syndrome Virus in Wild & Farm Populations of Shrimps Post Covid-19 Lockdown 560
- Investigation of the characteristics of trained immunity in tilapia head kidney macrophages 561
- Preparation of colorimetric spoilage indicators using plant anthocyanin extracts for intelligent packaging application in fish 562

- Appertization as a sustainable technology to preserve green mussel in traditional Ready-to-serve form and its commercialization 563
- Mathematical modelling of the drying characteristics of marinated anchovy in infra-red dryer 564
- Unraveling the charisma of flavored 'muziris' oysters: an exploratory study 565
- Drying kinetics of clam in hot air-assisted continuous infrared dryer 566
- ICAR-CIPHET Fish Steaking Technology for easy and hygienic fish dressing and waste management 567
- The effect of high-pressure processing on the quality of seafood meat – A review 568
- Industrial extraction as well as microscopic, biological, chemical and structural characterization of salt from commercial marine red seaweed *Kappaphycus alvarezii* (Doty) L.M. Liao and its comparison with other edible salts 569
- Environmentally friendly nanochitin preparation from shrimp shell chitin using organic acid hydrolysis enhanced by steam explosion 570
- Protein hydrolysate from pink perch (*Nemipterus japonicus*) head waste during surimi processing: Optimization of extraction condition by response surface methodology and their characterization 571
- A demonstrative investigation on icing as an implementable solution to foul smell association with shrimp peeling waste 572
- Supplementation of agri-wastes based hydrochar to augment microalgae biodiesel production for sustainable fisheries 573
- Domestic Market Fish Waste to Green Innovation: recovering high value enzymes as a path to sustainable resource utilisation 574
- Real-time authentication of shrimp species identity using ion mobility-rapid evaporative ionization mass spectrometry prevents seafood fraud 575
- Development of microbial hydrolysis as a green pretreatment technology for the tropical red seaweed, *Gracilaria corticata*, during 3-G bioethanol production 576
- Formulating microbial degradation as an eco-friendly strategy for lobster shell waste management 577
- An investigation into the incidence of non-lactose fermenting *Enterobacterales* in fresh seafood 578
- Detection of *Cronobacter sakazakii* in seafood by colony hybridization using a biotin-labelled probe 579
- Phylogenetic diversity of quinolone-resistant ESBL-producing *Escherichia coli* isolates from seafood 580
- Marine fishing methods in India: An Economic Analysis 581
- Vulnerability of fishery-based livelihoods to climate hazards: Insights from small-scale fisher households in Kerala state 582
- Dried fish powder from *Stolephorus* sp. Improves health status of children: A nutritional study in tribal district of Odisha 583
- Exploring the Consumer Perceptions of Novel Fish Skin Leather Developed Using Discarded Fish Skins 584
- Novel fish-based products for better health and nutrition: Interventions among vulnerable population in India 585
- Stakeholder consultative process in participatory social impact analysis and beneficiary assessment in project evaluation 586
- Quantifying Women's Empowerment in Aquaculture: A Study in Jagatsinghpur, Odisha 587
- Risk sharing and informal credit transactions in marine fisheries: Implications for policy 588
- Biodiversity – Environment impact and participatory social impact assessment for certification of shrimp farming in coastal region of Andhra Pradesh 589

- Value added fish products: A potential alternative for livelihood improvement & entrepreneurship development in Northeastern region of India 590
- Import rejections of Indian seafood products in international markets – Trends and causes..... 591
- Impact of rising fuel prices on gillnet and longline fishing Vessels' operations at Thoppumpady Fishing Harbour, Kerala..... 592
- Fish Consumption in India: Evidence from Indian households..... 593
- Occupational hazards faced by marine fish retailers in the coastal state of Odisha, India..... 594
- Eco-tourism Initiatives in the mangrove and coral reef areas of the Gulf of Mannar and Palk Bay- An outlook 595
- Fish demand paradigms and perspectives across Telangana, India 596

Nature-based Solutions for Sustainable Agri-food Systems

- Bio-drainage systems in the food industry: Concept and design for zero discharge production unit..... 598
- Need for ecosystem approach for water quality management in Mangaluru, south India..... 599
- Contextualizing nature-based solutions for sustainable sewage treatment in traditional urban water bodies to promote urban agriculture in Madurai, India 600
- Community-level physiological profiling of soil microbial communities under varied salt loads 601
- Cut-soiler assisted subsurface sodicity reclamation increases rice-wheat yield in Indo-Gangetic plains 602
- Impact of agri-food system integrated with eco-friendly nutrient management technologies on farm-based tribal livelihoods of Madhya Pradesh..... 603
- Enhancing sustainable agri-food systems through optimal spacing and phosphorus management through organic and inorganic sources 604
- Assessment of SOC stocks and SOC density on the cotton growing belt of South Gujarat as influenced by diversified crop condition..... 605
- Simulated cut-soiler (PSSD) reduces soil salinity and improves mustard production in saline arid regions 606
- Enhancing sustainable agri-food systems through optimal spacing and phosphorus management in irrigated blackgram 607
- Risk assessment and management of arsenic in rice soils: A case study in Nadia Bengal 608
- Salinity management through cut-soiler-constructed preferential shallow sub-surface drainage for higher crop production in salty ecologies 609
- Carbon sequestration through composting of aquatic weeds in the Kuttanad region of Kerala, south India..... 610
- Biochar: A tool for mitigating climate change 611
- Build-up or depletion of soil phosphorus and potassium of alfisols after long-term manuring, fertilisation and continuous cropping? 612
- Engineered microbes for waste biomass-based pigment production 613
- Sustainable intensification and diversification options for enhancing productivity and farm income in tobacco-based systems of Andhra Pradesh..... 614
- Pond liming: A nature-based solution for invasive aquatic plant species management and ecosystem restoration. 615
- Traditional farming system as a nature-based solution to enhance ecosystem services: Role of species richness and management intensity 616
- Development of chitosan-based packaging films impregnated with clove oil for aflatoxin management in chilli and nutmeg..... 617

- Isolation and characterization of anti-inflammatory isochromanyl compound from an intertidal brown seaweed *Turbinaria conoides* *618*
- Investigating the potential of bio-optics for assessing the health status of Vembanad Lake in Kerala, south India 619
- Qualitative and quantitative appraisal of ecosystem services of Chettuva–A small tropical Indian estuary 620
- Biochar technology for sustainable aquaculture 621
- Coastal habitat restoration and improving community resilience by artificial reefs along the Indian coast 622
- Potential Arka microbial consortium mitigates drought stress and improves yield in cowpea (*Vigna unguiculata*) 623
- Ecological and biological criteria to prioritize the selected coastal ecosystem for biodiversity conservation: Andhra Pradesh prospective 624
- Micro-level environment management plan for aquaculture and allied sector and mapping for Mulavukad, a coastal village, in the Vembanad Lake Ecosystem, Kochi, Kerala, India 625
- Water quality parameters and phytoplankton composition of Kumbalangi backwaters during blooming and non-blooming period 626
- Correlation and regression studies on growth, yield attributes and nutrient uptake of traditional rice varieties under System of Rice Intensification (SRI) 627
- Drought-tolerant rhizobial and non-rhizobial endophytes induced osmotic stress tolerance in black gram (*Vigna mungo L.*) by the footprints of metabolomics 628
- Promoting sustainability and adaptation in modern agriculture with nano-enable biomaterials 629
- Using nature-derived polymers, the concept of developing nano-delivery systems for agricultural and food applications 630
- Natural chemicals and revolutionary nanotechnology-based control strategies for the plant protection and food packaging industries 631
- Management of insect pests infesting brinjal under organic farming 632
- Bio-efficacy of various bio-pesticides against brinjal shoot and fruit borer *Leucinodes orbonalis* *633*
- Management of brinjal shoot and fruit borer using selected biopesticides 634

Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems

- Site-specific spraying system for eco-friendly disease management in vegetable crops 636
- Automation of irrigation pump for enhancing agricultural water productivity 637
- Picro-DB: A comprehensive genomic resource portal for *Picrorhiza kurroa*, a medicinal plant 638
- Effect of accelerated ageing on seed coat anatomy 639
- Mid-infrared spectroscopy for assessment of soil health in India 640
- Soil test crop response based online fertilizer recommendation system for FCV tobacco yield targets in northern light soils of Andhra Pradesh 641
- Does the method to calculate soil water dynamics in a crop model change yield predictions, and what it means for climate change impact assessment? 642
- Benefits and implications of adopting raised bed pneumatic precision multi-crop planter: Ground breaking technology 643
- Exploring occupational hazards and the role of life saving gadgets among small-scale motorised fishermen of the southern coast of India 644

- Revolutionising agriculture: Harnessing the power of digital technology 645
- Adoption of agricultural technologies *vis-à-vis* communication networks 646
- Development of sustainable agri-food system by digital food hubs 647
- Integrating digital and Hi-Tech farming practices for enhanced agricultural safety and productivity: A case study in Pali District, Rajasthan, India 648
- Diversity in fished taxa of Andhra Pradesh: Mined insights from marine fishery resources database 649
- Dugong habitat and distribution: An Ensemble Distribution Model-based approach for conservation planning 650
- Long short-term memory based regression approach for freshness assessment of Genetically Improved Farmed Tilapia 651
- Convolution neural network-based nitrogen deficiency detection in plants using leaf images 652
- Introducing the AI-DISC Mobile App: Advancing intelligent crop health management through Artificial Intelligence for disease identification in crops 653
- Compact field-savvy instrument for rapid detection of aflatoxins-B1 in maize using a hyperspectral imaging system with machine learning 654
- Evaluating the impact of agricultural practices on Lake Vembanad through water colour assessment using Forel-Ule datasets 655
- Potential of Generative AI and Large Language Models (LLMs) in advancing digital agriculture – A review 656
- Denoising based Stacked Autoencoder Deep Learning Models for onion price forecasting 657
- Integrated robotic weed management using AI and Internet of Things 658
- Patents on artificial intelligence provides insights for technological advancements and Competitive intelligence in aquaculture sector 659
- Harnessing modern agriculture: The growing role of Internet of Things (IoT) and Machine Learning technologies in predictive analytics 660

Policies and Institutions for Transforming Agri-food Systems

- Impact of improved forage cultivation on milk productivity and fodder availability in Bundelkhand region of Uttar Pradesh: A doubly robust analysis 662
- Impact of blending policy on mustard oil prices in India: Insights from a Bayesian Structural Causal Inference Model 663
- Role of local leadership and collective action to adopt soybean cultivation innovations in ex-sand quarry land: A case study from Cibulan Village in West Java, Indonesia 664
- Drivers of adoption of sustainable land management practices and its impact on food security and income variability: A case study from Jhansi District of Uttar Pradesh 665
- Enhancing entrepreneurship in fisheries through effective client management from Agri-Business Incubation Centre: Strategies and policies for success 666
- Promotion of spice cultivation in agroforestry systems in Palakkad District, Kerala, south India 667
- A silver bullet or a policy quagmire: An evaluation of the prospects of FDI in spices and plantation crops 668
- The value chains of selected agribusinesses in the states of Uttar Pradesh and Uttarakhand: An analytical framework for way forward 669
- Learning from the pandemic: Lessons on resilience from the marine fisheries sector in India 670
- Rebuilding with communities: CIT model analysis of stakeholder consultation in marine fisheries sector in India 671

- Technology-led transformation in a Kerala fishing village: Evidence and insights for a policy shift 672
- Unleashing the potential of aquaculture for youth employment and livelihood security 673
- Governance gateway for achieving sustainable food system – A case of marine fisheries governance in Andhra Pradesh 674
- Buyer-seller meet as a tool to foster farmer-market linkage towards assured marketing of farm produce: An experience of Ernakulam KVK 675
- Policy perspectives on emerging invasive alien aquatic species in Indian waters: Balancing contemporary fish-food demand, national priorities, and sustainable development goals 676
- Role of policies and institutions in transforming millet-based food systems 677
- Current trends, constraints, and future prospects of biopesticides in pest management 678
- Cereal market outlook for India to 2040-41 and crop diversification: Implications for nutrition and environment 679
- Impact of integrated farming systems on farmers income and dietary diversity in India: A case study 680
- Transformative research priorities for gelatinous marine organisms in India: Exploring the diversified potential future food resource and its sustainable management plan 681
- Sustainability of the sugar sector vis-a-vis new biofuel policy in India 682
- Impact of agricultural interventions on farm income and asset holding of SC farmers: A case study of the Schedule Caste Sub Plan (SCSP) scheme in Jhansi, Uttar Pradesh 683
- Crop size fixation in FCV tobacco: A proficient policy instrument to ensure supply-demand balance and price stability 684
- Litchi-based integrated nutri-farming systems for augmenting farm income and sustainability 685
- Crop diversification towards high-value commodities in the state of Maharashtra 686
- Sustainability assessment of banana value chains in Palakkad District, Kerala: An insight into the 'Auction System Value chain' 687
- 'Urban-agri'–A transformation in agri-food system to achieve sustainable development 688

International Partnership for Research, Education and Development

- Impact assessment of Academia: Accounting and valuation of human capital in indian fisheries higher education 690
- News value of the Agriculture Sector 691

10-13 OCTOBER 2023 | KOCHI | KERALA

XVI AGRICULTURAL SCIENCE CONGRESS 2023

Invited Talks

Rethinking food crisis responses

Channing Arndt

Senior Director for Transformation Strategies of CGIAR and IFPRI

The recent past has been marked by multiple, often overlapping, crises. The COVID-19 pandemic, various natural disasters, and the ongoing war in Ukraine, have all had strong implications for the global food system, with often highly heterogeneous implications for countries and regions. Now, in 2023 and into 2024, a looming El Niño event has already prompted important policy decisions and significant movements in global markets for key commodities. This string of crises has, to date, already set back the global development agenda by about 1.5 years. The El Niño event in the Pacific has the potential for further substantial disruption, particularly as it interacts with ongoing climate change. This talk will consider the cumulative implications of the Covid-19 pandemic, the ongoing war in Ukraine, and the projected El Niño event for the achievement of the SDGs. I will focus on analyses using economywide simulation models to measure the near-term impacts of the crises on agri-food systems, poverty, and food insecurity. Looking backward, I will present the implications of the crises as derived from models and consider where the models have done well and where the models have done not so well to the extent permitted by available data. Looking forward, I will provide projections on the implications of El Niño for selected countries. An important message is that response to crises must improve. Looking in terms of ability to simulate implications of crises and develop appropriate, timely, and actionable policy responses, crisis response capability is improving. And, it must continue to do so. Climate change promises a far more volatile world both in terms of climate/weather, with a marked increase in the frequency and severity of extreme events, and substantial risks associated with a transition to a globe with net zero emissions. To confront this reality, simulation is necessary once again. I will briefly present a structural approach to biophysical and economic modeling that incorporates climate uncertainty and allows for rigorous comparison of climate, biophysical, and economic outcomes across global mitigation regimes and provide a few example of how the approach has been used to develop robust policy conclusions.

Keywords: Climate change, Climate uncertainty, Covid 19, El Niño

Contributions of gene editing towards achieving the SDGs

Stuart J. Smyth
University of Saskatchewan, Canada

The Sustainable Development Goals (SDGs) were launched in 2015, with the top three goals being poverty eradication, improved food security and increased human health. All 17 SDGs have a target achievement date of 2030. These are ambitious and inspirational goals that require substantial innovation and technology adoption for successful achievement. Innovations in plant breeding have substantially contributed to transforming the efficiency of food production since the mid 20th century, with innovations emerging in the current millennium demonstrating enhanced potential to improve crop yields, the nutritional values of food crops and environmental impacts. These outcomes underpin several SDGs, but in particular the first three. As climate change is expected to become increasingly variable, with greater impacts on agriculture, the ability to ensure increased food production is going to be increasingly important, as higher yields directly contribute to reducing poverty. This presentation will discuss some of the potential contributions from gene editing technologies in terms of increased yield, enhanced nutrition and greater sustainability, highlighting their importance for achieving the leading three SDGs.

Keywords: Improved food security, Poverty eradication, Sustainable Development Goals (SDGs),

KEYNOTE LECTURE

Dietary guidelines for Indians and what Indians eat

R. Hemalatha

Director, ICMR-National Institute of Nutrition, Hyderabad, Telengana, India

This study examines the dietary patterns in India, taking into account various factors such as age, activity levels, income, and rural-urban settings. The findings reveal significant disparities in food consumption across different population groups. While cereals are consumed in excess by most groups, there is a substantial lack of intake of protective foods like pulses, legumes, milk, nuts, vegetables, and fruits. The analysis demonstrates that rural populations tend to consume higher quantities of cereals compared to their urban counterparts. Even the urban dwellers do not come close to the recommended levels of intakes; though, they exhibit higher consumption of protective foods compared to the rural people. However, the urban population have higher intake of added fats and oils, added sugars and foods from outside sources. These imbalanced dietary patterns raise concerns about their impact on the genesis of non-communicable diseases (NCDs). Inadequate consumption of protective foods, coupled with excessive intake of cereals and fats, lead to nutrient imbalance in both urban and rural populations, which may potentially contribute to the increased risk of diabetes, coronary heart disease, hypertension, stroke and other NCDs. Analysis showed association of low intake of vegetables and fruits with a higher risk of diabetes, while low intake of milk and milk products was linked to hypertension. To address these dietary imbalances and reduce the risk of nutrition-related diseases, it is crucial to promote a diverse and balanced diet that includes protective foods. Public health interventions should target specific groups, such as adult females from low socioeconomic backgrounds, to improve their access to nutritious foods. Additionally, raising awareness about the importance of incorporating a variety of protective foods into daily meals and reduction of foods with high fat, sugar and salt (HFSS foods) can help mitigate the rising epidemic of NCDs in the Indian population. However, both the rural (2012) and the urban data (2016) are old. More recent food consumption data might show a different picture with increasing purchasing capacity and growing availability of convenience foods and HFSS foods.

Keywords: Dietary imbalances, Food consumption, Protective food, Rural populations

INVITED LECTURE

Food processing to combat malnutrition in India

Sridevi Annapurna Singh

Director, CSIR-Central Food Technological Research Institute, Mysuru, Karnataka

India has a large population affected by all three kinds of malnutrition – undernutrition, micronutrient deficiencies and diet related obesity (and pathologies)–adversely affecting economic advancement due to poor education, cognitive and productivity losses thereby decreasing incomes, life quality and expectancy. By 2030, India is projected to lose 4% GDP due to malnutrition of its USD 6 trillion economy. Processing of food varies from minimal processing to ultra-processed foods and can be classified as primary, secondary or tertiary processing that leads to value addition. Globally, there is a transition from consumption of home cooked food prepared using whole grains and fresh produce to consumption of ready to cook / use, convenient processed foods. Food is processed before consumption to improve its sensory quality, safety, shelf-life and digestibility and create diverse products by mixing various elements and raw materials. Highly processed foods have high amounts of saturated fat, sugar and salt apart from chemical preservatives, artificial colours and other additives. They are made from refined flours (obtained after removal of micronutrient rich bran layers), and are poor in fibre and micronutrients. The Indian food processing industry is predicted to grow at an annual 11% to ~ USD 545 billion by 2025. Food processing plays a crucial role in improving digestibility, enhancing nutrient density and dietary diversity. Various techniques like malting, dehydration, heating/cooking, freezing, steaming, extrusion, fermentation, enzymatic modification and fortification can be used singly or in combination to improve the nutritional quality thereby combating malnutrition. A judicious selection of processing techniques for preparation of products, tailored for a targeted population, would aid in alleviating C problems. Some of these food processing techniques and strategies that offer convenience, are cost effective, nutritious and safe will be presented. The use of these nutrient dense products in intervention studies and their impact will also be discussed.

Keywords: Dietary diversity, Micronutrient deficiencies, Malnutrition, Processing techniques

INVITED LECTURE

Nutraceuticals in food and health

G. Bhanuprakash Reddy

Biochemistry Division, ICMR-National Institute of Nutrition, Hyderabad, Telangana, India

The production of foodgrains as well as horticulture production was very high in 2021-2022. Despite this impressive achievement in food production (security), ensuring nutritious food (nutrition security) remains a big challenge. Utilization of the food is one of the four dimensions of food security. While food utilization mainly refers to proper biological use of food in terms of providing essential nutrients including energy with respect to nutrition indicators such as stunting, wasting, underweight, and anemia, utilization of functional foods or nutraceuticals for optimal health in terms of prevention and treatment of disease is also equally important. Functional foods or nutraceuticals are food components that provide nutritional as well as medicinal effects. The benefits of functional foods or their bioactives are due to the presence of active compounds such as carotenoids, phytochemicals, and dietary fibers whose intake has been linked to positive health outcomes related malnutrition and in particular non-communicable diseases such as obesity, diabetes, cancer, cardiovascular and neurological disorders. There are different categories of functional foods based on chemical nature and biological action. The preventive role of these products and understanding the underlying mechanisms of action of functional foods is an area of research for the nutritional security and health, both in terms of economic benefits as well as health outcomes.

Keywords: Bioactives, Functional foods, Health, Nutraceuticals

INVITED LECTURE

Addressing dual burden of malnutrition: Role of food systems

Bharati Kulkarni

Indian Council of Medical Research, New Delhi, India

With the economic progress in the past few decades, there has been consistent increase in the government's investment in health infrastructure as well as in large scale programs for improving the health and nutritional status of vulnerable population groups. This has resulted in reduction in the prevalence of undernutrition and anemia over the last two decades; however, the magnitude of change is lower and the pace is slower than anticipated. On the other hand, there is worrisome concomitant rise in overnutrition which manifests the other end of the malnutrition spectrum. The burgeoning problems of overweight, obesity and associated non-communicable diseases such as diabetes, cardiovascular disease, cancers largely reflect unhealthy lifestyles, mainly poor-quality diets. Tackling the concomitant double burden of persistent undernutrition and rising prevalence of overweight and obesity is a significant policy challenge. Data from the national surveys show that the diets of all population groups are mainly cereal based lacking important food groups like pulses, green leafy vegetables, fruits, as well as animal source foods including milk and milk products, meat, fish and poultry. Lack of diverse diets which provide important nutrients like high quality protein, bioavailable iron, zinc, vitamin A and other micronutrients underlies the entire spectrum of malnutrition including childhood undernutrition as well as adult-onset obesity. Food environment plays a critical role in shaping the diets. Current evidence from population-based studies shows lack of availability and affordability of nutritious foods especially fruits and animal source foods. The nutritious fresh foods being perishable and available through fresh food markets need investment for their transport and safe storage. On the other hand, nutrient poor and obesogenic processed foods are available ubiquitously and favored by consumers due to their long shelf life, convenience and affordability due to small pack sizes. Advertising and aggressive marketing of the ultraprocessed foods has resulted in these foods occupying a large food budget share even in low-income households. Changing behaviors towards adopting healthy lifestyles is crucial for prevention and management of metabolic diseases associated with obesity. Food systems for a healthy food environment will have a crucial role for enabling people to adopt a healthy lifestyle. There is an urgent need to strengthen agriculture-nutrition linkages to make nutritious foods available, accessible and affordable for the low-income consumers from urban and rural areas which also include a large section of subsistence farmers and agricultural laborers.

Keywords: Diet diversity, Double burden of malnutrition, Micronutrients, Processed foods, Protein

KEYNOTE LECTURE

Pharmaceutical approach and food fortification for combating micronutrient deficiencies

K. Madhavan Nair

Former Head of Micronutrient Research and Scientist-F, ICMR-National Institute of Nutrition, Hyderabad, Telangana, India

Vitamin and mineral (micronutrients) deficiencies remain major risk factors in the global burden of disease, especially in LAMI countries and in India. The most conventional and widely practiced strategies to address micronutrient malnutrition are supplementation and food fortification. Both these strategies have been found to be effective in preventing and controlling the primary deficiencies of micronutrients of public health concern. Food fortification demands country specific regulation on standards for fortification, evidence base for impact, demand and availability, introduction of mandatory or voluntary which needs careful contextual consideration and extent of spread of deficit in specific micronutrients. Continuous monitoring using biomarkers and taking contextual corrective steps such as redesigning and withdrawing low impact interventions should form integral part of the system. The present evidence is insufficient to recommend either for or against the use of single or multivitamins and minerals supplements to prevent chronic disease such as CVD and cancer. Consideration for other public health strategies such as home/point of use fortification with multiple micronutrient powder sachets for children and multiple micronutrient supplements for pregnant women merits consideration for large scale trials. An attempt will be made in the presentation to highlight the challenges, knowledge gaps and research priorities in the area.

Keywords: Fortification, Micronutrients, Multiple micronutrient powder, Multiple micronutrient supplement, Supplementation

INVITED LECTURE

Food based approaches and the role of women in alleviating malnutrition

G. N. Hariharan

Executive Director, M. S. Swaminathan Research Foundation, Chennai, Tamil Nadu, India

The Goal 2, of SDG is a call "to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture" with specific targets such as universal access to safe and nutritious food, end all forms of malnutrition, double the productivity and incomes of small-scale food producers, sustainable food production and resilient agricultural practices and maintain the genetic diversity in food production. Hence, it is equally important that the poor and vulnerable sections, have access to sufficient and safe nutritious food. Food and Agricultural Organisation (FAO) estimated that 189.2 million are undernourished in India during the year 2019-20 (FAO, 2020). In the 2022 Global Hunger Index (GHI), India ranks 107th out of the 121 countries with sufficient data to calculate 2022 GHI scores. The most common micronutrient deficiencies in India are iron, zinc, iodine, and vitamins like vitamins A, B2, B6, folate B12, Vitamin C and D. FAO recommends diet supplements and food-based approaches to eradicate micronutrient malnutrition but indicates that in the long-term, food based approaches are more likely to be sustainable.Food is a basic need and it is important to ensure food and nutrition security for all and for ever through simple, inclusive, holistic and sustainable pathways are vital. Food based approaches strengthen the local resources for improving diets (including availability of nutri-rich food, dietary diversification) in both quantity and quality in order to overcome and prevent the impacts of malnutrition affecting the various stages of lifecycle. It also provides opportunities to the small and marginal farmers to produce nutritious crops and strengthen their livelihoods and ensure availability of these in the local markets and bridge the disconnect between agriculture and nutrition. There is a need for strong food-based approach and gender inclusive models to eradicate malnutrition at all levels.

In this backdrop, women play a pivotal role in ensuring nutrition security due to their central involvement in various aspects of food production, distribution, preparation, and caregiving. Recognizing the multifaceted roles and empowering women at the grassroots with adequate capacity building – the Nutrition Garden linked Community Hunger Fighter model of M.S. Swaminathan Research Foundation has demonstrated increment in nutrition security in communities, address gender inequalities, improved access to safe drinking water and healthcare as key outcomes. Zero Hunger is achievable with adequate investments in production systems and capacity building with suitable advocacy and awareness to draw attention to nutrition-related issues, leading to policy changes and initiatives that prioritize nutrition security.

Keywords: Dietary diversification, Gender inequalities, Nutrition security, Safe and nutritious food

INVITED LECTURE

Biofortification to combat hidden hunger

Siddhrth Tiwari

Scientist-E, National Agri-Food Biotechnology Institute (NABI) (An autonomous Institute of Department of Biotechnology, Government of India), Mohali Punjab, India.

Nutrition security provides easy access of adequate and good quality food to the people at all times. However, multiple constraints like climate change, lack of resources, ever-growing population etc. have threatened our food security and increased the risk of hunger and malnutrition. Biofortification of staple crops is a feasible and cost-effective means of delivering nutrients to populations that may have limited access to diverse diets and other nutrient interventions. Gain-of-function and loss-of-function are the two basic biotechnological approaches to characterize the function of unknown gene and/or used for the improvement of crop for a certain trait. Our current research work focuses on the metabolic engineering of crop plants for nutritional quality improvement. Vitamin A deficiency (VAD) is a severe health problem, especially in South-East Asia and African countries. Banana plays an important role towards nutritional security in the world. The application of conventional breeding for genetic improvement in banana is difficult due to the ploidy level and nature of parthenocarpic fruit development. Thus, the application of modern biotechnological applications could be considered a promising approach for improving pro-vitamin A (β-carotene) in banana fruit. We aimed at enhancing pro-vitamin A content in banana fruit using two approaches: (a) gain-of-function (over-expression) and (b) loss-of-function (CRISPR/Cas9). The homologs of *1-deoxyxylulose-5-phosphate synthase* (*DXS*) gene were functionally characterized and a promising candidate was transformed into banana embryogenic cell suspension (ECS) culture through Agrobacterium-mediated transformation. We observed a more than 20-fold increase in pro-vitamin A carotenoid content in the fruit-pulp. Besides overexpression, we demonstrated the establishment of the CRISPR/Cas9 mediated editing in banana by precise targeting of the *phytoene desaturase* (*PDS*) gene as a proof-of-concept. Subsequently, we implemented this approach for the creation of mutation in the *lycopene epsilon-cyclase* (*LCY-ε*) and *carotenoid cleavage dioxygenase 4* (*CCD4*) genes in the banana genome. Overall, our results establish that the genome editing and over-expression of candidate gene(s) of the carotenoid pathway can be used as an effective mode for pro-vitamin A biofortification in banana.

Keywords: Banana, β-carotene, Biofortification, Malnutrition, Pro-vitamin A, Vitamin A

INVITED LECTURE

Nutrition communication in India: From rhetoric to reality

SubbaRao M. Gavaravarapu

Scientist F and Head, Nutrition Information, Communication and Health Education (NICHE) Division, ICMR-National Institute of Nutrition, Hyderabad, Telengana, India

The imperative to address India's persistent malnutrition crisis, especially its triple burden, demands a paradigm shift in nutrition communication strategies – a transition from rhetoric to actionable reality. This presentation delves into the multifaceted evolution of nutrition communication in India, informed by a synthesis of reviews and empirical studies. By scrutinizing the trajectory, challenges, and progress, this paper underscores the urgency to bridge the gap between awareness generation and transformative behavioural change. Historically, nutrition communication in India predominantly relied on didactic campaigns, often limited by a one-size-fits-all approach. However, more recent studies and campaigns exemplify the need for evidence-based, culturally sensitive communication. Anchored in a synthesis of scholarly literature and evidence-based insights from our own studies [alluding to multiple approaches like using various media and methods; Information, communication Technologies (ICTs); Food labels as a public health tool of communication; vendor education using culturally sensitive messaging; social media influence on food choices and dialogue and consortium building for policy advocacy], this presentation underscores the need to move towards contextually relevant messaging, acknowledging the diversity in dietary habits as well as sensitivity to socioeconomic cultural milieu. In response to the imperative of comprehensive nutrition communication, national programmes rhetorically necessitate community inclusivity and coordinated approaches. However, insights from successful initiatives can unveil contextual success factors, simplifying intricate dynamics. Reviews indicate that nutrition communication's success hinges on formative research, community engagement, and contextual relevance. The 'infodemic in COVID19 pandemic' has shown that the challenges persist when risk perception is high and self-efficacy is low among people. In such a scenario, public perceptions often diverge from actual risks. In the era of technology-driven communication, with the ascent of new media as health information sources, understanding the influence of authenticated versus unauthenticated health messages on public perceptions becomes important. Similarly, the role of consumer education and nutrition literacy in using food labelling as a tool for fostering health-conscious choices cannot be understated. Communication effectiveness also necessitates multisectoral partnerships and common narratives but several allied sectors rarely or never communicate between themselves. While challenges exist in aligning communication efforts across sectors, lack of communication among themselves makes nutrition communication rhetorical. This continued chasm underscores the need for sustained dialogue, interdisciplinary efforts, anchored in rigorous research and scaling up the successes, to ensure that nutrition communication becomes a catalyst for substantive improvements in dietary behaviours and public health outcomes, of course, with an understanding that nutrition communication is a 'necessary' but not a 'sufficient' condition for addressing all the nutritional problems.

Keywords: Communication, Advocacy, Behaviour Change, Infodemic, Inter-sectoral dialogue, Nutrition

KEYNOTE LECTURE

Demand for and supply of agri-food commodities in India

P. K. Joshi

Former Director, South Asia International Food Policy Research Institute

Indian agri-food system has transformed from a deficit to self-sufficient and surplus, and from import to export oriented. The production as well as consumption of different food commodities increased and diversified remarkably. The production and consumption diversified in favor of high-value commodities such as fruits, vegetables, dairy products, meat, and fish. The per capita consumption of cereals and coarse cereals declined overtime. There are projections that India will continue to be surplus in rice, wheat, milk, fruits, vegetables, fish but deficit in pulses and edible oils. Role of technologies and policies will play key role in increasing enough production to minimize import of pulses and edible oils. The future of Indian food-system appears to be quite impressive in achieving the Sustainable Development Goals (SDGs), especially Goal 1 (No Poverty). However, there is slow progress in achieving Goal 2 (Zero Hunger). To accelerate the progress in achieving Goal 1 and 2, it requires (i) more investment in agriculture, including agricultural research, (ii) improve input-use and water-use efficiency, (c) conserve natural resources, (d) make agriculture climate resilient, (d) strengthen domestic and global value chains, and (e) make agriculture globally competitive. In addition, role of innovative institutions, such as cooperatives, farmer producer organizations, contract farming, and self-help groups, will play key role in empowering small holders to harness the global opportunities. On consumption side, especially achieving Goal 2, the on-going social safety-net programs may continue with some modification. Efforts are also needed to improve dietary diversity, reduce post-harvest losses, promote millets and bio-fortified food commodities, improve food safety, and popularize nutrition education. With these efforts, India will accomplish Sustainable Development Goals, and make Indian agri-food system more efficient, competitive, nutritive, and sustainable without adversely affecting the environment.

Keywords: Food consumption, Food demand, Food diversification, Food supply

INVITED LECTURE

Resource efficient and environment friendly production of pulses

Sanjeev Gupta

Indian Council of Agricultural Research, New Delhi, India

India is the largest producer, consumer, processor and importer of pulses in the world accounting for nearly 28% global production, 39% world's consumption and 15% of International Trade. In recent years, India witnessed a phenomenal increase in pulses production from 14.66 million tons to 27.69 million tons during this decade. This phenomenon may be termed as 'Pulses Revolution' in India which resulted into the increase of per capita availability of pulses from 44 g (2015-16) to 52 g (2021-22), reduction in import from 6.61 million tons (2016-17) to 2.52 million tons (2021-22). This could be possible mainly due to fast paced varietal and technological developments, improved access of quality seeds, increased input supply through governmental schemes and price support system. Efforts have been made to make pulses resource efficient and climate resilient. Over 85% of pulses are grown in rainfed conditions where these are thriving mostly on resource scared conditions. Drought tolerant varieties are important to adapt them at terminal stress in rabi pulses. Heat stress is crucial and impacting crop growth and phenology. The 1^0C rise above the and 1^0C below mean temperature reduced the productivity of winter pulses by 14 kg and 10 kg per hectare, respectively. Though pulses have wide adaptive mechanism to cope with adverse abiotic factors, such as deep rooting system, high degree of dehydration tolerance, phenotypic plasticity, wide ranging sensitivity towards photo-thermoperiods and higher moisture retention capacity. All these attributes enable them to thrive well under any non-specific abiotic stresses and provide them to adapt in diverse climatic conditions such as from tropical, sub-tropical and temperate conditions. The water requirement of pulses is about one-fifth of the requirement of cereals, though, response of different pulses vary towards diverse climatic conditions as per their genetic make up. Nearly 270 climate resilient varieties of pulses have been developed during the decade. Reduction in crop duration as in mungbean from 75 to 55 days, cowpea from 75 to 60 days, lentil from 140 to 120 days and chickpea from 135 to 110 days led to fit the crops in different growing situations like rice fallow cultivation and summer cultivation and thus helped in crop diversification and cropping system manipulation. The global warming potential of pulses is one-eighth of the cereals. The nutrient requirement of pulses is one-fourth to one-sixth as compared to cereals and therefore these are environment friendly and their cultivation is ecologically sustainable.

Keywords: Global warming potential, Pulses production, Rice fallow cultivation, Summer cultivation

INVITED LECTURE

Impact of climatic changes on food safety and nutrition

Ng. Iboyaima Singh

Dean, College of Food Technology, Central Agricultural University, Imphal, Manipur, India

Nutrition and food safety are significantly impacted by climate change. It has an effect on food availability, accessibility, and quality, which ultimately has an effect on human health and wellbeing. Here are some key ways in which climate change impacts food safety and nutrition:

Crop production: Unusual weather conditions including droughts, floods, and heat waves can have a negative influence on crop yields and food production. Food shortages, price hikes, and decreased access to nutrient-dense foods may follow from this.

Food quality and safety: Variations in temperature and humidity can encourage the development of diseases, pests, and poisons in food. Temperature increases can raise the danger of bacterial contamination and foodborne diseases. Changes in rainfall patterns can also affect water quality and raise the danger of waterborne infections.

Changing nutritional value: Crops' nutritional value can be affected by climate change. Significant elements like iron, zinc, and protein may be less abundant in staple crops like rice, wheat, and legumes as a result of increased carbon dioxide levels in the environment. This puts people's health at risk for poor dietary quality (deficiencies in micronutrients), especially in areas where these crops are a staple food source.

Shifts in food production and availability: Climate variations can affect crop distribution patterns and agricultural methods. There may be changes in dietary habits and a reduction in the availability of nutritious foods produced locally if some geographical areas are no longer suited for conventional food crops.

Livestock, fisheries, and seafood: Changing rainfall patterns and rising temperatures can disturb ecosystems, which in turn affects fish population health and abundance as well as livestock productivity. The safety and accessibility of seafood may be impacted by changes in fish populations and the spread of toxic algal blooms brought on by ocean acidification and warming. This may result in decreased access to sources of animal-based protein and consequent nutritional deficits.

Food access and security: Climate change can worsen food insecurity, which can result in stunting and malnutrition, especially in vulnerable groups including children and pregnant women. Disruptions in food production and increased food prices can limit access to diverse and nutritious diets, leading to malnutrition and negative health outcomes.

Global food safety and nutrition are seriously threatened by climate change. Adopting sustainable agriculture methods, improving water management, and creating resilient food systems that are adaptable to shifting environmental conditions are all necessary to address these issues.

Keywords: Global food safety, Climate change. Sustainable agriculture methods, Water management

INVITED LECTURE

Nutraceutical functions of milk and milk products: Prospects and challenges

Ashish Kumar Singh

Joint Director (Academic) and Dean, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Health and wellness of people appears to be the major challenge in achieving the Sustainable Development Goals-2023 as it affects the growth, development, productivity and economics. Recent UNICEF report pointed out that although there is marginal decrease in Global Hunger Index (GHI), But the low and lower-middle income economies are facing the major burden of malnutrition including stunting, wasting, low-birth weight and anaemia; whereas developed countries encountered the issues related to over-nutrition such as obesity, metabolic disorders etc. Majority of nutrition related issues are attributed to improper diet and dietary practices during the infancy and early childhood. Breast milk or mother's milk is the perfect example of nutraceuticals as it is designed by nature to provide all essential nutrients and therapeutic components in desired amount and also in best bio-available form. The bioactive components present in colostrum and mature milk include nutrients, minerals, trace elements and pre-vitamins as well non-nutrients (mostly bioactive) such as immunoglobulin, hormones, growth factors (Insulin-like growth factors), cytokines, prostaglandins, enzymes, lactoferrin, transferrin, nucleotides, polyamines and human milk oligosaccharides (HMO). In addition to these, they also exhibit several extra-nutritional roles to promote the development and well-being of infants. Furthermore, a strong need is felt to develop infant formula, for pre-term and neonates suffering with specific metabolic disorders. Clinical evidences suggested the putative role of milk nutrients specially the whey proteins, bioactive-peptides, oligosaccharides, phospholipids, conjugated linoleic acids (CLA) and medium chain triglycerides.

Milk mining through advanced technological interventions (separation technologies) has enabled us to isolate the wide array of components present in milk and more than 500 compounds have been identified so far. Health claim validation investigations further contributed significantly in elucidating the mechanisms associated with therapeutic virtues of milk molecules. Liquid milk and dairy powder fortification with minerals (Ca, Zn & Fe) and Vitamins (A, D, B_1, Folic acid, B_{12}) in several countries seems provisions. Fusion trend has also influenced the dairy food formulations and blending of raw materials form different food groups for better nutritional status or for the improvement of quality of resultant product has gained momentum in last few decades. Development of low calorie and/or no fat products required substantial alteration in formulations and removal of milk fat and sugars or salt have numerous undesirable consequences on quality attributes of finished products. Search for fat, sugar and salt replacers have resulted in availability of various alternatives, which could be effective in minimizing or completely eliminating these macromolecules. Probiotic foods containing viable probiotic microorganisms in requisite number in dairy matrix, their viability and metabolic activity throughout processing, packaging, storage are of paramount significance because of their ability to improve gut health. More than 500 probiotic products have been introduced in the past decade. These products have received varying levels of success, mostly in congruence with their overall health benefits. The

nutritional and therapeutic properties of milk nutrients as affected by different processing interventions are a matter of thorough investigation. Heating not only improves the digestibility of milk proteins, but also lead to production of metabolites as Maillard reaction products. Likewise, a wide array of metabolites has been identified with multiple functions in products and human health. It is opportune time to utilize milk metabolomics to explore the novel milk molecules with novel functionality. Non-bovine milk has attracted the attention of researchers, dairy industry and consumers because of unique nutritional profile and nutraceutical functions. Demand for non-bovine milk is increasing considering their positive health benefits which have necessitated the technology development for novel products and ingredients from it. Although, milk and dairy products are integral part of diet but there is need to create awareness regarding the emerging evidences highlighting the health promoting role of milk nutrients.

Excess consumption of milk nutraceuticals related effect is not available for majority of compounds. Moreover, the effective delivery system to have a site specific availability is crucial with certain bioactive molecules. Probably, these are the areas that desire active collaboration with pharmacologists. A close association with them would be essential to understand the mechanisms of action, their effective dose regimen, kinetics parameters and also potent toxicity. Commercialization of functional dairy products is in nascent stage due to the non-validated evidences. At global level fortified milk products, probiotic dairy products, prebiotic-enriched fermented milks and milk protein ingredients have gained prominence among the commercially available function foods. In India it is still in nascent stage. The pace of commercialization and technology transfer from Research & Development organization is quite slow. Closer interactions among the stakeholders and simplification of existing modalities for increasing the participatory research i.e. "Ease of Doing Business". It is also opportune time to harness the enabling "Start-up Ecosystem" for attracting the enterprising and their entrepreneurial virtues for technological developments and technology transfer.

Keywords: Fortified milk products, Functional dairy products, Milk mining, Milk nutraceuticals

Theme 2: Climate Action for Sustainable Agri-food Systems
Technical Session 1

INVITED LECTURE

Extension strategies for mitigation and adaptation of climate change in Eastern Himalayan regions of India

Anupam Mishra
Vice Chancellor, Central Agricultural University, Imphal, Manipur, India

Mountains are among the most vulnerable habitats on the planet Earth harboring rich biodiversity. Climate change caused by anthropogenic forces has emerged as a major problem worldwide in terms of socioeconomic and environmental sustainability. Agriculture is universally recognized as a highly vulnerable sector susceptible to climate change, and risks from adverse climate events posing an imminent threat to food security and livelihood sustainability. Globally, agricultural practices must adapt quickly to assure future food security in view of dual challenges of climate change and increasing population.To make climate adaptation planning more robust, assessing resilience in different regions is essential for the development and scaling up of appropriate, site-specific, context-specific interventions and policies that strengthen agricultural system resilience. Adaptation is critical for mitigating the harmful effects of climate change, particularly in the agricultural sector. This paper seeks to draw insights based on an analysis and discussion of the multi-scalar and multi-indicator assessment through profiling of resilience in the Eastern Himalayan Regions of India, based on the development of a climate-resilient agriculture index. Farmers' views and response to drastically changing climatic conditions are perceived as critical policy strategies that can potentially mitigate the adversities of climate change and simultaneously feed the increasing population. In this context, this paper systematically analyses farmer perception and adaptation strategies in India's Eastern Himalayan region, from the jurisdiction of the Central Agricultural University, Imphal, Manipur, spread across the seven states of North East India. Farmers in this region acknowledge climate change events such as temperature rise, unpredictable and decreased rainfall. They are receptive to a wide range of adaptation strategies, which are incremental and systemic. Transformational adaptations such as substantial changes in land use, cropping systems, and adopting natural farming need further nudging by all stakeholders to ensure their acceptance by farmers as a long term intervention against climate change. The paper reiterates the role of extension strategies in influencing adaptation of climate smart agriculture practices relevant to Eastern Himalayan region of India and emphasizes on the role of policy makers, agriculture institutions and farmers in efficient execution of these strategies in the target areas.

Keywords: Agricultural practices, Climate change, Extension strategies, North-Eastern India

INVITED LECTURE

Opportunities in Big Data Analytics and ICTs to accelerate climate adaptation

Sudhanshu Singh

International Rice Research Institute (IRRI)-South Asia Regional Centre, Varanasi, Uttar Pradesh, India

Climate change will continue to pose a significant negative impact on the global agricultural sector due to rising temperatures, rainfall variability, and intensifying extreme weather events, which will lead to reduced crop yields and higher food prices. The priority regions for climate action are in South Asia and Southeast Asia, especially due to the predicted negative impact on the livelihoods of farmers and other value chain actors, especially in rice sector. Frontier technologies like artificial intelligence (AI), Internet of Things (IoT), big data analytics (BDA), machine learning (ML), remote sensing, etc. hold huge promise for engineering smart innovations and solutions to combat climate change. Advances in the field of agriculture lead to the generation of huge data in the form of geospatial maps, soil health, crop production, market information, survey data, weather information, etc. In BDA, these are processed in cluster mode to extrapolate the real-time situations for providing customized services to different stakeholders. Real-time programming is possible with AI concepts and IoT devices for making appropriate farm decisions. With the lens of BDA and ICTs, we can analyze climate data, generate helpful insights such as trends and patterns, and implement climate forecasting models. The climate-informed crop calendars including early warning and predictive advisory services based on climate forecasts, crop monitoring and risk area identification can be delivered for better farming decisions and risk reductions. Data-driven agronomic intelligence system is one of the recent developments for precision farming, which provides soil and crop management recommendations for each location, using ML methods. This location intelligence helps fertilizer manufacturers to produce custom blended fertilizers to address specific regional soil fertility problems. Seed, pesticides, and the market sector can all benefit from similar knowledge and intelligence to reduce costs while increasing resource use efficiency. Developed and maintained by IRRI, there are a number of ICT tools, IoT solutions and digital databases (e.g., AutoMon^{PH}, CF-Rice, COMPARE, Crop Manager, Rice Doctor, RIICE, RKB, MapAWD, SECTOR, Seedcast, EasyHarvest, PRiSM, WeRise, etc.), aiming to support the scientific research and practical farm management needs in rice sector. Thus, application of BDA and ICTs in climate-smart agriculture can play a potential role in helping smallholder farmers to maximize their productivity and profitability through effective monitoring of climate change, thereby mitigating and adapting to its impacts. However, taking these technologies and ICT tools to the farmers' fields becomes a challenge, especially where socio-technical and institutional constraints are prevalent.

Keywords: Big Data Analytics, Climate-smart agriculture, ICTs, Smallholder farmers.

KEYNOTE LECTURE

Genome editing and the remarkable lives of plant pathogenic bacteria

White Frank[1]*, Antony, G.[2], Huguet-Tapia, J.C.[1], Yang, B.[3] and Zhang, P.[1]

[1]Department of Plant Pathology, University of Florida, Gainesville, FL USA 32611
[2]Department of Plant Science, School of Biological Sciences, Central University of Kerala, Tejaswini Hills, Periye, Kasaragod-671320, Kerala, India
[3]Division of Plant Sciences, Bond Life Sciences Center, University of Missouri, Columbia, MO, USA, 65211

Xanthomonas oryzae pv. *oryzae* (*Xoo*) is the agent of bacterial leaf blight, or just bacterial blight (BB), of rice. The disease is endemic in India and throughout Asia, and, increasingly, present in the African continent. An understanding of BB has provided tools for the engineering of broad resistance to BB and represents an ideal target for genome editing for the improvement in rice. Xoo is highly dependent on a family of virulence factors, which are named the transcription activator-like effectors or TALEs. TALEs direct the induction of a corresponding set of host disease susceptibility (S) genes, which are members of the nodulin 3 protein (N3) family. N3 proteins were subsequently shown to function as sucrose transporters and renamed SWEETs. Asian strains of Xoo target three SWEET genes in nature. The first S gene was *Os8N3* and now known as *OsSWEET11*; *Os11N3* is *OsSWEET14*; and *Os12N3*, *OsSWEET13*. BB is, in part, a battle over control of the expression of three host S genes and parallels the classical gene-for-gene resistance concept, with a gene-for-gene susceptibility. Four naturally occurring recessive resistance (R) loci in rice have been identified that correspond with each SWEET locus. The effectiveness of the resistance is dependent on the TALE genes of the pathogen. Xoo strain harbor TALEs that bind to sequence specific elements in the S gene promoters. Genome editing allows for interruptions in the TALE binding site and the consequential S gene expression and for the simultaneous modification of all TALE target sites in a single transformation. In fact, TALEs were used initially in S gene edits prior to the arrival of CRISPR-Cas systems. At the same time, rice has evolved a variety of resistance strategies that specifically interfere with TALE function. Variants in the TALE composition of Xoo strains arise in bacterial populations that can potentially evade newly edited resistant S alleles and other R genes, and strategies, including variations in edit composition, additional resistance (R) gene stacking, and field strain monitoring, will be presented.

Keywords: Recessive resistance, TALE, SWEET gene, *Xanthomonas oryzae*

INVITED LECTURE

Generating gene edited resources for basic science in chickpea

Santosh Kumar Gupta, Hastiram, Debasis Chattopadhyay*

National Institute of Plant Genome Research, Aruna Asaf Ali Marg, New Delhi-110 067, India

Chickpea is considered recalcitrant to in vitro tissue culture amongst all edible legumes. The clustered, regularly interspaced short palindromic repeats/CRISPR-associated protein 9 (CRISPR/Cas9)-based genome editing in chickpea can remove the bottleneck of limited genetic variation in this cash crop, which is rich in nutrients and protein. However, generating stable mutant lines using CRISPR/Cas9 requires efficient and highly reproducible and efficient transformation system. So far, callous-mediated shoot regeneration has been achieved in a limited chickpea accessions. In general, a growing cotyledon attached to its embryo is used for chickpea transformation resulting in chimeric transgenic plants even after antibiotic selection. This leads to production of transgenic as well as non-transgenic seeds. We have developed an efficient method to introduce exogenous DNA into cells. Generally, gene editing is performed with known genes for applications. However, functions and utility of genes are known by conducting academic science. We are establishing a protocol to edit 100 chickpea genes at a go to know their functions and utility. The bottleneck and advantage in this procedure is introducing multiple guide RNAs in a single chickpea explant and having a chimeric plant having editing in different genes in different cells, and having different seeds having different gene mutations. To identify the edited gene in different seeds of a plant is a challenge. The talk will describe the progress in this direction.

Keyword: Chickpea, Gene editing, Transformation

INVITED LECTURE

Genome editing for improving stress tolerance in rice

Santosh Kumar, V. V.[1], Shivani Nagar[1], Dipankar Barman[1], Pragya Yadav[1], Sourabh Karwa[1], Jyoti Priya[1], Ramawatar Nagar[2], Soham Ray[1], Monika Dalal[2], Gopala Krishnan, S.[1], Viswanathan Chinnusamy[1*]

[1]Molecular Physiology Lab, Division of Plant Physiology, ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India
[2]ICAR-National Institute for Plant Biotechnology, New Delhi-110 012, India

Rice is the major food crop, and contributes to about 40% of the food grain production of India. India remains the world's largest rice exporter for more than a decade with an export of 17.8 million tonnes of Non-Basmati Rice worth Rs. 51,088.72 Crores/USD 6,355.74 Million during the year 2022-23. Therefore, rice cultivation is important not only for food and livelihood security of India but also for the food security of importing countries. In India Rice is cultivated in an area of 47 mha with an average productivity of about 2.8 t/ha. Rice uses more than 50% of the irrigation water is it has a low WUE. Rice grown in rainfed ecosystems (38% of the total rice grown area) suffers from drought stress. Dwindling fresh water scarcity and global climate change demands development of high WUE and drought tolerant rice varieties with high yield. Our lab is working of functional validation of genes and improving stress tolerance of rice using genetic engineering and CRISPR-Cas genome editing in a mega rice cv. MTU1010. The candidate genes targeted for genome editing in our lab include *DROUGHT AND SALT TOLERANCE* (*DST*), *Protein Phosphatase 2C* (*PP2C*s) Clade A group, *MIR169*, *Farnesyl Transferase* (*FTA*) and Phytomelatonin Receptor (*PMTR*). Mutations in *MIR169*, *FTA* and *PMTR* showed pleiotropic effect on plant development. Mutants of *PP2Cs* showed enhanced abiotic stress tolerance. We developed four different mutant alleles of *dst* gene and identified two lines free of introduced exogenous DNA. These *dst* mutants exhibited reduced stomatal density, at least, in part due to downregulation of stomatal developmental genes. The *dst* mutants exhibited tolerance to osmotic and salt stress in seedling stage in hydroponics study and adult plant stage pot culture studies. The *dst* mutants use about 25% less water per unit leaf area as compared with WT MTU1010 cultivar. Further, these mutants showed >20% yield enhancement over wild type plants under field conditions in a transgenic net house in kharif 2021 and 2022. Mutants with high yield and stress tolerance developed in this study will be useful to release as variety and as a genetic stock for introgression of *dst* mutations in other indica varieties for genetic improvement in yield and climate resilience.

Keywords: Abiotic stress tolerance, CRISPR-Cas, Stomatal development, Transcriptome, WUE

INVITED LECTURE

Reshaping the rice genome to meet the emerging challenges

R. M. Sundaram*, S. K. Mangruathia, C. N. Neeraja, K. B. Kalyani, V. Papa Rao

*Director, ICAR-Indian Institute of Rice Research (ICAR-IIRR), Hyderabad, Telengana, India

Rice is the most widely cultivated crop in India with an estimated acreage of ~ 43 mha and grain production of ~130 million tons. The crop has shaped cultural and societal evolution, and holds the key of food security of country to feed more than 140 billion population. Despite the significant progress in total food grain production, particularly rice production in the recent years stagnating productivity (~2.8 tons/ha) is major area of concern in rice. One of the principal reasons for low productivity of rice in the country is that significant rice growing area under adverse ecologies such as hills, saline soils, rainfed areas, acid soils etc. Therefore, genome engineering of rice needs to be focussed for enhancing the crop productivity in these adverse ecologies. Rice genomics has seen tremendous progress during past two decades, specifically after decoding the rice genome, where ICAR played a critical role. With the advent of new sequencing technologies, the resequencing of more than 4000 rice accessions has brought breakthrough advancement in the field structural and functional genomics. The mining of massive genomics data helped identification of novel genes, superior alleles of these genes and their haplotypes, thus facilitating genomics-assisted, trait-oriented breeding. Several rice cultivars have been developed through marker assisted breeding, which was possible only because of availability of a wealth of genomics data in rice. The emerging challenges of climate change, changing pest and disease scenario, grain quality and nutrition enhancement, and development of fertilizer use efficient cultivars, etc. require a roadmap and strategies for exploitation of the enormous genomics information. Genomic studies of wild rice species and landraces will help in identification of novel alleles and genes that can be deployed for development of high yielding climate resilient cultivars. While the first-generation breeding technologies (domestication and selection, cross breeding, MAB) were based on random genome engineering, the second-generation breeding tools (cis-genic, transgenic, and genome editing) are based on targeted genome engineering. Specifically, the precise and quick breeding through genome editing offers tremendous possibilities to reshape the rice genome for the benefit of farmers and society. Indian researchers have demonstrated capabilities in using genome editing as a worth tool for rice improvement. The high yielding genome edited lines of Samba Mahsuri developed at ICAR-IIRR and drought and salt tolerant MTU1010 developed by ICAR-Indian Institute of Agricultural Research (ICAR-IARI) have already entered multi-location evaluation trials of All India Coordinated Research Project on Rice (AICRPR) for possible release and notification. The reshaping of rice genome through genome editing can bring another revolution to meet the emerging global challenges, particularly those posed by a rapidly changing climate. In addition to structural genomics, equal or more emphasis on functional genomics will determine the extent of success of these new breeding tools.

Keywords: Genome editing, Genomics, MAB, *Oryza sativa*, Wild rice

INVITED LECTURE

Genome editing for an ideal low-seed, high-leaf glucosinolate oilseed mustard

Avni Mann, Juhi Kumar, Roshan Kumar and Naveen C. Bisht*

DBT-National Institute of Plant Genome Research, New Delhi-110067, India

Genome editing technology like CRISPR/Cas9 has emerged as an excellent and rapid plant breeding tool for exploring basic plant biology as well as for increasing agricultural GDPs. Although CRISPR-based genome editing has shown its applicability in different plant genomes since 2013, the genus *Brassica* has come across this precise gene modification tool only since 2015. In polyploid *Brassica* species, CRISPR/Cas9 technology has been established for the functional validation of novel genes as well as for improving various agriculturally important traits including the enhancements of seed numbers and oil contents. The globally cultivated oilseed *Brassica* crops – *Brassica napus* (rapeseed) and *Brassica juncea* (mustard) are rich in seed glucosinolate content. The presence of high amounts of seed glucosinolates is known to be anti-nutritional and limits the value of the seed oil for human consumption and the seed meal as animal feed. Over the last 6-7 decades, a major breeding objective in rapeseed and mustard cultivars has been to bring down the seed glucosinolate content within the Canola quality limit. However, such Canola quality rapeseed and mustard cultivars are low glucosinolates in all parts of the plants rendering them vulnerable to generalist pests and pathogens. The ideal lines should have low glucosinolate content in the seeds while retaining high glucosinolates in the source tissues (leaves and pod wall) for an uncompromised defense. We recently reported CRISPR/Cas9-based editing of glucosinolate transporter (*GTR*) family genes in mustard (*Brassica juncea*) to develop ideal lines with the desired low seed glucosinolate content while maintaining high glucosinolate levels in the other plant parts for uncompromised plant defense. Use of three gRNAs provided highly efficient and precise editing of four *BjuGTR1* and six *BjuGTR2* homologs leading to a reduction of seed glucosinolate content from 146.09 *µmoles*/g dry weight (DW) to as low as 6.21 *µmoles*/g DW. Detailed analysis of the *GTR*-edited lines showed higher accumulation of glucosinolates in the foliar parts. When tested against the pathogen *Sclerotinia sclerotiorum* and generalist pest *Spodoptera litura*, the *GTR*-edited lines displayed a defense response at par or better than that of the wild-type line. The *GTR*-edited lines were equivalent to the wild-type line for various seed yield and seed quality traits. Our result presents a breakthrough in the breeding of oilseed Brassicas for oil and meal quality without compromising the protection provided by glucosinolates to all the vegetative parts of the plant.

Keywords: CRISPR/Cas9 genome editing, Canola, Glucosinolates, *GTR*, Indian oilseed mustard

KEYNOTE LECTURE

An international perspective on trade in gene-edited crops: Issues and current status

Michael G. K. Jones

Crop Biotechnology Research Group, Western Australian State Agricultural Biotechnology Centre, Food Futures Institute, School of Agricultural Sciences, Murdoch University, Perth, Western Australia 6150, Australia.

More food will need to be produced from less land to feed the growing world population sustainably whilst preserving biodiversity for future generations. This will require the application of the best science and technology, including in the areas of AgriBio, Agritech and Food Tech. The genetic potential of crop plants in the field underlies all these technologies, and the new suite of technologies described as Genome- or Gene-Editing (abbreviated here as 'GEd') is providing exciting new opportunities for genetic crop improvement. GEd technology is already contributing both to a new understanding of gene function and directly to better crops. Significantly, the potential now exists to break the nexus between Genetically Modified (GM) plants and GEd plants, and to avoid the issues that have prevented wider use of GM crops. The main factors to consider that relate to commercial application include:

Confirming that no 'external' nucleic acid sequences are present, by sequencing the site of gene-editing, Q-PCR to show the absence of backbone T-DNA, and checking the sequence at the edited site to determine that there is no new ORF or new allergen. Complete genome sequencing is not required.

The possibility of off-target edits – the history of safe use of foods in which many mutations/edits are present shows that the vast majority off-target mutations/edits are of no biological significance to consumers

Licensing GEd technology

Unintentional low-level presence of GEd seeds/produce in bulk trade–sensible agreement on accepting low-level presence of GEd produce (eg 1%) in bulk shipments would solve this possible trade issue.

National and international policies/regulations on GEd produce are advancing rapidly. International harmonisation, or at least alignment, is a pre-requisite for achieving the full benefits and enabling international trade in GEd produce. Many countries in N & S America and the Asia-Pacific, and more recently in Africa and Europe, have already or are now reassessing their regulatory regimes. The underlying principle is that if the GEd undertaken could have been achieved by conventional breeding (e.g. by mutagenesis or wide crosses within a species' gene pool), then there is no reason why produce developed using GEd, which achieves the same ends as conventional breeding but more rapidly and precisely, should be regulated any differently from conventionally bred produce. The current international regulatory status of GEd crops will be described, focusing on trade in the Asia-Pacific region, where two-thirds of the world's population reside.

Keywords: Crops, GEd, Genome editing, Regulations, Path-to-market, Science diplomacy, Trade harmonisation

Theme 3: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Technical Session 3: Genome Editing: IPR Policy for Product Development and Socio-economic Considerations

INVITED LECTURE

New seed technologies: Socioeconomic considerations

R. Ramakumar

Professor, School of Development Studies, Tata Institute of Social Sciences, Mumbai, India

This paper is a discussion on how social scientists can constructively engage with new technological developments in agriculture and use multi-dimensional and multi-disciplinary frameworks in their research. It focuses on the GM seed technology, and specifically addresses questions around the introduction of Bt-Cotton seeds in India. The issues raised vis-à-vis GM crops would equally be applicable to the prospective editions of gene-edited crops. Firstly, the paper argues for a better appreciation of the socioeconomic contexts in the study of new agricultural technologies. Secondly, it outlines a multidimensional framework within which the technological and socioeconomic variables could be analysed together to understand the net social value of a technology. Thirdly, in doing so, it also outlines a set of economic, institutional, and sociocultural factors that need to be factored in and accounted for in any analysis of new seed technologies. Here, the paper tries to distinguish between policy failures and technological failures in the case of Bt-Cotton in India and argues for a nuanced analysis that does not conflate the two.

Keywords: Bt-Cotton, Genetic regulation, GM crops, Indian agriculture, Science policy

INVITED LECTURE

Scope of genome edited livestock for India

T. J. Rasool*, Binita Nautiyal, Avinash Premraj and Abi George Aleyas

Camel Biotechnology Center (CBC), Presidential Camels and Camel Racing Affairs Center, Al Ain, Abu Dhabi, UAE

Livestock production has increased multiple times during the last century by the adoption of various technologies starting from selective breeding to whole animal cloning. However, the rate at which the demand for animal products is increasing necessitates rapid targeted methods to increase the trait of interest within specified period of time or generations. Further, the patterns of consumption of livestock products are also diversifying that demand directional improvement of livestock products. Among the available modern techniques for improving animal food production, Genome Editing offers a powerful technique that can alter the genetic makeup of animals at specified regions of the genome. It permits the modification of endogenous genes, integration of exogenous genes and deletion of undesired traits in very specific targeted manner. The technique has immense potential in country like India where faiths play a major role in the consumption pattern of livestock products. Principally there are three major techniques, TALEN, CRISPR/Cas9 and the ZFN. Though the CRISPR /Cas 9 is well studied and used in many species TALEN also is of importance in livestock. Even though the methodology appears to be simple to comprehend and can be carried out in most of the modern Biotechnology labs at cellular level, to translate it to the field requires a fully functional embryo technology and animal cloning lab as well. The application of genome editing in livestock have more scope for monogenic traits as polygenic traits will require additional gene clusters to complement the trait of interest. Even the monogenetic traits also have to be supported by other connected tissues and organs to optimize the full potential of the technique. The major livestock species of India that has potential for genome editing are cow, buffalo, sheep, goat, pig and chicken. The major traits of interest that can be manipulated are disease resistance, sex ratio alteration, introducing sterility for population control, for improving pollness frequency, improving food conversion efficiency, growth, removal of food allergen, heterologous organ farming etc. The availability of species specific institutes in the ICAR system of the country offers an ideal platform for developing the genome edited livestock in India

Keywords: CRISPR/Cas 9, Livestock, Genome editing, Monogenic, TALEN

INVITED LECTURE

Preparedness of Indian dairy sector for food security

A. K. Srivastava and Yajuvendra Singh

U.P. Pt. Deen Dayal Upadhayaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India

Indian dairy sector is much prepared to tackle the challenges of food security in India. Still the best efforts are going on to uplift the livelihood of even landless and marginal farmers of the country. Keeping in view the limited resources and rapidly growing human population, the Indian dairy industry is preparing to cope up the challenges in multiple ways. Indian Dairy Sector is creating an appropriate dairy development policy to boost the milk production in promising districts and states. Statistical information reveals that 81% of milk in India is produced by 10 states, while the remaining 19% is produced by other states and union territories. Therefore, there is a need to increase the milk supply chain in regions with a shortage of milk. Thus, it would be crucial to encourage dairy farming among small and landless farmers. Here it is to mention that only about 10 % of total milk is being collected by co-operatives for commercial processing and value addition. The breed conservation programme of Indian native indigenous milch and dual purpose breeds of cows' viz. Hariana, Sahiwal, Gir and Tharparkar. in their respective native localities, under Rashtriya Gokul Mission (RGM) programme of DADF, Government of India has been undertaken. Under this programme we have started conservation and improvement indigenous breeds of cattle by grading up and selective breeding and propagation of elite germplasms to farmers and institutions associated with breed improvement programme. It has helped us in increasing the per capita productivity of our indigenous breeds of cattle. This is the reason why despite of very slow growth rate of our milch animals, our milk production is increasing rapidly day by day. Now more focus is being given on the concept of "One World, One Health," which is based on the understanding that humans, animals, and the environment are inextricably linked, indicating that the world has suddenly realized the interrelation between ecology, animal diseases, and public health, striving to restore and maintain harmony and synergy. For improving the immunity and health status of dairy animals, the vaccination programme against various diseases on mission mode has been started. The climate resilient livestock management system through the interventions of advanced technologies in housing, feeding, breeding, milking and cleaning of dairy animals has also been developed, so that their production, reproduction may not be affected by the adverse climatic conditions in different seasons.

India is now prepared to have more and more number of organized dairy farms. It is because the people are adapting dairy farming as business. Here various advanced innovations, technologies in breeding, feeding, milking etc., which has enhanced the précised production have been utilized. A very sincere effort has been made to develop various alternatives of feed and fodder to maintain quality fresh feed and fodder to our dairy animals throughout the year, so that the dairy animals do not face the problems of feed and fodder scarcity. Various short and medium duration fodder cultivars of several

crops that can withstand up to 2-3 weeks of exposure to drought in rainfed areas have also been developed. These include: Sorghum (Pusa Chari Hybrid-106 (HC-106), CSH 14, CSH 23 (SPH-1290), CSV 17); Bajra (CO 8, TNSC 1, APFB 2, Avika Bajra Chari (AVKB 19); Maize (African tall, APFM 8). These cultivars can be sown immediately after the rains under rainfed conditions in arable lands during kharif season and are ready for cutting by 50-60 days. Cultivars of rabi crops like Berseem (Wardan, UPB 110) and Lucerne (CO 1, LLC 3, RL 88) were second crop with the available moisture during winter. Perennial fodders like APBN-1, CO-3 and CO-4 can also be grown under limited irrigated conditions. The production of Silage and Hay for supplementation of dairy herds during scarcity period has also been started at commercial scale. The storage facility of feed and fodder has also been improved which are protecting them from being rotten. Indian dairy industry has immense potential to contribute to India's economic development and in food and nutrition security of the country. Therefore, dairy industry must be supported through policies and investments that promote growth and innovation. By doing so, we may make the dairy industry sustainable and thus, it can also continue to create jobs, boost rural development, and contribute to India's food security and export potential.

Keywords: Food Security, Preparedness, Indian dairying

INVITED LECTURE

Transforming the animal feed sector for food and environmental security

Raghavendra Bhatta

Director, ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru, Karnataka, India

The global demand for meat, dairy, and poultry products is on the rise due to population growth and changing dietary preferences. As a result, the animal feed sector plays a pivotal role in meeting this demand. However, the conventional practices of feed production have raised concerns about their environmental impact, particularly in terms of greenhouse gas emissions, resource utilization, and food waste. Transforming the animal feed sector is crucial to enhance both food and environmental security. The production of animal feed is a significant contributor to greenhouse gas emissions, primarily due to land use change, deforestation, and the energy-intensive processes involved. Transforming the animal feed sector involves adopting sustainable practices that reduce its carbon footprint. These include using responsibly sourced ingredients that can help reduce deforestation associated with feed production. Incorporating alternative protein sources, such as insect meal or algae, can reduce the environmental impact of traditional protein crops like soy and corn. Improving the energy efficiency of feed production facilities through modern technology and renewable energy sources can significantly reduce emissions. A major transformation opportunity in the animal feed sector lies in recycling food waste and by-products. Instead of discarding these materials, they can be repurposed as nutritious animal feed, reducing the demand for primary feed ingredients and minimizing waste. This approach aligns with the circular economy concept, contributing to both food security and environmental sustainability. Another approach is the precision feeding that involves optimizing the nutrition of animals based on their specific requirements, thereby reducing overconsumption of feed. Advanced technologies, such as precision feeding systems and sensors, enable farmers to monitor the health and performance of their livestock closely. By avoiding excessive feed, this approach minimizes nutrient wastage and greenhouse gas emissions associated with digestion. Transitioning toward organic farming practices within the animal feed sector can also have a positive impact on environmental security. Organic farming emphasizes sustainable crop rotation, reduced chemical use, and improved soil health. Organic feed production supports healthier ecosystems, reduces chemical runoff into waterways, and promotes biodiversity. Mitigating greenhouse gas emissions within the animal feed sector can contribute significantly to environmental security. Strategies for reducing emissions include developing additives and feed supplements that mitigate methane emissions from livestock that can reduce their carbon footprint, implementing efficient manure management practices, such as anaerobic digestion and composting can capture methane emissions and reduce water pollution and optimizing nutrient content in animal diets helps reduce excess nutrient excretion, which can lead to water pollution and emissions. Transforming the animal feed sector is crucial for both food security and environmental sustainability. By reducing the carbon footprint of feed production, recycling food waste and by-products, implementing precision feeding, promoting organic farming, and mitigating greenhouse gas emissions, we can enhance environmental security while meeting the growing demand for animal-based products. Collaboration among stakeholders, including farmers, researchers, policymakers, and consumers, is essential to drive these transformations and ensure a sustainable future for the animal feed sector.

Keywords: Anaerobic digestion, Animal feed sector, Composting, Food security, Environmental sustainability, Recycling

INVITED LECTURE

Meat sector visioning and action agenda for continued food security

S. B. Barbuddhe, Yogesh Gadekar and B. M. Naveena

ICAR-National Research Meat Institute, Hyderabad ,Telangana, India

Livestock production is crucial in providing food security and financial stability for more than two-thirds of the population in India. Animal-sourced foods are highly valued for their nutritional content and bioavailability. India produced 9.29 million tonnes of meat during 2021-22, setting a global record in buffalo meat production. The annual per capita availability of meat in India is 6.82 kg head^{-1} annum^{-1}. There is a wide gap between the demand and availability of meat. The deficiency of high-quality protein in the diet is often associated with undernourishment and malnutrition. According to the National Family Health Survey (2022), over 70% of people in India consume non-vegetarian food. With the projected human population of 160 crores by 2050, it is crucial to ensure the availability of animal-sourced food to ensure nutritional security. Only small quantity of meat produced in India is currently processed into value-added products, in comparison to developed countries. India has the potential for value addition and meat processing, which can generate employment opportunities, increase the shelf life of meat, and generate additional income for stakeholders. The impact of climate change on livestock production has serious implications for food security, particularly as this issue becomes even more pressing in the future. It is crucial to implement policies that help mitigate and adapt to the challenges, to protect the sustainability of livestock production. Few potential strategies for adapting animal-agricultural systems to the changing climate include improving animal breeding practices to improve productivity and production efficiency, anti-methanogenic feeding, changing producers/farmers perception, use of efficient machineries, green cooling technologies, and incorporating advances in science and technology. Lab-grown meat, also called cultured meat or cell-based meat has been proposed to address various environmental, ethical, and health concerns associated with traditional animal agriculture. The meat produced in India has great demand in the international market. The country has exported animal products worth `32,597.39 crores during 2022-23. The export earnings of meat from the country have been almost stagnant during the last few years. Various strategies are being followed to increase the meat production and export. These include- establishment of Disease-Free Zones, National Animal Disease Control Programme, Animal Husbandry Infrastructure Development Fund (AHIDF), male buffalo calves rearing. The prospective areas/states need to be identified for the establishment of meat zones. In the area where a good number of food animals are available, such areas can be converted into meat zones wherein processing units would be nearby animal mandis/markets. The machinery and other accessories would be available at one place. Establishing animal markets with adequate infrastructure like shelter with feeding and watering facilities for animals, and weighing balances will help to trade the animals. Adequate infrastructure facilities for clean meat production, processing, marketing, and quality assurance also need to be established. The slaughter policies in the country need to be revisited. Culling unproductive stock is essential for sustainable meat production. Collaborative and concerted efforts in breeding, feeding, management, and meat value chain would help competitive meat production. Further, the implementation of traceability in the meat value chain has the potential for boosting export. To achieve sustainable meat production in India, it is crucial to involve all stakeholders, including farmers, policymakers, researchers, and consumers.

Keywords: Bioavailability, Eradication of malnutrition, Meat value chain, Nutritional content, Meat production

INVITED LECTURE

Dairy value chain for food and income security

Dheer Singh

Director, ICAR-National Dairy Research Institute, Karnal, Haryana, India

The dairy industry plays a pivotal role in ensuring both food and income security, contributing significantly to the global economy and millions of individuals well-being. It is driven by a profitable and sustainable dairy value chain, which encompasses a sequence of interconnected activities ranging from feed production, animal husbandry, milk collection, processing, distribution, and consumption. This chain links various stakeholders including farmers, processors, retailers, and consumers, forming a complex system that directly influences food and nutritional security. From a food security perspective, dairy is a rich source of essential nutrients, including protein, vitamins, and minerals, making it a valuable component of balanced diets worldwide. Furthermore, the versatility of dairy products, spanning from liquid milk to cheese, yogurt, and butter, adds to their significance in meeting diverse dietary preferences. Economically, the dairy value chain is a heavyweight contributor to national GDPs and export earnings for many nations. Remarkably, over 80% of the world's dairy farms are smallholders, highlighting the role of dairy in alleviating poverty by granting these farmers better access to markets, finance, and technology. Additionally, the dairy sector's resilience to economic shocks, relative to other agricultural commodities, underscores its significance in fostering economic stability. However, the challenges like milk prices fluctuation, inadequate infrastructure for milk collection and transportation, issues related to animal health and welfare, greenhouse gas emissions and water usage require solutions for sustainable positive impact.

India, with its vast population, strives for food and income security. The Indian dairy value chain involving milk production by smallholders, cooperatives, and private enterprises, culminating in processing, distribution, and consumption is pivotal in achieving these goals. Milk, a dietary staple, combats malnutrition and enhances public health, thus encouraging food security. One of the standout features of the Indian dairy value chain is its ability to provide income security for a multitude of stakeholders, particularly small and marginal farmers. Dairy farming offers a relatively low-cost entry point to agriculture and is often a lifeline for rural households. The sale of milk provides regular cash flow, enabling families to meet daily needs, invest in education, and weather economic uncertainties. Additionally, dairy cooperatives, exemplified by the success of Amul and other upcoming farmer producing companies, have empowered farmers by collectively aggregating resources and negotiating better prices. However, challenges such as fluctuating milk prices, inadequate infrastructure, and climate variability persist. To address these challenges and further enhance food and income security, it is crucial to promote sustainable practices across the dairy value chain. This includes efficient and climate-resilient farming techniques, improved animal husbandry, and modern processing infrastructure, such as cooling milk cans to prevent spoilage during transportation by vendors. Government policies are pivotal in shaping the dairy sector's impact on food and income security. Supportive policies, focusing on yield improvement, fair pricing, and value addition, benefit rural economies and nutrition. Promoting innovation and technology in areas like feed management, processing, value addition and genomics boosts productivity and diversification. The Indian dairy value chain is a prime example of how strategic interventions can address these challenges by recognizing the nexus of nutrition, livelihoods, and sustainability. Emphasis should be on research, policy innovation, and investments for a more secure and prosperous future.

Keywords: Climate-resilient farming techniques, Dairy value chain, Diversification, Milk production, Supportive policies

INVITED LECTURE

Sex sorted semen for higher production and income security: Perspective and prospective

A. Kumaresan[1]* and K. M. Bujarbaruah[2]

[1]ICAR National Fellow, Theriogenology Laboratory, SRS of ICAR-National Dairy Research Institute, Bengaluru – Karnataka, India
[2]Former Deputy Director General (AS), ICAR and Vice-Chancellor, Assam Agriculture University, Assam

In India, sex sorted semen assumes much significance in view of (1) Farm mechanization significantly reduced the role of bulls in agriculture (2) Disposal of males, especially in crossbred cattle, is a major problem faced by the dairy farmers and (3) Scrub bulls roam around streets and disseminate poor germ plasm and diseases by mating the accessible females. Skewing sex ratio and obtaining offspring of desired sex has been made possible with the development of fluorescent activated sperm sorting using the differences in DNA content between X- and Y-bearing spermatozoa. Although flow cytometry-based sperm sorting is commercially used in case of cattle, the technique has its own demerits like altered sperm quality and fertilizing potential leading to reduced conception rates (because of DNA dye, LASER exposure, centrifugation and other insults), cost associated with semen straws and IPR issues making us entirely dependent upon IPR holding companies abroad, which needs to be done away with through indigenously refined method. Generally, it is possible to obtain 3 males and 3 females during the reproductive life time of a cow using unsorted semen. On the other hand, if sexed semen is used for breeding, it is possible to obtain 5 females and one male in the same period. On a conservative estimate, this translates into and additional gain of 2 cows and three heifers, and 12000 kg milk in a period of 10 years of age from a single cow. Therefore, use of sexed semen, no doubt, is one of the ways of accelerating the genetic improvement and productivity of cattle, and income security of the dairy farmers. However, the cost associated with the use of sexed semen and poor conception rates in cattle bred using sexed semen, limits its use on a large scale. This situation warrants development of an alternate method for sexing of semen that (i) is easy to perform and effective to separate X-bearing spermatozoa with high accuracy (ii) do not affect the sperm fertilizing ability (iii) reduce the cost of production and (iv) improve the fertility with sexed semen. Current and futuristic technological possibilities for sexing of semen, its implications on genetic improvement, possible effects of its large-scale application on reproductive efficiency and performance of cattle, and the need for evolving a definite policy for use of sexed semen are discussed.

Keywords: Alternate technologies, Bovine, Fertility, Skewing sex ratio, Sperm sex sorting

INVITED LECTURE

Fast track breeding approaches in fruit crops for targeted genotype development

Sanjay Kumar Singh*, Satyabrata Pradhan, Sankaran, M., Anjani Kumar Jha, Kowsalya, K. B. and Maruvarsi, P.

ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka, India

Conventional fruit breeding a time taking and slow process majorly due to their long juvenility periods, heterozygosity, complex reproductive biology, poor understanding of inheritance of horticultural traits, high field maintenance cost, and requirement of large population for making an effective selection. Introduction of resistance gene(s) from wild fruit species is time-consuming as it requires repeated backcrossing with effective donor parents. A period of >50 years is needed in order to obtain a new apple cultivar expressing a trait originally present in a wild apple, and a fruit quality that can compete with the world's leading cultivars. Numerous agro-techniques have been tested to reduce the juvenile phase in hybrid fruit in different crop species, however, it has been impossible to reduce the juvenile phase upto <18 months. Speed or Fast-track, a system which shortens the breeding cycle, addresses these limitations and vulnerabilities. Fast-track breeding approaches assist in overcoming long juvenility in fruit trees *via* the transgenic expression of the desired gene(s). The breeding time for fruit trees can be shortened to one-fifth of the conventional breeding approaches. The *Arabidopsis LFY* gene has been expressed in fruit trees for shortening the breeding period and has yielded the desired results. In transgenic citrus plants, the juvenile phase was considerably reduced. The suppression of the apple *TERMINAL FLOWER 1* homolog *MdTFL1* resulted in a significantly reduced juvenile period. Similarly, attempts have also been successfully applied in plum. Time bound shortening of breeding cycle can be accomplished using a variety of technologies, including genotyping, marker-assisted selection, high throughput phenotyping; gene editing, genomic selection, and re-domestication, all of which can be combined with speed breeding to assist plant breeders to keep up the pace with a changing climate and growing human population need. Fast-track or speed breeding system is still under the nascent stage in several fruit crops though it needs to be explored for hastening the total breeding process especially in the perennial fruit crops thus achieving precision in breeding in fruits of national importance like mango, citrus, banana, walnut etc.

Keywords: Fast Track Breeding, Fruit Crops, Genotypes development, Targeted Genotype Development

INVITED LECTURE

Targeted breeding in vegetable crops for safe production

K. Madhavi Reddy

Principal Scientist, Division of Vegetable Crops, ICAR-Indian Institute of Horticultural Research,Bengaluru, Karnataka, India

Vegetables are rich in essential vitamins, minerals and antioxidants providing good health from a range of phytonutrients. However, the vegetable production is severely affected by many biotic and abiotic stresses. In order to overcome the major biotic stresses, pesticides are being used indiscriminately at farm level, causing increasing concern about the safety of vegetables among consumers. Conventional breeding techniques are being used to overcome the major production constraints in vegetable crops by the researchers to a greater extent. However, to overcome emerging diseases and pests the targeted advanced breeding techniques allow precise modifications into improved varieties, offering viable supplement or alternative to traditional breeding methods. Advances in genome sequencing technologies combined with efficient trait mapping procedures, marker-assisted breeding, genome editing, multi-omics approaches, availability of high quality reference genome assemblies, doubled haploid technologies, genomics-assisted breeding, haplotype-assisted breeding, pangenomics, super-pangenomics and speed breeding techniques, accelerate the use of beneficial alleles for targeted breeding in vegetable crops. Targeted and rapid assembly of beneficial alleles using optimized breeding strategies and precise genome editing techniques could deliver ideal varieties of vegetable crops for the future. Further, the genome-wide association approach (GWAS) overcomes several limitations of traditional gene mapping by providing higher resolution, often to the gene level, and using samples from previously well-studied populations in which commonly occurring genetic variations can be associated with phenotypic variation. Pangenomics and super-pangenomics can encompass most of the genetic diversity of a species and is proved to be a powerful tool for studying genomic evolution and the origin and domestication of species, and for providing information for plant improvement. Understanding novel genetic variation from the related gene pools and their use in plant breeding applications has now become a reality because of the recent breakthroughs in sequencing and phenotyping. Genome editing allows plant breeders to make very precise changes to DNA. Genome editing can be used to make changes to a plant by targeting at a specific location in a gene within the DNA. Genome editing can be used to add, remove or alter DNA in the plant genome. Omic approaches provide information on molecular variation in breeding lines beyond the expected genetic variation they contain. Genome editing based on CRISPR-Cas9, is revolutionary tool for editing the plant genome directly. As the paradigm shifts from individual DNA marker to haplotypes, future cultivar development will be driven by the breeding strategies to expedite and incorporate superior haplotypes in breeding populations. The efficient crop breeding programs with an enhanced genetic base will accelerate the progress of forward breeding. Accelerating the breeding cycle through doubled haploid technology and also speed breeding techniques, revolutionizes the time required to achieve genome fixation. By rapid production of climate-resilient crop varieties, the above-mentioned approaches offer huge opportunities to improve breeder's response to growing challenges that vegetable crop improvement faces. Furthermore, it is important to note that use of superior varieties along with integrated pest and disease management practices will help in safe vegetable production at reduced cost of cultivation.

Keywords: Beneficial alleles CRISPR-Cas9, Genome editing, Integrated pest and disease management, Pangenomics, Superior varieties

INVITED LECTURE

Sensors, new molecules and smart packaging in PHM of horticultural crops

Ram Krishna Pal

Former Director, ICAR-National Research Centre on Pomegranate, Solapur, Maharashtra, India

Horticultural produce, mainly fruits and vegetables, plays a significant role in human diet. These are powerhouse of essential vitamins, minerals, fibres and antioxidants, making them protective food. Consumption of fruits and vegetables is significant for building immunity in the human body. It is more relevant now since the recent Covid-19 pandemic compromised the human immune system of a large section of the affected population. Perishability of these products after harvest is a primary concern, particularly in tropical and subtropical agro-climatic regions worldwide. The living nature of harvested horticultural produce makes it more challenging for their quality assurance during subsequent distribution and marketing. Several pre and postharvest management practices can extend the shelf-life of horticultural produce. However, treatments concerning food safety issues such as PHI (postharvest interval for consumption after pesticide application), MRL (Minimum Residue Level) of chemicals are the foremost concern. In the new artificial intelligence arena, sensors, new molecules, and intelligent packaging play a crucial role in the postharvest management of perishable horticultural produce. This paper highlights some critical issues in using these relevant technologies in the postharvest management of horticultural produce.

Keywords: Biosensor, ClO_2, DPA, Harvest maturity, 1-MCP, Magnetoresistive sensors, Melatonin, Polyamines

INVITED LECTURE

Horticultural Crops: Potential for developing Functional foods and nutraceuticals

T. John Zachariah, R. Sivranjani and K. Nirmal Babu

ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India

Eating habits and trends in food production and consumption, coupled with changing life styles, have health, environmental and social impacts. Diet has implications on gut health, overgrowth and imbalance of intestinal microbial flora, and consequent health issues. Functional foods are the foods that provide benefits beyond basic nutrition and play a positive role in reducing or minimizing the risk of certain diseases, enhancement of immunocompetence, improving health and wellbeing. Nutraceuticals are the substances which are not traditionally recognized nutrients but which have positive physiological effects on the human body. Nutraceuticals include different kinds of products such as dietary supplements, functional beverages, genetically engineered foods, herbal/ protein/minerals/vitamin supplemented products and other processed products. Horticultural Crops like fruits, vegetables, nuts spices etc., are really good source for developing Functional foods and nutraceuticals.

Keywords: Bio-active components, Disease, Functional Foods, Nutraceuticals

INVITED LECTURE

Integrating climate change into fisheries management: Opportunities for sustainable and resilient fisheries

E Vivekanandan

Senior Scientific Consultant, ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala, India

Climate change is expected to disrupt fisheries, from resource distribution and abundance to timing and locations of fishing, fish preservation, marketing and consumption. This will exacerbate the already existing negative effects of unsustainable fishing practices and pollution on fish stocks. In addition, the lives and properties fishing communities are affected by increasing intensity of cyclones and sea level rise. The importance of taking climate issues seriously and mainstream them into fisheries management for sustainability has been realised. SDG 13 on Climate Action urges taking urgent action to combat climate change and its impacts by (i) strengthening resilience and adaptive capacity to climate-related hazards and natural disasters; (ii) integrate climate change measures into national policies, strategies and planning; and (iii) improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. SDG 13 has integrated and indivisible character as well as interlinkages and synergies of cross-cutting reinforcing relationship and aids achievement of SDG 14 on Life Below Water. However, as SDGs 13 and 14 are likely to have notable trade-offs, it is important to ensure that adaptation approaches are consistent with broader development objectives. Adaptation measures are required at local and national levels by mainstreaming climate change into fisheries policy and management using climate smart technologies, green fishing, ecosystem approach, improved fish value chains, access to affordable insurance, gender equity, and safety at sea. Sustainability of fisheries *vis-à-vis* climate change impacts could be achieved by (i) implementing effective fisheries management and policies to address ecological, social and economic benefits; (ii) ensuring equitable access to resource and services to enhance livelihood of fishers; (iii) ensuring efficient value chains to reduce food loss, and increase profitability; (iv) increasing consumption and access to healthy, safe and high quality aquatic food particularly in areas with low food and nutrition security; (v) improving accessibility of aquatic food products to international markets; and (vi) ensuring effective regional and global cooperation. A number of challenges remains for effective implementation of climate adaptation measures in fisheries management; they relate to governance structure and capacity, uncertainty, rights disputes, and finance. To address the challenges of climate change, creation of climate adaptation plans and integrating with fisheries management is required by engaging scientists, fishers, trader, processors, policy makers and other relevant stakeholders.

Keywords: Adaptation options, Implementation, SDGs, Stakeholder engagement

KEYNOTE LECTURE

Better exploitation of fish/shellfish leftover *via* the conversion to functional ingredients and food additives

Soottawat Benjakul*

International Center of Excellence in Seafood Science and Innovation, Faculty of Agro-Industry,Prince of Songkla University, Hat Yai, Thailand

Fish and shellfish have become popular for consumers due to their delicacy and nutritive value and they also play a crucial role in economy for many countries. During processing, a large amount of leftover is generated and considered as waste or byproducts, which are commonly discarded or used as animal feed, etc. The type and amount of byproducts vary with species as well as processing methods used. Utilization of byproducts, especially the conversion to high-valued functional ingredients, has drawn the immense attention from fish processing industries and nutraceutical company. In addition, there was no religious constraint for those products used as the food ingredient, food additives, nutraceutical or cosmeceutical. This leads to the great profit or increasing revenue for industry. Also, the marine resources can be utilized potentially under bio-circular-green economic model (BCG). Fish processing byproducts or leftover include skin, scale, bones, and viscera, etc., which can be generated during evisceration or filleting processes. The important products from fish skin include collagen and hydrolyzed collagen containing active peptides with bioactivity such as skin nourishment or bone strengthening activities. Fish bone containing collagen and hydroxyapatite can be manufactured to biocalcium with high bioavailability and biocompatibility. Fortification of those products at an appropriate level in food and drinks as the functional ingredients can be achieved with consumer acceptability. Viscera can serve as the excellent source of proteases, in which trypsin and pepsin constitute as the major enzymes. Those two enzymes can be stabilized in the selected matrix for shelf-life extension and particularly for their stability in human gastrointestinal tract. Those proteases can be used as the supplement or digestion aid for patients with depleted digestion system. For shellfish, shell and cephalothorax are considered as the major byproducts. They can be used for production of shrimp oil rich in n-3 fatty acid and astaxanthin. Shell can be converted to chitin and chitosan, while hydrolysis technology is implemented for production of chitooligosaccharide (COS) with the wide range of bioactivity. COS with antioxidant and antimicrobial activities can be used as the food additives or nutraceuticals. The activities of COS can be enhanced via the conjugation with plant polyphenols. Thus, COS-plant polyphenol conjugate can serve as the potential substances for wider uses in several industries. Although several products can be successfully transformed from fish and shellfish processing byproducts, the further development of prospective technologies are still required, especially to improve the bioactivities and consumer acceptability.

Keywords: Byproducts, Bioactivity, Fish, Food ingredient, Nutraceutical, Shellfish, Utilization

INVITED LECTURE

Innovations in Fish Processing Technology for Increasing Efficiency and Reducing Wastage

Ravishankar. C. N.

ICAR-Central Institute of Fisheries Education, Versova, Andheri (West), Mumbai, India

Globally, fish has been realized as a nature's super-food with the global per capita availability for consumption of 20.2 kg year^{-1} person^{-1}. Aquatic system has provided 157.4 million tons of aquatic animals as food and served as a source for 25 million t of easily digestible proteins packed with essential amino acids and health beneficial peptides. Marine fish is well-recognised for their richness in therapeutic fatty acids including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The richness in terms of essential micronutrients like vitamins and minerals has made the fish as a better and sustainable choice to address the nutritional issues at global scale. India has contributed 8% (162.48 lakhs tonnes) to the global fish production with the very below global per capita average annual consumption (6.31 kg year^{-1} person^{-1}). Global as well as Indian fish production has significant quantity as wastage due to post-harvest loss and process related waste generation, and nearly accounts to 27-39%. In the contest of Indian fisheries, minimizing post-harvest loss and improving the waste utilization through innovative solutions could greatly transform the aquatic food system to support the food and nutritional security of India. Innovations in technologies through research and development could strengthen the strategies to minimize the post-harvest fish loss. Innovations are demanded in fish processing methods, product development, processing machineries, handling tools, and supply chain. Implementing the developments happening in allied sectors, including information technology and artificial intelligence to strengthen the forward and backward linkages will result in a well-managed supply chain and cold chain. Bridging the information, knowledge and technological gaps between producers and consumers would be a key for reducing the post-harvest fisheries loss. The innovations in technologies to be friendly with local culture and should satisfy the peculiar local needs for better adoptions by many numbers so as to achieve the transformation envisaged in aquatic food system for building a healthy and wealthy nation.

Keywords: Aquatic food system, DHA, EPA, Essential amino acids, Nutritional security

INVITED LECTURE

Quality certification standards in fish product processing for consumer food safety – An Indian perspective

Satyen Kumar Panda

Advisor, Food Safety and Standards Authority of India (FSSAI), Ministry of Health and Family Welfare, Government of India, Kotla Marg, New Delhi-110002, India

Fish and fishery products are an important source of protein and essential nutrients for a large part of the Indian population. However, the safety and quality of fish and fishery products can be compromised by a variety of factors, including poor handling, processing, and storage practices. To address these concerns, various quality and safety standards have been developed to ensure the safety and quality of fish and fishery products for consumers. In India, the Food Safety and Standards Authority of India (FSSAI) is the apex body responsible for ensuring the safety and quality of food products, including fish and fishery products. FSSAI has laid down a number of regulations and standards for fish and fishery products, which include standards related to product formulation, additives, contaminants and residues. These regulations set out specific requirements for the processing, packaging, labelling, and storage of fish and fishery products to ensure their safety and quality. In addition to FSSAI regulations, Bureau of Indian Standards (BIS) has also developed number of voluntary product specific standards for frozen, canned, dried fish products that can be certified for quality and safety. Marine Products Export Development Authority (MPEDA) has also developed a set of guidelines and certification schemes for aquacultured products to ensure that Indian fish and fishery products meet the requirements of international markets. Quality certification standards play a crucial role in ensuring the safety and quality of fish and fishery products for consumers. In India, FSSAI being the apex food regulator, is unswervingly working for buttressing the food safety ecosystem of the country by pan-India surveillance and monitoring programmes. However, there are a number of challenges that need to be addressed in order to ensure the effective implementation of these standards. These challenges include the multiplicity of regulatory/development agencies, inadequate integration of safety measures at primary production stage, and limited implementation of traceability systems. By addressing these challenges, India can improve the safety and quality of its fish and fishery products, and meet the demands of both domestic and international markets.

Keywords: Fishery products, Food safety, Quality certification, Traceability systems

INVITED LECTURE

Gender in Fisheries and Aquaculture: A research agenda for driving transformational change for food Systems

Holly M. Hapke

School of Social Sciences, University of California-Irvine, Irvine, CA 92612, USA

In this presentation, Dr. Hapke reviews the last two and a half decades of research on gender in fisheries and aquaculture. She discusses what knowledge has been achieved and then presents an agenda for moving gender and fisheries science research forward to drive transformational change in food systems. Women's involvement in the fisheries and aquaculture sector as a whole remains invisible, and women have been relatively excluded from national development policies and programs. The neglect of post-harvesting activities and the exclusion of women from research and policy have created gender inequities and differential impacts on men and women – often to women's detriment. Failure to account for sex, gender and other social factors in fisheries and aquaculture research results in weak science and, often, policy failure. Such failures also hinder transformations of food systems that will be required to achieve sustainable development goals. While much progress has been made to address these issues, broadening and deepening the scope of theoretically informed gender analysis in fisheries and aquaculture research is not only necessary for achieving social equity in the sector, it is critical for the development of robust fisheries and aquaculture science. Dr. Hapke will delineate several concepts that are central to gender analysis in fisheries and aquaculture research and demonstrate how advancing research around these concepts will strengthen fisheries and aquaculture science and thereby drive transformational change in food systems for sustainable development.

Keywords: Equitable food systems, Fisheries and aquaculture research, Gender

KEYNOTE LECTURE

Assessment and improvement of water productivity in rainfed and irrigated Districts of India: A pathway for transforming Agri-food Systems

Alok K. Sikka*, Upali A. Amarsinghe and Madhusha Perera

International Water Management Institute, Colombo, Sri Lanka

This paper finds that many rainfed districts in India, defined as those with low access to irrigation, have the potential to harvest water and improve water productivity. Providing irrigation in critical periods would increase yield and physical water productivity (PWP). There is potential for irrigated areas to increase PWP too; the excess surface runoff under normal to moderate drought conditions, harvested in ponds and tanks could reduce water stress in critical periods of crop growth. Both rainfed and irrigated areas with water stress should consider diversifying to high value drought tolerant crops to increase the economic water productivity to increase income under normal climatic conditions, and enhance resilience under drought conditions.

Keywords: Agri-food Systems, Irrigated, Rainfed, Water productivity

KEYNOTE LECTURE

Nature-based solutions can support a healthy climate, economy and planet

Vinay Nangia

Research Leader, Soil, Water, and Agronomy, International Center for Agricultural Research in the Dry Areas (ICARDA), Rabat, Morocco

Water scarcity is increasing, especially in dry environments with climate change and degradation of natural resources. About 41% of the Earth's land area is classified as dryland; wherein the farming system is characterized by low annual rainfall with much of it falling in the winter and spring. Drylands are reported to be among the most vulnerable to land degradation caused by climate change and anthropogenic activities, and, in case of the global temperature rise over targeted 1,5 °C, they will be more susceptible to increased surface warming than humid areas. This would in turn mean increased vulnerability to droughts, decreased water availability, reduced crop yields and increased disease transmission. Reports also state that areas covered by drylands are expected to substantially expand by the end of the 21st Century reaching almost 60% of the global land coverage. Dryland agriculture, especially in Africa, is required to produce more food and welfare for rapidly increasing populations but with less freshwater resources. Conventional responses to this situation focus on increasing yields, improving irrigation efficiency and managing demand. We argue that those strategies are either not working under current conditions or not sufficient anymore to cope with the daunting demand for more food in water scarce dryland regions. A paradigm shift in how we manage water is needed going into the future. The debate on how better to handle agricultural water allocation and use with increasing scarcity has been intensified over the last decade and is producing new transformative solutions. Nature-based solutions (NbS) that conserve water, can sustain climatic stresses, produce food with high nutritive value but are good for nature are the need of the hour. The formal conceptualization defines nature-based solutions as *"actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"* (IUCN, 2016). NbS can often incorporate traditional knowledge and should ideally involve a wide range of stakeholders–in particular, local communities. Hence, nature-based solutions can be more broadly categorized as managed interventions to restore the environment or ecosystems specifically, by eventually having a positive impact on the local communities. ICARDA success stories in this regard relating to valuation of ecosystem services in Aral Sea Basin to improve agricultural water productivity in Central Asia, micro-catchment rainwater harvesting in West Asia, improving *khadin*-based systems in Rajasthan, conservation agriculture in North Africa, etc. will be presented in this lecture.

Keywords: Drylands, Ecosystem services, Rainwater harvesting, Water productivity

INVITED LECTURE

Innovations in rainwater harvesting technologies and their utilisation

Suhas P. Wani

Former Director, Research Program Asia & Director, ICRISAT Development Center, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Globally 80% of agriculture is rain-fed, whereas in India it is 55% which solely depends on rain and the management of rainwater must be innovative, efficient, science-based, scalable, and inclusive with proper and honest implementation of IWRM and not business as usual (BAU) for sustainable water management of water to meet the sustainable development goals (SDGs). In India, the growing population, increasing family incomes with associated social changes, increasing land degradation, and fragmentation, and water scarcity are further aggravated due to the impacts of climate change. Most populated India in the world with 1.36 billion people is already a water-deficient nation in 2013 with decreased per capita, water availability of 977 m^3 in 2010. In India by 2030, 51% of the population will be in the upper middle and high income as compared to 24% in 2020. Water scarcity could be physical, economic, or institutional. Globally about four billion people live under conditions of severe physical water scarcity. India receives half of 1150 mm of annual rainfall in just 15 days making floods and drought a fact of life in the country. India should not face a water crisis but it is the mismanagement of water resources particularly in agriculture that creates scarcity. Water stress is primarily a blue water issue, and large opportunities in managing rain-fed areas, (green water) need to be harnessed in the landscape. Only 0.27 billion people will face water scarcity against 6.5 billion facing blue water stress by 2050 if both green and blue water are considered. Freebies like free power supply adversely affect the efficient use of water resources. Water management must be the business of all stakeholders and a *carrot-and-stick approach* (punitive as well as rewarding measures) is urgently needed. Emphasis must be on integrated watershed management emphasizing efficient use of green water (soil moisture), rainwater harvesting, and its efficient use through drip, sprinklers, and information on when and how much water needs to be applied using IT-based solutions/Apps. The new paradigm of *"Fork to Farm"* overcoming the MSP culture is a must to transform agriculture in India. AER and market-based crop planning are a must. The knowledge delivery system (extension system) must be strengthened through MSMEs through digital agriculture to be promoted by the FPOs. Convergence of government schemes avoiding compartmentalization, linking with corporates through PPP, skill development, and extension services. Unified integrated and centralized IT platform for extension, inputs supply as well as marketing with responsibility and accountability with *plug-in* and *plug-out* options for the states. Researchers and extension staff must adopt a demand-driven approach rather than a supply-driven approach for providing integrated solutions to farmers' complex issues. Importantly, change of mindset of all actors from policymakers, research managers, administrators, editors of scientific journals, and scientists to promote demand-driven research and extension for the small farm-holders. It calls for changing evaluation parameters for the scientists, researchers as well as extension personnel to ensure that the majority of farmers get the needed extension support.

Keywords: Integrated watershed management, Rainwater harvest, Sustainable development goals

INVITED LECTURE

Managing poor quality water for Sustainable Agri-foods Systems

P. S. Minhas

ICAR–National Institute Abiotic Stress Management, Baramati, Pune, Maharashtra, India

Country has witnessed continuous surge in irrigation particularly a boom in aquifer withdrawals during the last five decade for sustaining food security. A typical scenario has emerged with groundwater development, i.e., arid and semiarid region facing scarcities of water are also generally underlain with saline ground water aquifers. Currently the excessive groundwater with drawls are necessitating for the utilization of non-conventional waters like the brackish groundwater, saline drainage water, and wastewaters. However, indiscriminate use of these waters and the absence of proper soil–water–crop management strategies pose grave risks to soil health and environment. Development of salinity, sodicity, and toxicity problems in soils not only reduces crop productivity and quality, but also limits the choice of crops. Their management signifies the methods, systems, and techniques of water conservation, remediation, development, application, use, and removal that provide for a socially and environmentally favorable level of water regime to agricultural production systems at the least economic cost. To minimize harmful effects of saline irrigation, remedial measures have been developed at the crop, root zone, farm, and district/basin levels. These include water quality driven conjunctive uses, chemical amelioration of soils and irrigation waters, mobilising native calcite through phyto-remediation, growing tolerant crops, and other specialised tillage, fertiliser use and irrigation practices. The integrated use of these component technologies is recommended for their economic viability under site-specific conditions. But on the whole possibilities have emerged to safely use saline waters otherwise designated unfit This has led to the replacement of too conservative water quality standards with site-specific guidelines, where factors like soil texture, rainfall, and crop tolerance have been given due consideration. Issues that require further attention include the utility of resource conservation technologies, simulation models to perceive their long-term impacts based upon ion chemistry of irrigation waters for typical agro-ecosystems, role of deficit irrigation/micro-irrigation techniques, feasibilities for non-food but economically viable crops, etc. Thus future investments are required for comprehensive programs like those were implemented on reclamation of alkali/saline lands by taking into consideration a range of factors, such as water availability and quality, land-use options and strategy, and national strategies for climate change management and national water and food security priorities.

Keywords: Brackish water, Conjunctive use, Salinity, Sodicity, Soil amendments

KEYNOTE LECTURE

Soil health enhancement for sustainable agriculture production

Brahma S. Dwivedi[1*], Siba P. Datta[2] and Sanjib K. Behera[2]

[1]Agricultural Scientists Recruitment Board, Krishi Anusandhan Bhawan-I, Pusa, New Delhi-110 012, India
[2]Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal-462 038, Madhya Pradesh, India

With the recognition of the fragility of natural resources, public interest in soil health has increased tremendously throughout the world. It is now increasingly understood that the health of soil is closely linked with the health of other living beings inhabiting the planet, and thus indivisible from the well-being of the society. In fact, a decline in the health of soil and other natural resources is considered one of the most important second generation problems of post-Green Revolution era threatening sustenance of agricultural production. Restoration and enhancement of soil health assumes tremendous significance across the world, more so, in the developing countries due to ever-increasing population pressure on finite land resources. The challenge is much bigger in India, as it supports over 16% of the global population through only 2% of the world's geographical area. The per capita land availability continuously decreased from 0.34 ha in 1951-52, to 0.14 ha in 2012-13, which is likely to come down further. The health of Indian soils got deteriorated over the years, as evident through depletion of soil organic matter, emergence of multi-nutrient deficiencies, expansion of area under salt-affected and acid soils, and soil compaction. Excessive removal of nutrients by crops and their inadequate replenishment led to widespread deficiencies of at least six nutrients *viz*. N, P, K, S, Zn and B in Indian soils along with sporadic deficiencies of Fe and Mn. Besides, soil erosion continues to be the major land degradative process, and soil pollution is emerging as a new challenge. Vagaries of climate change are likely to further aggravate the pace of soil health deterioration. Most of the soil health ailments could be effectively addressed though judicious management. There is need to precisely monitor the existing and the emerging soil health problems, and generate holistic solutions through multi-disciplinary research adopting advanced tools and techniques. Scientific literature frequently underlined benefits of restoration of degraded lands, precision nutrient management, integrated use of organics and fertilizers, conservation agriculture, integrated farming systems and land use planning as important soil management options. A better understanding of soil biodiversity and biological processes may help harnessing the same to develop low-cost and eco-friendly soil management options. Enabling policy support and investment would be inevitable to ensure faster development, dissemination and adoption of the technology recommendations.

Keywords: Conservation agriculture, Land degradation, Multi-nutrient deficiency, Soil biodiversity, Soil organic matter

KEYNOTE LECTURE

Agroforestry: A nature-based solution for mitigation and adaptation to climate change

B. Mohan Kumar*

Former Vice-Chancellor, Arunachal University of Studies, Namsai, Arunachal Pradesh, India;

Anthropogenic climate change driven by the rising atmospheric CO_2 concentrations is the most important environmental problem of the planet today. India, the third-largest contributor to anthropogenic C emissions and energy consumption in the world after China and the United States, has committed to achieving net-zero emission targets by 2070. The country's total greenhouse gas (GHG) emissions, however, have been increasing almost linearly from 746.5 Mt CO_2-equivalent in 1970 to 3375 Mt CO_2-e in 2019, with the energy sector contributing ~75 % (2,129,428 Gg CO_2-e). Nature-based solutions such as agroforestry are increasingly being considered relevant for combatting the rising atmospheric CO_2 levels. Climate change mitigation and adaptation through agroforestry involve mechanisms such as (1) *Carbon sequestration*, (2) *Carbon substitution,* and (3) *Carbon conservation*. Agroforestry also plays a significant role in lowering the vulnerability of agricultural production systems by imparting enhanced resilience. To achieve carbon neutrality, India needs to cut GHG emissions primarily from the energy sector. GHG emissions from land use, livestock management, and food waste also must be reduced, besides sequestering C and offsetting emissions through biomass substitution of fossil fuels. Carbon sequestration (CS) through afforestation and reforestation gained popularity as a form of offset activities in the context of the Land Use, Land Use Change, and Forestry (LULUCF) approach of the Kyoto Protocol. The aboveground C stocks of agroforestry systems (AFS) in India ranged between 0.23 and 23.55 Mg C ha^{-1} yr^{-1} while CS belowground (roots) ranged from 0.03 to 5.08 Mg C ha^{-1} yr^{-1}. The soil C stocks in AFS (0-100 cm depth) in India, varied from 10.02 Mg C ha^{-1} for the *Ziziphus mauritiana*+grass system in the arid western Rajasthan to 229.5 Mg C ha^{-1} in the HGs of Mizoram. *The 4 per mille initiative* adopted at the COP21 in Paris is an attempt to lower atmospheric CO_2 levels and improve crop productivity by increasing the soil carbon stocks by 4 per 1000, or 0.4 % annually. Agroforestry also can serve as stepping stones and refuges for biodiversity conservation. In fact, more than 90 % of the biodiversity resources are found in human-dominated tropical landscapes (*biodiversity coldspots)*. Floristic diversity of Kerala homegardens was high (753 species along a transect from the sea coast to the mountains) and it included 43 IUCN Red-Listed species, making homegardens *circa situm* reservoirs of biodiversity. Agroforestry systems thus offer win-win, nature-based solutions to CS and biodiversity conservation.

Keywords: Biodiversity coldspots, Carbon conservation, Carbon sequestration, Carbon substitution, Homegardens

INVITED LECTURE

Carbon farming opportunities and action plan towards achieving SDGs in India

Ch. Srinivasa Rao*

Director, ICAR-National Academy of Agricultural Research Management, Hyderabad-500 030, Telangana, India

Indian population has recently surpassed (>1.43 billion) the China. Consequently, achieving zero-hunger by 2030 would become a greatest challenge for India. As per NRSA & NAAS 2010 report, about 120.72 Mha of land has been degraded which includes 104.19 Mha arable land and 16.53 Mha open forest land. As a result, almost 67% of the states of India are low (<0.5%) in soil organic carbon (SOC) which are being unsuitable for food production. The UN Sustainable Development Goals (SDG) Goal 15 has the target to achieve a Land Degradation Neutral (LDN) World by 2030. India also took a pledge at international climate negotiations to create additional carbon sink of 2.5–3 billion tonnes of CO_2 through additional forest cover by 2030 in India. Carbon farming (CF) opportunities in *carbon sequestration/storage* (zero-tillage; cover crops; green manuring; novel materials like biochar and tank silt; agroforestry, integrated farming system (IFS); organic farming; subsoiling, large-scale plantations etc.), *carbon emission reduction* (integrated nutrient management; fallow management; avoiding residue burning; recycling organic wastes etc.) and *carbon emission restriction* (renewable energy; clean energy industries; production of high-efficiency appliances etc.) collectively helps to achieve the SDGs in India. Nevertheless, there are several challenges in carbon farming such as landholders' interests, unsuitable land features, inadequate skills, management abilities, political instabilities, higher administrative expenses etc. In order to encourage farmers to use CF technologies, knowledgeable advising services, reliable soil test, identifying the challenges and solutions on local basis, incentives and subsidies for carbon farming farmers are pivotal to ultimately attain the goals of sustainable agricultural productivity and soil management. Policy and programmes with long-run investments required to identify and implement appropriate CF techniques through collective decisions with participation of government and NGOs, researchers, with community participation as a central focus.

Keywords: Carbon sequestration, Climate adaptation, Programs, Policies, SDGs, Technologies

INVITED LECTURE

Microbiome-based approaches for sustainable agriculture

Podile, A.R.*, Danteswari, Ch., Sarma, P.V.S.R.N. and Anirban Basu

Department of Plant Sciences, University of Hyderabad, Hyderabad – 500046, Telangana, India

Agricultural systems are at a critical juncture, grappling with the need to simultaneously address the challenges of food security, environmental degradation, and climate change. Nature-based solutions (NbS) offer a promising avenue to meet these challenges by harnessing the power of natural processes and ecosystems. Microbiome-based approaches, rooted in the study of microbial communities inhabiting agricultural ecosystems, have emerged as a key component of NbS. Microbiome-based approaches capitalize on the intricate relationships between plants, soil, and microorganisms. By elucidating the composition and functions of microbial communities, these approaches contribute to improved soil health and fertility, enhancing nutrient cycling and reducing the reliance on synthetic fertilizers. Crucially, microbiome research aids in enhancing crop resilience against diseases and climatic stressors, thereby bolstering the adaptive capacity of agri-food systems in a changing climate. Additionally, the application of microbiome-based approaches aligns with regenerative agricultural practices, promoting sustainable land management, carbon sequestration, and ecosystem restoration. Our ongoing research on the microbiomes of pigeon pea, groundnut and little millet has uncovered a multitude of relationships between the composition of the root microbiome and several soil edaphic variables. The microbiome of wild seed exhibits significant differences when compared to its cultivated crop species in the context of pigeon pea and groundnut. We also observed that the crop wild progenitors, originating from various locations, exhibit a diversified ancestral microbiome, in the case of little millet. Dominant bacterial phylotypes only responded to soil chemistry, whereas higher trophic levels within the soil compartment, such as protists and invertebrates, were notably influenced by climate conditions. Our work on application of synthetic communities derived from root endophytes of pigeonpea improved the survival rate of the plants under various abiotic conditions. As microbiome research advances, a more nuanced understanding of these interactions will be pivotal for optimizing plant-microbe associations and harnessing their benefits for agriculture and ecological restoration.

Keywords: Groundnut, Little millet, Microbiome, Pigeon pea

KEYNOTE LECTURE

Addressing nutritional security through natural resource management

Suresh Kumar Chaudhari

Deputy Director General (NRM), Krishi Anushandan Bhawan-II, Pusa, New Delhi-110001, India

Natural Resource Management plays a significant role in achieving food and nutritional security amidst declining soil health, increasing input cost/cost of cultivation, land degradation and climate change. Food insecurity, non-availability of food and nutrient deficient food grains lead to chronic malnutrition in human. Therefore, it is essential to prioritize and implement sustainable soil management practices across different landscapes to ensure food and nutritional security in the country. In India, widespread occurrence of nutrient deficiency have direct impact on animal and human health through food chain. For achieving nutritional security, several NRM strategies namely agronomic manipulations/crop diversification, bio-fortification, balanced nutrient application (including micronutrients), conservation agriculture, regenerative agriculture, organic farming, sustainable resource management have been discussed in this chapter. Similarly, developing and implementing soil governance and legal frameworks and policies at global, regional and national level is the need of the hour. Depletion of nutrients takes place when the removal being done continuously but replenishment has not been done properly. The main reasons for the depletion includes, erosion, removal from vegetation cover, monocropping system, high nutrient demanding crops, use of excess of fertilisers, weed flora, oxidation, mineralisation, leaching, removal of residues etc. Thus, their replenishment is quite necessary. The One Health concept has gained recognition and support from various organizations, including the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organization for Animal Health (OIE). By embracing the One Health approach, it is possible to improve disease surveillance, response, and prevention strategies, leading to better overall health outcomes for humans, animals, and the environment.

Keywords: NRM, Nutritional security, One Health concept, Sustainable soil management practices

INVITED LECTURE

Nature-based soultions for climate resilient agriculture: Embracing the 5A approach

Indira Sarangthem[1]*, Lokesh K, Mishra[1] and Shravan M. Haldhar[2]

[1]Dean, College of Agriculture, Iroisemba, Central Agricultural University, Imphal, Manipur, India
[2] Associate Professor, College of Agriculture, Iroisemba, Central Agricultural University, Imphal, Manipur, , India

Nature-based solutions (NBSs) are at the forefront of sustainability debate as the United Nations Decade on Ecosystem Restoration commences. These comprise a wide range of methods that can be used in modeling various integrated approaches for ensuring agri-food security and simultaneously addressing the environmental concerns. In this regard, the design and establishment of multidimensional *"5A approach" comprising Agriculture, Apiculture, Aquaculture, Agro-forestry and Animal Based Farming* as NBSs opens up a portfolio of eco-innovative rational options, which is scalable and adaptable by farming communities thus offering a realistic and promising path towards climate resilient agricultural practices. The focus of this work is to explore the potential role of the "5A approach" as Nature-based Solutions in assuring a sustainable agriculture production system in the modern day. This work specifically aims to expose application options for the "5A approach" in various areas of the agri-food supply chain, establish links with societal concerns, future challenges, and perspectives and analyze potential adoption by farmers. The paper hypothesizes that "5A approach" simultaneously addresses the sustainability variables and the concerns regarding "how and where we produce our foods" that significantly impact the diversity of the available diet on our food plate. Embracing the "5A approach", as NBSs, addresses five vital aspects involved in agri-food chain right from the seed sowing stage to the serving of food on the consumers' plate. These are: (1) Sustainable practices with a focus on production; (2) Use of nature friendly methods for soil and water conservation; (3) Amelioration – for restoration of conditions for plants, water, soil, or air, as well as climate change mitigation; (4) Conservation – with a focus on biodiversity and ecosystem connectivity; and (5) Food diversity that may promote human health. The strategy bridges the traditional barrier between productivity and conservation, providing farmers who choose the 5A approach with utility, purpose, adaptability, and scalability.

Keywords: 5A approach, Diet diversity, Nature-based solutions, Sustainability.

INVITED LECTURE

Criticality of soil and water in one health approach

Anil Kumar Singh[1*] and Arvind Kumar Shukla[2]

[1]National Academy of Agricultural Sciences, NASC Complex, DPS Marg, New Delhi-110012, India
[2]Rajmata Vijayaraje Scindia Krishi Vishva Vidyalaya, Gwalior-474002, Uttar Pradesh, India

One health approach emphasizes on the interrelationship between plant-animal-human-environment health and has received considerable attention recently for varied reasons. However, the role of soil and water in this continuum has not received the attention due. In agricultural production systems, soil, water and agro-chemicals (fertilizers) play a critical role and the way they are managed affects plant health with spill over impacts on animals (including fisheries), human health and environment (GHGs emission). Emphasis on NPK and unbalanced fertilizer application has resulted in micronutrient deficiencies. Element-wise deficiency reported is Zn (36.5%), Fe (12.8%), Cu (4.2%), Mn (7.1%), and B (23.4%). Mo deficiency while Al toxicity (not an essential element) has also been observed sporadically in acid soils. This has been reflected in an unenviable record for India, a food exporting nation, having the largest population of malnourished children and anemic women. Micronutrient application has not only contributed in enhancing the food grain production but also helped in sustaining soil health and fortifying the country's nutritional security. Food and fodder produced on these soils without supplementation of deficient micronutrient(s) have resulted in malnutrition in animals and humans alike. Many diseases in humans and animals are linked to these micronutrient deficiencies. In case of micronutrients, sometimes the difference between deficiency and toxicity levels is narrow e.g. B. Obviously optimum management has to consider this aspect. Nitrogenous fertilizers are used extensively for crops and their application has been continuously increasing to feed the billions. Excessive use with low use efficiency is resulting in wide spread contamination of ground water, water bodies and emission of nitrous oxide, a GHG more hazardous than methane. In the mid-1940s and 1950s, blue baby syndrome was discovered. The cause was use of nitrate-contaminated water in preparing infant food. Industrialization, urbanization, life style changes and dietary habits of the continuously increasing population are resulting in huge volumes of polluted water, most of it untreated, entering the natural ecosystems. Increase in water borne diseases like diarrhea, is a consequence of lack of adequate treatment and disposal. Arsenic poisoning in animals and humans, which is considered carcinogenic and widespread, is a result of excessive use of ground water for irrigating rice. Unregulated use of waste waters in peri-urban agriculture has resulted in heavy metals like Cd, Cr, Pb entering the food chain affecting plants, animals and humans. This paper highlights the importance of a holistic approach to address this complex issue.

Keywords: Deficiency, Micronutrients, One health, Toxicity, Water

KEYNOTE LECTURE

AIIA (Assimilate, Interpret, Innovate and Adapt) Model in *Smart Agriculture*

J. Adinarayana*

Professor, Centre of Studies in Resources Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India

Food security Vs climate change necessitate amendment of the existing tried-and-tested technologies employed in agriculture with a substantial quotient of innovativeness. One such innovation is adapting cutting edge technologies in Precision Agriculture (PA). However, understanding highly non-linear and stochastic behaviour of the parameters associated with agricultural automation and research requires capturing dynamic to real time data from several diverse sources. While making PA smarter (Smart Agriculture), emphasis will be more on capturing data and interpreting them using novel sensing platforms to make farm operations more intelligent, predictable and efficient (assimilate, interpret and adapt – AIA model). This includes critical human and physical infrastructures such as proximal ground agro-environmental sensors and its enabled IoT, AIML, low-orbital spatial platforms, etc. This AIA model can be enhanced to a dynamic AIIA (assimilate, interpret, innovate and adapt) smart agriculture model with the adoption of (i) systems-approach in the Earth's outer skin, called critical zone (often defined from bedrock to treetop) and (ii) employing an ensemble of Agile and CI/CD (Continuous Integration/ Development) techniques. Thus, AIIA model requires with the use of disruptive sensing systems/platforms and its enabled technologies such as cloud infrastructure and exploratory data analysis under the premise of Big Data, data standards for better data and knowledge discovery for better *GeoFarmatics* and decision making. In this talk, a few major disruptive technologies/ platforms such as IoAgTs, Omics, AIML, Big Data analytics, UAVs, etc. will be investigated. The talk also covers on how these disruptive technologies are leveraged with agriculture systems to make contemporary agriculture more automated (digital) and smart (innovative) that helps to improve informatics culture and for taking informed decision making. A few novel systems/platforms/ pipelines will be showcased with a new paradigm of SMART (Scientific, Marketable, Affordable, Reliable and Time-saving) infrastructure in the SA through interdisciplinary and consortium-based projects carried out at Agro-Informatics Lab of CSRE, IIT Bombay.

Keywords: Critical infrastructure, Critical-zone, Disruptive technologies, Smart Agriculture, Systems-approach

INVITED LECTURE

Digital agriculture for agri-food systems disruption in India- Prospects and problems

E. V. S. Prakasa Rao

CSIR-Fourth Paradigm Institute, NAL Wind Tunnel Road, Bengaluru-560037, Karnataka, India

Digital Agriculture (DA) is a recent development in India and promises a paradigm shift in the agri-food systems. Digital technologies pervade agri-food systems-farmer, input/technology provider, governance, consumer. DA uses remote sensing, IoT, drones, cloud computing, big data analytics, AI, image processing, blockchain, robots. It covers land and resources, farm inputs, Farming as a Service (FaaS), food products, marketing, finance, insurance. It has a potential to improve the agri-food value chain and transparency to benefit all the stakeholders. It needs an ecosystem of linkages among science-government-private sector, farmers. The flow of DA includes data collection, integrated modelling and analytics, connectivity, delivery and control, public-private sectors, equity and ethics. The digital transformation in the agri-food value chain involves data analytics for farm, farmer information system, digital warehouse solutions, digital buying platform, digital consumer engagement. From the current systems approach in digital agri-food sector, systems of systems have to evolve to meet the growing challenges of agri-food sector. Indian government has taken several progressive steps in the digitization of agri-food sector. Emerging technologies such as generative AI, Digital Twins, signal processing algorithms for image analytics, robotics, variable rate application (VRA), on-farm experimentation methods, recyclable sensors, 3-D printing of foods, AI in circular agri-food bioeconomy, electronic patches for detection of biotic and abiotic stresses and many others need validation and translation to viable economic models. Realization of big data in agri-food sector has been underutilized; it is constrained by optimum utilization of available data and completeness of data, quality and standardization of data, interoperability. Equity and ethical issues of DA have not received much attention. Data privacy, data ownership, cyber frauds, monopoly of data, societal engagement, research policy and funding, public narratives of DA, profit sharing mechanisms, capacity building, DA in times of conflicts and natural disasters, digital infrastructure, south-south collaborations, public and private investment will need much attention to take forward the new paradigm of digital agri-food systems in India. Digital agri-food systems could help meet the Sustainable Development Goals (SDGs) of the United Nations- 1,2,5,9,12,13.

Keywords: Agri-food sector, AI, Data infrastructure and ethics, SDGs, System of systems

KEYNOTE LECTURE

Artificial Intelligence systems for agriculture

Sanjay Chaudhary

Professor and Associate Dean, School of Engineering and Applied Science, Ahmedabad University

Although over that past half century significant progress has been achieved in reducing hunger and poverty as well as improving food security and nutrition, in the process we have observed serious degradation of the natural resources including soil, water, biodiversity etc. Climate change is another huge and complex challenge to food security for ever increasing population. It is high time to concentrate and focus on sustainable and regenerative food production systems. There are various technologies which can help to capture big data in real-time manner and provide useful advisory services for effective farm and resource management. More and more innovative applications using Data Science, Big Data Analytics, Artificial Intelligence, Remote Sensing, Internet of Things, Computer Vision, Machine Learning and Cloud Computing are emerging for various domains. We need to look at and expand the technologies that will help create efficient agricultural systems that are economically, socially, and environmentally sustainable. The talk will address how concepts of Artificial Intelligence can be used to develop intelligent systems to solve agricultural problems.

Keywords: Artificial Intelligence, Big Data Analytics, Cloud Computing, Intelligent systems, Remote sensing

INVITED LECTURE

Artificial Intelligence: Case studies in Indian agriculture

Alka Arora, Chandan Kumar Deb, Sudeep Marwaha and Rajender Prasad

ICAR-Indian Agricultural Statistics Research Institute (IASRI), New Delhi, India

The agriculture sector plays a pivotal role in the economic growth and food security of nations across the world. With the increasing global population and the need for sustainable agricultural practices, there is a growing demand for efficient and innovative approaches in agriculture. The emergence of Artificial Intelligence (AI) and other cutting-edge technologies presents a significant opportunity to transform the agriculture sector and address its challenges. In this paper, we are presenting some case studies with applications of AI in Indian Agriculture.AI techniques are applied to measure and analyze plant phenotypic traits and these models achieved high precision aiding in crop improvement. SpikeSegNet- a deep learning-based encoder-decoder network has been developed for spike identification and counting with 98% accuracy. A model named "PanicleDet" based on YOLOv5 accurately identifies critical stages in rice panicle development, outperforming other detection models. m—Senescencica applications has been developed for senescence classification and quantification using machine learning models. Developed "SlypNet" model, using advanced deep learning networks, extracts plant morphological features with high precision, contributing to yield estimation. AI models aids in non-destructive counting of siliques in Indian mustard and leaf counts for rice plants, facilitating genotype categorization and improving plant phenotyping. In the realm of Plant and Animal Disease Diagnosis, there are notable case studies involving AI-DISC (Artificial Intelligence Based Disease Identification for Crops) and AI-DISA (Artificial Intelligence Based Disease Identification in Animal), mobile applications designed to tackle diseases in crops and livestock using artificial intelligence. Substantial dataset of around 1.4 lakh images was collected in three years, through collaborations with State Agricultural Universities and ICAR Institutes. The core of AI-DISC revolves around model development, employing advanced deep learning models such as GoogleNet, EfficientNet, and DenseNet, specifically tailored for classifying various crop diseases. These models exhibit impressive testing accuracy, ranging from 95% to 98%. AI-DISC currently covers 19 crops and 50 diseases. AI-DISA, an upcoming AI-powered mobile app, focuses on livestock disease classification and presently offers detection capabilities for three bovine diseases. It experimented with different variants of YOLO, with YOLOv5m outperforming others. These models, built through deep learning techniques, are deployed on a NVIDIA GPU server infrastructure, enabling convenient access and image analysis through the mobile app. In conclusion, the discussed case studies underscore the substantial influence of Artificial Intelligence (AI) in the fields of Plant Phenomics and Plant and Animal Disease Diagnosis. AI's integration into agriculture offers immense potential to boost productivity, minimize environmental impacts and advocate for sustainable farming methods. Through AI, farmers can base their decisions on data, enhance crop yields, optimize resource usage such as irrigation water, and play a pivotal role in ensuring global food security. Thus, the incorporation of AI into agriculture stands as a promising avenue to revolutionize the industry and usher in a more sustainable and resilient future.

Keywords: Artificial Intelligence, Disease diagnosis, Plant Phenomics, Sustainable farming

INVITED LECTURE

Opportunities and challenges in application of AI in building innovative climate smart digital agriculture solutions

Satyajit Dwivedi

Regional Director, EMEAP, SAS

The intersection of Artificial Intelligence (AI) and digital agriculture presents a transformative potential for creating innovative, climate-smart solutions to address the challenges of modern farming in the context of climate change. This paper delves into the opportunities and challenges of applying AI in the development of such solutions. The integration of AI technologies into agriculture offers opportunities to revolutionize traditional practices. AI-driven data analysis can provide cost effective solutions for irrigation management integrating real-time weather information, soil conditions, and crop health, enabling farmers to make informed decisions that optimize resource use and increase productivity. Machine learning algorithms can predict crop water requirement in advance aiding in the adoption of adaptive strategies to mitigate the impact of climate change. Furthermore, AI-powered automation integrated with remote sensing data with proper calibration can minimize deployment of costly sensors and streamline labour intensive tasks, leading to efficiency gains and scale. While the potential is immense, challenges to build and deploy AI driven solutions are many. Access to accurate and localized data is crucial for AI systems Addressing data gaps and connectivity issues remains a hurdle. Machine Learning techniques have been used for detection of data anomalies and imputation of missing value to enrich the data quality. A comprehensive data quality process for application of AI models for climate smart agriculture is absent. The overall data to decisioning process including AI modelling requires lifecycle management, capacity building among farmers and business stakeholders using social network frameworks. Ethical considerations such as data privacy and algorithmic bias must also be carefully navigated to ensure equitable outcomes. In this paper, a comprehensive data quality process to enhance the accuracy of the models and a social network based agromet advisory framework for effective roll out of climate smart digital agriculture solutions.

Keywords: Algorithmic bias, Artificial Intelligence, Data privacy, Machine learning algorithms, Smart digital agriculture solutions

INVITED LECTURE

Biofortified food commodities for achieving sustainable development goals (SDGs)

Anjani Kumar

International Food Policy Research Institute-SAR, New Delhi-110012, India

India ranks 107th among 121 qualifying nations in the recently published 2022 Global Hunger Index. It says that India suffers from a level of hunger that is serious and hence demands immediate attention and action by both centre and state governments, and this is required not just for humanitarian reasons but also for developmental ones. Besides food nutritional insufficiency at the household level, a large part of the Indian population suffers from micronutrient deficiencies, also known as "hidden hunger." Micronutrient deficiencies are often the cause of increased mortality and morbidity and of increasing the health burden on the nation. Apart from the wellbeing of the citizens, micronutrient malnutrition negatively affects overall productivity and development of any nation. Rightly, controlling micronutrient malnutrition has become a priority for the Indian policymakers. Bio-fortification presents an alternative that can not only improve the nutritional content of the staple foods poor people already eat but is also comparatively inexpensive, cost-effective, sustainable, and long-term means of delivering more micronutrients to the poor. Substituting biofortified cereal varieties for conventional ones has the potential to increase micronutrient intakes meaningfully. The biofortified food commodities can play a pivotal role in accomplishing the sustainable development goals. This paper examines the role of biofortified commodities to address the challenges of micronutrient deficiencies in India. Our analysis shows that if existing varieties of rice and wheat can be replaced by biofortified varieties, zinc and iron intake would increase substantially (by about 33 percent). The acceleration in the adoption of biofortified varieties needs an integrated approach which include development of an efficient seed distribution mechanism, effective procurement system and inclusion of biofortified food commodities in the comprehensive food distribution system.

Keywords: Biofortification, Malnutrition, Procurement, Public distribution, Seed distribution

INVITED LECTURE

Sowing sustainability: G20's vision of Agri-food Transformation for One Earth, One Family, One Future

Smita Sirohi* and Sulakshana Rao

Ministry of Agriculture and Farmers Welfare, Government of India, Krishi Bhawan, New Delhi-110 001, India

The development paths of high-income countries (HICs) cannot be replicated by low- and middle-income countries (LMICs), as the conditions that enabled HICs' success are no longer available. These paths are also unsustainable, with prevailing agricultural practices threatening agrifood systems, causing biodiversity loss, and increasing hunger. Ensuring global food security, a crucial component of Sustainable Development Goal 2 (SDG 2), has faced setbacks in recent years. The challenges posed by the COVID-19 pandemic, cross-border conflicts, and the ongoing climate crisis have further intensified the hunger and malnutrition crises, compounding the difficulties faced by low- and middle-income countries (LMICs) in their pursuit of development. With just seven years left to achieve the zero hunger SDG, the situation in 2030 is expected to mirror that of 2015. Changing this trajectory is crucial, as continuing the status quo will lead to irreversible consequences. However, altering course is challenging due to trade-offs between short-term gains and long-term sustainability. Achieving a fair transition, where those who can bear the costs support affected parties, is essential but difficult. In light of the need to change the current trajectory to avoid irreversible consequences, it becomes evident that addressing this challenge requires a multifaceted approach and ongoing efforts. Many countries and international organizations are dedicated to building resilient food systems, but the magnitude of the issue demands a sustained and comprehensive response. The potential for transformative actions is influenced by current and future preferences in political economy dynamics, emphasizing the need for stakeholders to understand and navigate these dynamics effectively. The G20, comprised of major economies with significant influence in agriculture, stands in a unique position to spearhead the development of sustainable, equitable, and resilient agriculture and food systems worldwide. Recognizing this shared responsibility, the G20 nations, under the Indian Presidency, have made resolute commitments to strengthen global initiatives aimed at improving food security and nutrition on a global scale. Drawing upon G20 policy documents and international agreements, this paper explores the G20's strategic objectives in redefining agri-food systems. This paper serves as an elucidation of the pivotal outcomes arising from the G20's engagements in the agricultural sector. It underscores the importance of these outcomes and their implications for the broader landscape of global agriculture and food security. Furthermore, it delves into the critical research and policy imperatives necessary to foster a sustainable transformation of the Indian agriculture sector.

Keywords: Agri-food Systems, Food Security, Global Challenges, G20 leadership, Sustainable development

Theme 9: Policies and Institutions for Transforming Agri-food Systems
Technical Session 1: Food System Transformation: Role of Policies and Institutions

INVITED LECTURE

Economic analysis of diversification of food diets through social safety net programs

Surabhi Mittal[1]*, Dylan Walters[2] and Mini Varghese[3]

[1] Economist-Asia, Health Economic Unit, Nutrition International, Asia Regional Office, New Delhi – 110 016, India
[2] Project Director, Health Economic Unit, Nutrition International, Asia Regional Office, 180 Elgin Street, Suite 1000, Ottawa, ON, K2P 2K3
[3] Country Director-India, Nutrition International, B-28, 2nd Floor, Qutab Institutional Area, New Delhi – 110016, India

In India, Social Safety Net Programs (SSNPs) like Public Distribution System (PDS), PM-POSHAN and Integrated Child Development Scheme (ICDS), are a one-stop platform to meet a significant portion of the daily dietary requirements of the most vulnerable households, who also complement these meals through food purchased from markets and their own production. While staple foods continue to remain the focus of the PDS platform, there is a significant opportunity to leverage PM-POSHAN and ICDS for greater nutritional outcomes through a more diverse basket of nutritious food. Nutrition International carried out a series of analyses (public health and nutrition (PHN), economic, platform and political) that aimed to develop a set of recommendations and options for the government to consider in terms of the most feasible path for pursuing diet diversification with the goal of reducing the nutrition gap. The objective of the economic analysis was to estimate the cost of diversifying and to identify which of the meals options recommended by PHN analysis are most feasible from the perspective of cost, consumer preference and availability. The analyses were undertaken separately for each of the population groups– pregnant women, lactating mothers, children between seven months to three years, and children between four to six years under the ICDS, primary and upper primary school children under PM-POSHAN and beneficiary households of PDS. The Economic Analysis estimated the cost of a diet (meal per day per beneficiary) for each of the population group under different diet and policy scenarios. Further the economic feasibility of these scenarios was analyzed based on the current budget of the SSNPs. The study found that in Telangana, there is an opportunity to diversify food baskets and meals by introducing millets, a variety of pulses and food groups like milk, fruits, and green leafy vegetables under ICDS and PM-POSHAN. Although there is low economic feasibility of diversified diets given the current budgets. To meet the goal of reducing nutritional gaps an increase in additional financial allocation will be required. 15-20% increase in budgets will be required to achieve the minimum diet diversity under SSNPs. For diet diversification to be successful, it is critical to align it with local preferences and availability. This, combined with awareness raising and nutrition literacy among beneficiaries, can together meet long-term goals of nutritional security. Though, the key challenge to diversifying will be in balancing the demand for diversified foods with their availability and planning for required investments to meet budgetary gaps.

Keywords: Cost of diet, Diet diversification, Nutrition, Social safety net programs, Telangana

INVITED LECTURE

Transforming food systems in marginal environments: Strategies and implications

Shalander Kumar* and Jat, M. L.

International Crops Research Institute for the Semi-Arid Tropics, Patancheru-502 324, Hyderabad, India

Food systems worldwide are facing multifaceted challenges due to rapid population growth, environmental degradation, and climate change. The marginal environments, characterized by low agricultural productivity, asset poverty, inequities, high market risk and poor governance and high vulnerability to climatic variability and change, pose unique and pressing challenges for ensuring food security and sustainability. Food systems' inability to produce enough nutritious food to feed a growing population equitably, and the negative impacts of food systems on the environment and natural resources under climate change are of immediate concerns. Finding creative ways and alternative development pathways are needed to ensure that people have enough nutritious food under these riskier environments. This paper provides key insights and strategies for transforming food systems in such marginal environments. It highlights the critical importance of addressing the complex interplay of socio-economic, ecological, and technological factors to achieve sustainable food security. Firstly, we discuss the significance of understanding the specific characteristics and vulnerabilities of marginal environments. Moreover, recognizing the diversity within marginal environments is vital, as the strategies for transforming food systems must be tailored to local conditions and cultural contexts. Secondly, we explore innovative and sustainable agricultural practices and technologies that can enhance productivity and resilience in marginal environments. Regenerative agriculture approaches, digital innovations, and carbon farming hold promises for mitigating the challenges posed by climatic change. Integrating traditional knowledge systems with modern techniques can also enhance the sustainability of agricultural practices. Thirdly, we delve into the role of policy frameworks and governance structures and institutional innovations in supporting the transformation of food systems in marginal environments. Enabling policies are essential to incentivize sustainable practices, promote equitable access to resources, and foster resilience-building initiatives. Furthermore, we argue to make a strong case for promoting local food systems in view of increasing shocks and high rate of malnutrition. Investments in sustainable agriculture can create employment opportunities, improve income distribution, and strengthen local economies. Lastly, we emphasize the need for a holistic approach that considers the interconnectedness of various elements within food systems, including production, distribution, consumption, and waste management. To achieve meaningful transformation, interventions should be integrated across these domains, promoting circular economies, and minimizing food waste. The policy planning and action need to have as a long-term perspective looking at trade-offs and synergies considering the fragility and potentially increasing shocks in these regions.

Keywords: Climate resilience, Local food systems, Nutrition sensitive, Systems approach

INVITED LECTURE

Changing pattern of demand for agri-processed commodities in India

Seema Bathla

Professor, Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi-110 067, India

With rising incomes, urbanisation, and integration of domestic and global markets, the demand for high-value agricultural crops such as fruits and vegetables, dairy products, chicken, and fish has witnessed a significant increase over the years. This research examines the consumption patterns in India to understand the trends in the food system, and their impact on the composition of food trade and scale of the food processing sector. The analysis is undertaken from 1993 to 2020 based on the NSS and CMIE data on household consumption expenditure, GoI-National Accounts Statistics data on gross domestic product (GDP), FAO data on export and import, GoI-NSS unorganised food-beverage enterprises and ASI organised industry data at NIC three-digit level. The preliminary analysis reveals the following. First, food constitutes 45 to 50% share in total expenditure of households. The major shift in the food basket is away from cereals towards primary processed fruits-vegetables-dairy products, and highly processed foods (pasta, juices, noodles), edible oils, and eating in restaurants. Notably, the structure and composition of expenditure on food has altered more in the urban areas than that in rural areas. Second, the composition of India's food trade, though changed over the years, shows concentration in primary food exports (basmati rice, oilseeds, meat) and stagnancy in the value-added processed items. Not much change is seen in imports, except in the case of processed palm oil and edible oils, implying a greater dependence on domestically produced food. Third, the food processing industry has undergone a structural change and is able to cater to consumers' demand for diversified products. While the organised food-beverage sector has shown a decelerating rate of growth in the real gross value added per factory over the years, growth in the unorganised sector has doubled (4.33% per annum) during 2010/11-2015-16 over 2000/01-2010/11. There is higher growth in the processing of fruits-vegetables; animal-vegetable fat and oils; other food products; and prepared animal feeds. Fourth, a growing food consumption and dietary transition has led to 4.78 percent growth in GDP per annum in the overall food-beverage-tobacco industry during 2011-12 to 2021-22. However, the share of processed food in the national income remains low at 1.7 percent compared to 15.7 percent share of agriculture and allied activities. Based on these findings, we draw key policy implications to strengthen the agri-value supply chains and post-harvest management practices, which allow better synergies between agriculture and industry to increase their global competitiveness.

Keywords: Agriculture policy, Consumption expenditure, Food trade, Food processing industry

INVITED LECTURE

Marketing channels and market prices: Evidence from high-value crop producers in India

Ashok K. Mishra

Morrison School of Agribusiness, W. P. Carey School of Business, Arizona State University, 7231 E Sonoran Arroyo Mall, Tempe, AZ 85212, USA.

The early 1990s saw the economic liberalization of the Indian economy. The wave of globalization also encouraged reforms in the agricultural sector, including credit institutions, trade, access to technology, and the increasing role of the corporate sector. Smallholders cultivating fruit and vegetables receive less than 20% of the consumer price. Other studies confirm that farmers' share in the consumer price is quite low, and private marketing networks could benefit the smallholders. Indeed, in the first decade of the 21st century, structural transformation in agri-systems paved the way for organized food processing and retailing, input service providers through an innovative model of Rural Business/Service Hubs. In developing countries marketing of fresh agricultural products is severely challenged due to lack of access to markets, network of transportation and storage facilitates. Over the past decade the Indian government has stepped up efforts to provide smallholders with marketing outlets, including contracting firms and government-supported outlets like "Mandis." This study examines the choice of marketing outlets by fruits and vegetables producers in India and the impact of choice of marketing outlet on market prices received for the products. The study uses 1,349 producers of fruit (pomegranate) and vegetable (okra, onions, baby corn), high-value crops. The study reveals that vegetables producers receive higher market prices for their products by selling through government-sponsored marketing outlets "Mandis", while fruit producers receive higher market prices by selling to post-harvest contractors and private traders. The findings suggest that one-size-fits-all policies will not improve market efficiency and market prices received by Indian fruit and vegetable producers.

Keywords: Fruits and vegetables, Mandis, Marketing outlet, Perishability, Producers' price

INVITED LECTURE

Role of FPOs and contract farming in agri-food system transformation: Evidence and policy issues

Sukhpal Singh

Professor, Centre for Management in Agriculture, Indian institute of Management, Ahmedabad, Gujarat, India

Contract farming and farmer producer organisations have emerged as two institutional innovations in developing country agribusiness space for linking smallholders effectively with modern and profitable markets. These two institutions are being promoted in many situations as a policy step by the state to bring about crop diversification, reduce costs of cultivation as it can provide access to better inputs and more efficient production methods, for better price realisation, for improving farm incomes and employment. But the practice of contract farming has been problematic as borne out by many studies of the nature and impact of contract farming on the local economies and farmers. It is for this reason that for some time now, FAO has been looking at the issue and designing and propagating responsible contracts and contract practices.

The Union Ministry of Agriculture and Farmer Welfare also prescribed a model contract farming Act in 2018 for states to adapt. On the other hand, the Government of India is investing in FPOs especially the more innovative legal entity of Farmer/Producer Companies (F/PCs) for some time now including a major policy initiative to promote 10,000 new FPOs by the 2024. In the above context, this paper assesses the status and role of contract farming and that of FPOs in agro-food transformation and therefore, smallholder development. It examines the major provisions of the 'Model contract farming and service (promotion and facilitation) Act, 2018 as informed by various studies (including authors own studies) on various marketing channels used by farmers including contract farming and their experience. Similarly, an assessment of FPO performance and their impact on member livelihood is carried out based on author's recent case studies of 33 PCs along with their member and non-member interviews carried out during 2019 and 2020. Based on this assessment of contract farming practice and functioning of PCs, the paper makes suggestions for improving contract farming regulation and policy to leverage it for smallholder inclusion and livelihood improvement along with their aggregation into FPOs/PCs which also requires a better policy design and its implementation. The two mechanisms together can facilitate food systems transformation which is pro-smallholder and also sustainable.

Keywords: FMod value chains, Market linkages, Producer companies, Small producers, Vertical co-ordination

Panel Discussion 1: Quality Education for Transforming Agri-food Systems

Current systems of higher education in agriculture and its transformation to food security

M. S. Chauhan

Vice Chancellor, GBPUAT, Pantnagar, Uttar Pradesh, India

In India, the agricultural education systems play important role to meet out the sustainable goals. Quality education and technology development and timely dissemination are the major component to improve the food security and sustainability. Providing quality agricultural education to the students and stakeholders with the recent development of climatic change is going to transform to food security and sustainability. Current agricultural education systems in India are in need of fundamental reform. There are many constraints for improving the quality of higher education in agriculture. The lack of suitable input and coordination, the limited frame of reference associated with educational nationalism, underutilized sources of knowledge, the need for globalization of educational content, gender imbalances and efficient faculty members, narrow disciplinary approaches used in organizing learning, and the low funding and policy support in terms of scholarship and its impact on recognition systems at institutions engaged in higher education in agriculture. Recent advances in ICT, ML and IoT coupled with policy cooperation make it possible to achieve significant advances to transformation into enhanced agricultural productivity. In will focus my panel discussion on current systems of higher education in agriculture and its need in fundamental reform in order to support improvements in global food security and environmental sustainability.

Keywords: Agricultural education systems, Environmental sustainability, Food security, Higher education

Kulagar traditional framing system for sustainability, soil quality and soil carbon sequestration in the Konkan region: A survey

Narendra Pratap Singh* and Basavashri Yadawad

ICAR- Central Coastal Agricultural Research Institute, Old Goa, Goa, India

Konkan region of Maharashtra, Karnataka and specially Goa are blessed with the diversity of tropical flora and fauna due to the proximity to the Western Ghats. The hot humid climate and presence of heavy monsoon made this region a biodiversity hotspot with beautiful landscape. Farmers of Konkan region specially Goa, have a conventional homestead system of gardening transmitted from their ancestors called Kulagar. In Konkani word 'kull' means family and 'aagar' means store house, means multiple plants that possess a variety of products. It is potential system to conserve the crop diversity and also an integrated system which includes cash crops, plantation crops, spices, fruits, local vegetables, medicinal and aromatic plants and flower crops. The major crops found in Kulagar are arecanut, coconut, banana, and spices. Some of the Kulagar farmers have included complimentary enterprises such as dairy, poultry, goat farming etc. to increase farm profitability and income. The main objective of Kulagar is to meet out the food and nutritional requirement of the farm family and to generate year-round income. Kulagar system is also eco-friendly approaches for doubling farmer's income in which the residue generated in the system is recycled through mulching and composting. Natural springs/streams or wells act as a source of irrigation in Kulagar system and through technological interventions drip/sprinkler system of irrigation has become popular in the last decade. The soils of Goa are mostly Lateritic (81%). They are Sandy loam to Silt loam in texture, well drained and highly acidic (5.5 to 6.5 pH). These soils have moderate organic carbon but poor in phosphorous and potassium and soils often have poor water holding capacity with sufficient amount of micronutrients, high carbon stock in the soil. Kulagar systems are climate resilient and have shown the ability to respond to and mitigate climate change. Kulagar could be promoted on a wide scale in other parts of the country's coastal agro-ecosystems as a key strategy for improving livelihood and environment resilience in agriculture.

Keywords: Climate change, Ecosystem services, Kulagar, Soil quality

Reframing Indian coastal aquaculture and fisheries: An IPCC risk assessment perspective

Grinson George[1*]
[1]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

The 2016 Marine Fisheries Census of India unveiled a population of 37,74,577 marine fishermen residing in 3,477 marine fishing villages. These coastal communities are spread across the nine coastal states and the union territories of Puducherry, Daman & Diu, Lakshadweep, and Andaman & Nicobar. These communities showcase a diverse spectrum of socio-economic conditions, with fishing, aquaculture, agriculture, and tourism playing pivotal roles in shaping their livelihoods and economic prospects. However, the anticipated scenarios of climate change and the associated variability pose the greatest risk to the socio-economic and environmental stability of coastal regions. Climate change parameters, including Sea Level Rise (SLR), increase in Sea Surface Temperature (SST), Shoreline Change (SLC), and environmental hazards like floods, cyclones, storm surges, erosion, and drought are placing considerable challenges on the livelihoods of coastal communities. The assessment framework of the Intergovernmental Panel on Climate Change (IPCC) underscores the profound impacts that changing climatic variables are expected to exert on coastal ecosystems. Among the consequences are the increased frequency and intensity of extreme events like cyclones, rise in Mean Sea Level (MSL), saltwater intrusion, temperature increase, marine heatwaves, and unusual rainfall patterns. Effectively addressing these challenges necessitates a multifaceted approach, incorporating adaptation strategies such as implementing coastal protection measures, formulating land-use plans that consider sea-level rise and flooding risks, and developing policies that promote the sustainable management of coastal ecosystems. The vulnerability of coastal communities varies in intensity based on factors like physical characteristics, population density, and related variables. The ICAR-Central Marine Fisheries Research Institute (CMFRI) conducted a comprehensive study, which enabled us to discern the vulnerability framework of different coastal districts across India's maritime states and union territories. This framework holds the potential to guide the restructuring of Indian coastal aquaculture and fisheries, facilitating effective mitigation and adaptation strategies to address these challenges.

Keywords: Climate change, Indian coastal communities, Vulnerability framework

Impact of climate change and mitigation strategies for sustainable livestock production in coastal Regions

Veerasamy Sejian*
Rajiv Gandhi Institute of Veterinary Education and Research, Vazhudavur Road, Kurumbapet, Puducherry-605 009. India

Climate change is rapidly emerging as a global critical development issue affecting many sectors in the world, and is considered to be one of the most serious threats for sustainable livestock production in the coastal regions. The direct impacts of climate change on livestock are on growth, milk production, and reproduction. The indirect impacts of climate change on livestock include reduced water and pasture availability, sudden disease outbreaks and expanding regions of disease prevalence. In the present changing climate scenario, apart from heat stress, there are other stressors such as nutritional and walking stresses which constrain livestock production. Hence, it is not only heat stress that needs to be mitigated but also nutrition and exercise stresses are of great concern. Therefore, research efforts are needed to establish the cumulative impacts of these critical environmental stressors. Mitigation of environmental stress impacts on livestock requires multidisciplinary approaches which include animal nutrition, housing, and animal health. It is important to understand the livestock responses to the environment in order to improve on existing amelioration strategies. Tremendous progress has been made in refining the existing thermal indices, and heat load indices have been specifically developed to cater the needs of the livestock industries. Technologies pertaining to rumen temperature measurement using rumen boluses and surface temperature measurement using infrared thermography are gradually making an impact in assessing thermo-tolerance in livestock. When combined with machine learning and real-time data interpretation these technologies offer great potential for precise control of individual animals. Research efforts are also focused on screening indigenous breeds of livestock in an effort to identify those breeds which have the ability to survive in multiple agro-ecological zones. With the development of advanced molecular biotechnological tools, new opportunities are available to characterize gene expression and identify key cellular responses to heat stress. These new tools improve the accuracy and efficiency of selection for heat tolerance. The future research priorities for mitigating the environmental stress in livestock in the coastal regions must therefore assess genetic components, including genomics and proteomics of heat stress in livestock, and develop alternate management practices to reduce these stressors and improve animal well-being and performance.

Keywords: Adaptation, Climate change, Heat stress, Livestock, Multiple stress, Thermo-tolerance

Natural farming for systemic transformation of coastal agriculture

N. Ravisankar
ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, Uttar Pradesh, India

India has a long coastline of about 7516 km in 8 states and 5 union territories. The coastal and island region is most important because nearly 250 million people living within 100 km of India's coastline. Some areas have a high population density of over 300 people per km^2. Unsurprisingly, coastal region is endowed with good amount of rainfall (1200 to 3100 mm), surface and ground water resources, rich in biodiversity, mostly of deltaic soils, humid to sub-humid condition suitable for growing of variety of crops. After the monsoon, wells, rivers and streams are used to lift water for irrigation. In general, paddy is the main food crop grown in this region although pulses, oilseeds, banana, coconut, arecanut, cashewnut and rubber are grown. Hence, crop diversification can be promoted with appropriate interventions. In spite of good potential for agriculture, the yield gap for various crops varies from 0.5 to 2.6 t/ha and the cropping intensity ranges from 140 to 210%. Studies have proved that land degradation of coastal and island region caused either by human activities or natural forces, is alarmingly increasing. Soil erosion, fertility degradation, salinization, water logging apart from pollution of coastal environment have been reported. Because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life, land degradation issue needs to be addressed on priority. Despite the use of fertilizers, pesticides and other purchased inputs such as seeds, the productivity gap exists and the constant increase in paid-out cost results in reduced profitability. Natural adversities like, cyclones, *Tsunami*, gales, heavy rains, floods, etc. which cause colossal loss to the crops are almost annual features of the coastal region. Addressing the land degradation concern of these regions along with reducing the paid-out costs will be a challenging task which needs multiple approaches. Natural Farming comprising of set of agro-ecological practices such as minimum disturbance to soil, application of locally prepared concoctions (*beejamrit, jeevamrit, ghanjeevamrit*) from livestock, mulching (soil mulch, cover crops, crop residues), muti-variate cropping during fallow, intercropping, prophylactic application of botanical preparations such as *agniaster, brahmaster, neemaster, dashparni ark etc,* trap crops, border crops and other eco-friendly pest control practices are emerging as alternate production system. It aims to reduce the land degradation by recycling of crop and animal residues and reduce the paid-out costs. Multi-location study on Natural farming in different agro-ecologies was initiated under All India Network Programme on Organic Farming from *kharif* 2020 including the coastal, hilly, rainfed and irrigated regions. Initial results indicates that legume and tuber crops with intercropping provides comparable yield with that of conventional organic and integrated crop management which are practiced without intercropping. Significant reduction in cost of cultivation under Natural farming was also observed besides improvement in soil organic carbon. However, adoption of integrated practices involving organic and natural farming needs to be done during initial 2 years in order to get better productivity and profitability in the coastal regions especially for crops with higher nutrient demand. Careful and systematic application of natural farming in the selected coastal regions with area, crop and resource specific approach will result in addressing the land degradation issues affecting the crop productivity and reducing the paid-out costs (market input costs) significantly.

Keywords: Coastal agriculture, Land degradation, Natural farming, Paid-out costs, Recycling

Agro-eco tourism for livelihood diversification and scaling of entrepreneurship among rural youth

Solomon Rajkumar, R.[1]*, Maneesha, S. R.[2], Paramesha, V.[1] and Parveen Kumar[1]

[1]Agro-Eco-Tourism (AET) Center, ICAR-Central Coastal Agricultural Research Institute, Ella, Old Goa-403 402, Goa,
[2]ICAR-Indian Institute of Spices Research, Kozhikode-673 012, Kerala

Agro-tourism has been experiencing steady growth worldwide, with an increasing number of tourists seeking authentic, nature-based experiences. According to the World Tourism Organization (UNWTO), rural tourism, which includes agro-eco-tourism, accounts for around 20% of all international tourism. This approach combines agriculture, sustainable practices, and tourism to create economic opportunities while promoting environmental conservation. It offers scope for the integration of farming activities, the tourism industry, and the farm business. It is absolutely, one of the livelihood strategies to link tourism activity with agricultural services, products, and experiences to satisfy the needs of both farmers and tourists. Natural farming units have great potential to showcase regional-specific traditional agricultural practices and rich biodiversity. Agro-eco-tourism is a strategy for long-term tourist development and multi-activity in rural regions that allows visitors to learn about agricultural situations, agricultural jobs, local goods, traditional food, and rural people's everyday lives, as well as cultural components and traditions. Furthermore, this activity gets visitors closer to nature and rural activities, allowing them to engage, be delighted, and enjoy the tour. Agro-eco-tourism allows visitors to get away from the hustle and bustle of city life and relax in a tranquil rural setting. It allows you to unwind and rejuvenate in a natural setting surrounded by breathtaking scenery. A conceptual framework for the development of agro-eco-tourism units for wider acceptance has been developed. The activities of agro-eco-tourism were categorized into primary (direct sales, education, hospitality, outdoor recreation, entertainment) and secondary (family functions, music concerts, cycling, hunting, fishing, cycling) depending on the farmer's socioeconomic condition and farm size. Further, agro–eco-tourism unit provides several ecosystem services such as in–situ conservation of animal, fish and plant genetic resources, improved production, profitability, employment to a farm family, residue recycling, soil fertility enhancement, etc. Agro-eco-tourism can have positive environmental impacts by encouraging sustainable farming practices, conservation efforts, and the preservation of biodiversity. It can also serve as a platform for educating visitors about the importance of environmental stewardship. While agro-eco-tourism offers many benefits, there are challenges to consider, such as maintaining a balance between tourism and the preservation of local ecosystems. Agro-eco-tourism is a promising avenue for livelihood diversification and scaling of entrepreneurship among rural youth.

Keywords: Biodiversity, Ecosystem service, Farming systes, Soil conservation

Repurposing agricultural subsidies for higher and sustainable agricultural development

S. K. Srivastava*, Prabhat Kishore and P. S. Birthal
ICAR-National Institute of Agricultural Economics and Policy Research, DPS Marg, Pusa, New Delhi-110 012, India

Subsidies play a key role in accessing the farm inputs and technologies, and disposing the output at remunerative prices by the financially constrained farmers. By making the food available at affordable prices, subsidies directly contribute to the food security. Central and state governments spend a sizable part of their total expenditure on subsidies in India. During the year 2019-20, about six lakh crore rupees were spent on subsidies out of which agricultural inputs and food subsidies constituted 37.1 per cent and 18.3 per cent share, respectively. During the last decade, agricultural subsidies (including fertilizer, power, interest subvention on short term credit, etc) almost doubled- from Rs 1.18 lakh crore in 2011-12 to Rs 2.21 lakh crore in 2019-20. Agricultural subsidy mainly comprised of subsidies on fertilizer, power and interest subvention for short term credit with the respective shares of 36.8 per cent, 36.6 per cent and 7.3 per cent in 2019-20. On per hectare basis, an average Indian farmer is provided subsidy of Rs 15835/ ha net sown area in a year which reduces the input cost (including labour) by 18.2 per cent. The subsidies are inequitably distributed across states, farm size categories and ecologies (rainfed/ irrigated). In the existing mechanism, input and output subsidies are primarily imbedded with the physical inputs and output prices, and vary directly with the use of the particular input and access to the public distribution system, respectively. This mechanism of extending subsidies has several benefits and drawbacks. The benefits include- improvement in productivity and competitiveness, control cost-push inflation, improve farm viability, etc. On the other hand, the drawbacks of existing mechanism are- inefficient input use, distort crop pattern and product mix, inequality in access to inputs, WTO commitments scrutiny, crowd-out investment, and fiscal deficit. although subsidy is a necessary short-term welfare measure, its quantum and disbursal mechanism need to be reviewed because the resulting negative outcomes outweigh the benefits. Ecological sustainability, equity and effectiveness are major arguments behind rationalizing and repurposing subsidies and supports for the Indian agriculture. In the recent years, Indian government-both at central and state level- are extending farm support with alternative ways such as direct cash transfer for farm inputs, income transfer, price deficiency payment, etc. These initiatives along with other ways of rationalizing and repurposing subsidies have been assessed and discussed.

Keywords: Agricultural subsidy, Mechanism, Sustainable agricultural development

From farm to fork: Role of FPOs and Agri-startups in India

Ranjit Kumar*, K. Srinivas and Sanjiv Kumar
ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India

For India to become *Atmanirbhar* and further to be a $10 trillion economy by 2035, agriculture needs to be profitable, resilient, sustainable and a bigger economic growth driver. For such multi-dimensional goals, all the players in agri-value chain must play significant roles employing new technologies for effective management of inputs, production, as well as post-production processes. India with about 14 Cr farmers, majority of them being small and marginal, continue to face several challenges from availability of quality inputs at right time and reasonable price, access to infrastructure, resources, and information, market access for the produce, etc. The concept of "farm to fork" refers to the entire journey that food products take from the point of production (farms and agricultural sources) to the point of consumption (the plates of consumers). At every stage, farmers and other stakeholders need to bring in some technologies to improve the efficiency in production, aggregation, processing, transportation, and marketing. "FPO" or "Farmers' Producer Organization" is a group of farmers joining together with the aim of improving their efficiency, access to resources, bargaining power, and overall income. Being a registered formal entity, the FPOs can borrow capital and create infrastructure facilities for value addition at farmers' doorstep. Currently, there are more than 20,000 FPOs in India registered under the Companies Act or Co-operative Society Act or other forms. On the other hand, by leveraging modern technologies and business model innovations, agri-startups help farmers become more efficient, reduce waste, and increase productivity in areas such as farming, processing, distribution, and marketing. They enable the farmers to make informed decisions, based on real time data collected from farmers' fields, markets, weather, etc. using sensors, IoT, AI & ML, drones, etc. However, with limited resources and capacity, it becomes difficult for any agri-startups to reach all the farmers individually. Synergy between FPOs and agri-stratups is the need of hour to bring effective transformation in the agri-value chain from farm to fork. The Farm to Fork strategy aims to reward all those farmers, fishers and agri-startups that help raise standards of food system, while improving the incomes of primary producers. People now pay increasing attention to environmental, health, social and ethical issues and they seek value in food more than ever before. Therefore, partnership and collaboration between FPOs and agri-startups can create a more equitable and efficient agri-food system, which would also help in achieving the majority of SDGs in India.

Keywords: Agri-startup, Agri-food system, Farm-to-fork, FPO, Market access, Modern technologies

Creating a start up ecosystem to empower youth and women in Amrit Kaal

Neeru Bhooshan
Assistant Director General (IPTM), ICAR, New Delhi, India

India is the youngest country in the world with her 50% population below the age of 25 and more than 65% below the age of 35. Youngsters are the nation's treasure which should be utilized in a productive way by ensuring their employment. The Startup India concept created an environment for Indian youth to start their innovation-based business, which was launched on 16th January 2016 with an objective to build a strong eco-system for nurturing innovation and startups in the country that would drive sustainable economic growth and generate large scale employment opportunities. Since the launch of Startup India initiative in 2016, DPIIT has recognised 92,683 entities as startups out of that 47% from tier 2 and 3 cities. More than 4,000 recognised startups are engaged in sectors relating to emerging technologies such as Internet of Things (IoT), robotics, artificial intelligence and analytics. The Government of India, is committed to the development of Agri-startups in the country. Due to the tremendous support, the numbers of startups in Agriculture and allied sectors have reached more than 7000 in 2022-23 from less than 50 before 2014-15. These agri-startups are working in different areas of agriculture & allied sectors such as precision agriculture, farm mechanization, agri logistics & supply chain, waste to wealth, organic farming, animal husbandry, dairy & fisheries, etc. The emerging technologies developed by agri- startups are providing various affordable and innovative solutions in agriculture and allied sectors. Indian Council of Agricultural Research (ICAR) has also contributed by opening 50 Agri-Business Incubation (ABI) Centres where 1000 plus startup/entrepreneurs were supported in different agri-based enterprises. Women Entrepreneurship Platform (WEP) is also an aggregator platform with the aim to overcome information asymmetry in the women entrepreneurial ecosystem. By showcasing all existing initiatives and providing domain knowledge it works towards empowering both prospective and present women entrepreneurs. The Fund of Funds for Startups (FFS) Scheme was established the to provide funding support to fulfil the needs of startups with a corpus of Rs. 10,000 crores, in the leadership of DPIIT and SIDBI to meet the funding needs of startups.

Under Startup India Seed Fund Scheme (SISFS) `537.25 crore has been approved to 148 incubators and `235.25 crore has been disbursed to the approved incubators. Over 50 regulatory reforms have been undertaken by the Government since 2016 to enhance ease of doing business, ease of raising capital and reduce compliance burden for the startup ecosystem. Startups are eligible for fast- tracked patent application examination and disposal. The Government bears the entire fees of the facilitators for any number of patents, trademark or designs, and startups only bear the cost of the statutory fees payable. Startups are also allowed to self-certify their compliance under 9 Labour and 3 Environment laws for a period of 3 to 5 years from the date of incorporation. These efforts bridges with over 15 countries that provides a soft-landing platform for startups from the partner nations and aid in promoting cross collaboration. DPIIT has notified Startups as 'fast track firms' enabling them to wind up operations within 90 days vis-a-vis 180 days for other companies. All these initiatives, policies and engagements of different stakeholders (public and private organizations), political will opens the path for creating a start-up ecosystem to empower youth and women in Amrit Kaal.

Keywords: Amrit Kaal, Artificial intelligence, Internet of Things (IoT), Robotics, Startup India concept

Bridging gender inequity in agriculture through innovation and technology

Malavika Dadlani
NAAS, New Delhi, India

The difference between development and sustainable development lies in adopting mindful changes with a holistic and long term perspective, rather than short term advancements and quick gains. Key to sustainable development is in giving equal opportunities to all. The ability to provide leadership must be identified in people irrespective of their caste, creed, gender, age, religion or social status, to bring in effective changes in a society. It has been seen that a nation moves forward when there is equality and women aspired growth and development as much as the men. It is well documented that rural women in most developing countries, especially in Asian and African regions, are often the primary users and managers of land, forest, water and other natural resources, besides being the main conservers and users of biodiversity. Realising that women empowerment is crucial to achieve all SDGs, as they represent nearly half the population, are the primary caregivers in the family, and key influencers in bringing up the future generation, Sustainable Development Goal 5 (SDG 5) aims to achieve gender equality and empower all women and girls. In order to achieve equal status, women need to be empowered with education and skill sets honing their interests and abilities, and be given equal employment opportunity and a role in decision making. This is particularly relevant in agriculture, where women and young girls can play an effective leadership role if empowered with equal rights, and access to knowledge and technology. A large proportion of rural women depending on farming and natural resources for livelihoods are directly impacted by droughts, floods and other vagaries of nature, which not only result in declining productivity, but may also cause serious health issues. The impact of such disturbances are more on women for their gendered roles in family care, food systems, as well as poor knowledge and access to technology for managing challenges of climate change, fluctuating market trends, and outbreak of serious diseases. Less involvement of women in decision making in agricultural activities and marketing, limited economic freedom, and scarce opportunities to benefit from technological advancements including linking with the agricultural value chains, not only curb women's progress but impact the well-being of the whole family and as a result, the community as a whole. Increasing women's resilience through better access to education, information, modern technologies, and financial services, and better employment opportunities can improve overall growth and help achieving SDGs. Good examples are emerging from various parts of world, including India.

Keywords: Financial services, Gender inequity, Modern technologies, SDG, Women's resilience

XVI AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 1

Ensuring Food & Nutritional Security: Production, Consumption and Value Addition

Problem of Malnutrition in India

Farm and Food-based Strategies for Combating Hidden Hunger

Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Addressing malnutrition in North-east India: Strategies and solutions for a healthier future

Narmada Hidangmayum* and Arunkumar, M. C.

Department of Human Development and Family Studies, College of Community Science, Central Agricultural University (Imphal), Tura, Meghalaya, India

*hnarmada@gmail.com

The prevalence of malnutrition in North-east India, as revealed by the National Family Health Survey (NFHS-5), is a cause for concern, particularly in states like Assam and Meghalaya. This study examines the variations in nutritional status across different states of the region and proposes a multi-pronged approach to combat malnutrition. The approach focuses on addressing both immediate and underlying causes of malnutrition. The proposed strategies include improving maternal health and nutrition, promoting breastfeeding and complementary feeding, implementing and scaling up nutrition-specific interventions, enhancing food security and dietary diversity, improving water, sanitation, and hygiene (WASH) practices, strengthening public health and nutrition services, building community awareness and engagement, targeting social protection programs, strengthening monitoring and evaluation systems, and fostering multisectoral collaboration. Successful implementation of these measures will require political commitment, funding, and collaboration among various stakeholders. By working together, significant progress can be made in reducing malnutrition and improving the well-being of children in North-east India.

Keywords: Malnutrition, Multi-pronged approach, North-east India, National Family Health Survey (NFHS-5), Nutritional status

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Problem of Malnutrition in India

COVID-19 pandemic impact on fish consumption paradigms across Kerala

Athira, N. R.*, Shyam S. Salim, Lowrane Stanley and Steny Rebello

[1]ICAR–Central Marine Fisheries Research Institute, Kochi, Kerala, India

*aathira31@gmail.com

Kerala marine fisheries are grappled with many disquieting factors, which include climate change, declining fish catch, unsustainable fishing practices, high cost of fishing, marketing exploits, and low-value addition. The COVID-19 pandemic induced stringent stress all over the state's food supply chain, causing changes in people's food consumption patterns. The spread of Coronavirus has created bottlenecks in the production, processing, transportation and logistics, leading to momentous shifts in fish consumption patterns as well as demand and supply of fish. The unavailability of fish due to the restrictions of the pandemic and hygiene issues in the fear of attack of COVID-19 is one of the two major reasons for the alterations in the fish consumption pattern. There was a sharp decline in demand, resulting in a price drop for many species, particularly those served as delicacies in restaurants. In this regard, the current study examines the culturally diverse attributes of fish consumption across households in Kerala with a total sample of 440 respondents. The overall objectives of the proposed study are to analyse the fish consumption paradigms across Kerala during three time periods of pre —COVID, COVID and Post COVID in terms of species, expenditure and source of purchase with particular focus on analysing the trends and pattern of fish consumption, identifying major factors that drive people in fish consumption, and assessing major constraints of consumption during the periods. The study provides insight into the fish consumption basket of the consumers. The study identified that during pre-COVID, Kerala had an average *per capita* fish consumption ranging from 26\-30kg, and due to the unavailability of fish, the consumption levels of fish during the COVID time have reduced considerably, thereby altering the consumption pattern and taste preferences. It was seen that consumers preferred locally known sources of inland species rather than marine species from relatively unknown sources during the pandemic. The consumption of local fish increased due to the non-availability and distortions in the supply chain. The lockdown disruptions have harshly affected the fish trade and, thereby, fish consumption in the region. Efforts to increase the local supply of fish with sufficient storage facilities were used to cope with such an unprecedented situation. The sources of purchases during pre-COVID were landing centres, vendors and retail centres, and during post-COVID, people relied more on fish vendors who sell directly to houses. However, during the pandemic, the reliance was on those who showed an online presence, with a fivefold increase from 5 to 26%. The demand for fish seems driven by accessibility to a wider variety of fish species for expanding the fish consumer base during all the periods. Tilapia holds the most preferred species during the pandemic, which continues to be the same post-COVID. Integration of existing marketing systems with preferred consumer preferences is perceived to be important for improving fish consumption to a great extent. In addition, assurance of branding and ensuring food safety standards must be explored more with stringent measures and governmental support for enhancing the fish consumption supply chain.

Keywords: COVID-19, Fish consumption, Lockdown, Maxdiff analysis

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Problem of Malnutrition in India

Clam (*Tegillarca granosa*) blood exudate powder– Recommended as a micronutrient-rich supplement to address hidden hunger

Asha, K. K*., Raviprasad Prabhu, Rehana Raj, Greeshma, S. S., Shravan Kumar Sharma, Martin Xavier[1], Abhaykumar, Laly, S. J[1], Anandan, R[1]. and Femeena Hassan[1]

*Mumbai Research Center, ICAR-Central Institute of Fisheries Technology, Sector 1, Vashi, Navi Mumbai-400703, Maharashtra, India
asha.santhosh5@gmail.com

United Nations Agenda 2030 towards the achievement of Sustainable Development Goal 2 on Zero Hunger calls for ending all forms of hunger by the year 2030. Micronutrient malnutrition or hidden hunger is an aggravating problem worldwide, and WHO estimates that over 2 billion people suffer from this condition. Hidden hunger affects crucial development outcomes, increases susceptibility to disease and deficits in efficiency and capability. Among mineral deficiencies, iron deficiency is by far the most prevalent globally, followed by zinc and iodine deficiencies. India has the highest burden of hidden hunger. National Family Health Survey-(III) states that about 55% of women suffer from iron deficiency anemia, 32% and 3.9% of adolescents have zinc and iodine deficiencies. Seafood is a low-fat food packed with high quality, easily digestible protein, vitamins and minerals, with clams being advocated as particularly good sources of micro-minerals, including iron and zinc. Due to the plentiful occurrence of clams in the estuaries and lakes, they form the crux of the sustenance fisheries of coastal fishing villages and prove significant for their economy. Copious beds of *Tegillarca granosa* occur along the southwest coast of Maharashtra and are referred to as blood clams due to the blood-red colour of its flesh, which comes from the blood pigment haemoglobin seen in this species. From the nutrition point of view, *T. granosa* is rich in easily digestible protein, fat, glycogen and minerals and forms a significant part of the diets of local fisher folk fulfilling their protein and mineral requirement. This paper describes the nutritional composition analysis and heavy metal profiling of clam blood exudate powder developed from fresh clams collected from Vashi Creek, Navi Mumbai. Blood from shucked clams was used for the determination of proximate composition, total amino acid and fatty acid profiles, mineral and heavy metal content using standard AOAC Official Methods of Analysis. The CBE powder was found to be rich in protein (72%), ash (18%) and low in crude fat (2.4%). Among the micro-minerals, iron (2.8 g/kg), zinc (0.2 g/kg), manganese (0.1 g/kg), selenium (4.5 mg/kg) cobalt (3.5 mg/kg) etc. were detected in significant levels. Heavy metals were determined to ascertain that the CBE powder was safe for consumption. Pb (0.99 mg/kg) levels were within permissible limits, while Hg was undetected. Cd (4.15 mg/kg) and Cr (4.15 mg/kg) exceeded limits of 1 mg/kg and 0.3 mg/kg respectively. Prior depuration of the clams is reported to reduce heavy metals by up to 80%.

Keywords: Blood clams, Heavy metals, Hidden hunger, Microminerals, SDG

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Problem of Malnutrition in India

Empowering fisherfolk communities for sustainable health practices and consumption: A path to food and nutritional security

Revanth Raju*and Anoop K. K.

School of Business Administration and Management, Faculty of Fisheries Management, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala, India

*revanthraju001@gmail.com

Fisherfolk communities play a pivotal role in ensuring food and nutritional security, especially in coastal regions and areas reliant on aquatic resources. This study aims to shed light on the challenges faced by fisherfolk communities and identify strategies to empower them to adopt sustainable health practices and consumption patterns, thereby contributing to enhanced food and nutritional security. The need for this study arises from the critical intersection of the health of fisherfolk communities and the sustainable utilisation of aquatic resources. Poor health practices and inadequate nutrition among fisherfolk jeopardise their well-being and hinder their ability to engage in productive fishing activities. Addressing these issues can improve overall health, increase productivity, and provide greater food and nutritional security for these communities. The aim is to assess fisherfolk communities' current health practices and dietary habits and identify the key challenges and barriers they face in maintaining healthy lifestyles. This study employs a mixed-methods approach, combining surveys, interviews, focus group discussions, and community consultations. Data will be collected from fisherfolk communities in coastal areas, examining their current health practices, dietary patterns, and perceptions of food security. Additionally, qualitative data will be collected to understand community perspectives and to co-create context-specific interventions. Preliminary findings indicate that fisherfolk communities face challenges related to limited access to healthcare, inadequate nutrition, and a lack of awareness about the importance of health and nutrition. However, there is an intense desire within these communities to improve their well-being. The findings of this study hold considerable utility for beneficiaries seeking to empower fisherfolk communities. The study's recommendations can inform the development of targeted interventions that are culturally appropriate, sustainable, and effective in improving the health and well-being of fisherfolk while contributing to broader food security objectives.

Keywords: Consumption, Dietary patterns, Fisherfolk community, Food Security, Nutritional security

ICAR-CIAE process technologies for entrepreneurship of women through processing and value addition of millets

Dipika Agrahar Murugkar* and Debabandya Mohapatra

ICAR-Central Institute of Agricultural Engineering, Berasia Road, Bhopal, Madhya Pradesh, India

*dipikaagrahar6@gmail.com

Millet crops such as pearl millet, sorghum, finger millet, and foxtail millet are major coarse grains cultivated in Madhya Pradesh, India. However, limited access to appropriate tools or machinery has hindered the production of these crops, particularly pearl millet. Suitable equipment and machinery should be introduced into the millet crop system from the outset to boost production and address this challenge. Improvement in millet crop systems is needed, which remains a challenge in India. In India, coarse grains like millet are consumed primarily as rice or ground flour. Other forms of consumption have not been widely adopted for various reasons. One significant challenge is the need for processing machinery for coarse grains. Small millet seeds make processing difficult, affecting their adoption. Traditionally, pearl millet and finger millet are consumed as rice, and a method using hands or pedal pounders is employed to dehull them, resulting in substantial losses. Hulled pearl millet, in particular, lacks storage capacity. Rice-like flour from hulled millets can turn bitter, limiting their consumption. Kodo and kutki, on the other hand, are consumed as rice, and their hard outer covering makes processing a challenge. The shelf life of rice or millet flour from hulled grains is limited to a few days, restricting commercial use. To address these issues, there is a need to improve the processing of coarse grains and increase their production. This requires the development of appropriate tools and machinery. Improving coarse grain processing and increasing production can help combat malnutrition and boost productivity. This is a crucial step that should be taken to promote the use of coarse grains in India. In India, more than 50 to 60 types of millet are traditionally grown. Millet-based diets are rich in essential nutrients like proteins, essential fatty acids, dietary fibre, B vitamins, calcium, iron, zinc, potassium, and magnesium. Recognising the health benefits of millet, the Indian government has also termed them 'Superfoods', which play a vital role in providing valuable resources for Indian farmers. ICAR-CIAE has developed machinery and process technologies to reduce the drudgery involved in millet production and processing activities. Additionally, efforts have been made to address several standard millet primary and secondary operations, which pose challenges during processing due to their size, shape, and physical characteristics. Millet-based products have been developed, which are either made solely from millet or serve as critical components in many popular snack foods. Given the limited shelf life of processed millet-based products, efforts have been made to enhance the nutritional value of millets and extend their shelf life. In summary, addressing the challenges in millet production and processing through the development of machinery and infrastructure and promoting awareness of the nutritional benefits of millet can contribute to their wider acceptance and utilisation in India.

Keywords: Entrepreneurs, Millets, Processing, Value addition, Women.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Problem of Malnutrition in India

Pre-breeding for biofortification in wheat (*Triticum aestivum* L.)

Bhudeva Singh Tyagi*, Vikas Gupta, Vishnu Kumar, Sindhu Sareen, Arun Gupta, Ashish Ojha and Gyanendra Singh
ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana-132001
*Bhudeva.Singh@icar.gov.in

Malnutrition caused due to undernourishment has led to a significant global health issue, affecting physical and mental development, vulnerability to diseases, mental retardation, blindness, reduced cognitive ability, and general losses in productivity. Several health organizations have shown concern about this issue at the global level, even though it is also covered under the Sustainable Developmental Goals (SDGs). Currently, more than 2 billion people are suffering from micronutrient deficiency across the globe. Notably, three micronutrients, iron, zinc, and vitamin A, are recognized as the most limiting factors for malnutrition. Keeping in view wheat as a staple food in the vegetarian diet, a breeding program was started, and new crosses were attempted with wild relatives to tap the genetic diversity and enrich the segregants for important micronutrients. A set of 14 exotic-based wheat genotypes and two check varieties were evaluated in four environments. The experimentation was conducted for two consecutive years, 2019–20 and 2020–21, at Karnal and Hisar locations. The variability observed in exotic-based genotypes is much higher than in check varieties. Simultaneous improvement of GFeC, GZnC, and GPC is possible due to strong and positive correlation among the studied traits. Two genotypes i.e., G7 (BFKW-7) and G3 (BFKW-3), are suitable candidates to be utilized as potential donors for simultaneous improvement of all three traits, as these are found to be both stable and have high trait value. G4 (BFKW-4) for GFeC and GPC, and G11 (BFKW-11) for GFeC and GZnC, and G10 (BFKW-10) for GZnC and GPC were also potential donors. These stable genotypes would be a potential source for high GFeC, GZnC, and GPC to develop biofortified wheat varieties.

Keywords: Genotype, Malnutrition, Micronutrient deficiency, Wheat

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Problem of Malnutrition in India

Spatiotemporal analysis of marine fish valuation in India – Insights and perspectives

Shyam, S. Salim*, Narayanakumar, R., Raju, S. S., Swathilekshmi, P. S., Anuja, A. R., Swatipriyanka Sen and Athira, N. R.
[1]ICAR–Central Marine Fisheries Research Institute, Kochi, Kerala, India
*shyam.icar@gmail.com

India, the second largest fish producer in the world, contributes about 6.5% of the global fish production. The present fish production of India is 16.24 million MT, with a contribution of 4.12 million MT from the marine sector and 12.12 million MT from the inland sector. The Indian marine fisheries sector also contributes enormously to the economy by creating foreign exchange, food security, direct employment and income. With changing consumption patterns, emerging market forces and technological developments, the fisheries sector has assumed added importance in India and is undergoing a rapid transformation. Amidst the slump in landings, the valuation of fish considerably increased because of the realisation of higher prices, the movement of fish from non-consumption areas to consumption areas and augmented fish consumption. The marine fish landings exhibit a wide range of volatility, which might have serious impacts on the fisheries economy of the country. The pandemic COVID- 19 also had multifaceted effects on marine fish landings as the lockdown put severe restrictions and reported a reduction in marine fish landings from different coastal states of the country. However, the demand for fish continues to increase, and people prefer more of marine fish. The present study on the valuation of fish, an empirical analysis, attempts to understand the valuation of fish vis-à-vis landings over the last 22 years spatiotemporally. The study was done based on the fish price realization at the point of origin (Landing Centre Prices) and point of last sales (Retail Centre Prices) for the time period 2000-2022 sourced from different projects of FRAEED, and the landings of fish were obtained from NMFDC, CMFRI. The objectives of the study are to assess the valuation of fish landings across different states vis-à-vis different major species, to analyse drivers of revenue, growth, and instability and to decompose the landings over to two time periods for identifying the decadal changes based upon the landing centre and retail centre prices. The study identified that the valuation showed differential growth across the different coastal states. Price remains to be the major contributing factor for the highest revenue over the time period. The decomposition analysis has indicated that high-value realisation is primarily due to the "price effect", not by "quantity effect". The prices of low-value fish species have not been stable for several reasons, and the prices varied depending on species, seasons and abundance of other fish and fishery products. During glut seasons, many species earned a lower price and thus fell into the low-value category. It is not the quantity of fish landed, but the value of the fish landed, that is important as it could offer breathing space to the fishermen if they fail to catch an adequate quantity. However, it has to be cautioned on the context of fish movement quality is ignored, and the self-sufficiency of fish in individual states is under question. To ensure quality, legislation is required to prevent fish movements across the state and to ensure fish availability for the people.

Keywords: Decomposition analysis, Landing Centre Price, Price instability, Retail Centre Price, Valuation.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Contributions of agricultural interventions to food security–A comprehensive review

Bambhaneeya, S. M.* and Garaniya, N. H.

Department of Soil Science, College of Agriculture, Navsari Agricultural University, Campus Bharuch, Maktampur- 392 012, Gujarat, India

*sureshsoilscience@nau.in

The Sustainable Development Goals commit the international community to achieve zero hunger by 2030 through a renewed focus on agricultural development for food security and nutrition. This paper presents a systematic review of published evidence of contributions by agricultural sector interventions to food security, including indicators and success factors. Overall, agrarian interventions encompass various approaches that improve food security. By focusing on productivity, diversification, sustainability, market access, and resilience, these interventions address the multifaceted aspects of food security and contribute to the availability, accessibility, and stability of food supplies for populations worldwide. Agricultural challenges and mitigation strategies must be reframed for integrated and planned efforts spanning the complete agricultural cycle, ranging from production to distributing farm products, without neglecting effective waste management. The current scenario of increasing global populations, dwindling resources, and scarce reuse/recycle practices highlights the need to employ such frugal steps actively throughout the world. In addition to critical innovations in scientific methods and techniques, effective management of infrastructure, distribution of farm products, waste treatment, skill development of the workforce, and engaging collaborations between public and private sectors would help equip farmers and producers to meet the increasing food security challenges. Agricultural interventions, such as improved seeds, modern farming techniques, and irrigation systems, have significantly increased agricultural productivity. Agricultural interventions addressing climate change challenges, such as promoting climate-smart agriculture, resilient crop varieties, and sustainable land management practices, are crucial for ensuring food security in changing climatic conditions.

Keywords: Agricultural interventions, Climate-smart agriculture, Food security, Mitigation, Resilient crop varieties

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Enhancing food and nutritional security of tribal farmers–A successful model under the Farmer FIRST Programme

Mooventhan, P.*, Anil Dixit and Uttam Singh

[1]ICAR-National Institute of Biotic Stress Management, Raipur – 493 225, Chhattisgarh, India

*p.mooventhan@icar.gov.in

This abstract outlines the success of the Farmer FIRST Programme (FFP), which aims to improve the food and nutritional security of tribal farmers by integrating agricultural enterprises into rice fallow areas. The project was implemented in the Baloda Bazar district of Chhattisgarh, India, specifically in five tribal villages: Bakla, Kharaha, Bamhani, Kurraha, and Kharri. The programme identified and implemented five modules, including crop-based, livestock-based, enterprise-based, horticulture-based, and NRM-based. Interventions were selected based on matrix ranking and agro-ecosystem analysis. The programme positively impacted, with more than 634 tribal farm families benefiting from the interventions. FFP interventions included goat farming with Sirohi, Jamnapari, and Barbari breeds, backyard poultry farming with Kadaknath breed, oyster mushroom production, Farmer Communication Centers (FCCs), low-cost Azolla production, nutritional home gardens through IIHR/TNAU vegetable seed kits, drudgery reduction equipment for women farmers through Custom Hiring Centers (CHCs), Agro Processing Centers (APCs), low-cost poly houses with drip and poly-mulching for vegetable production, and eco-friendly pest management technologies. These interventions played a vital role in generating additional income and bringing tangible changes to the socio-economic condition of the tribal farming community. In economic terms, each module generated an additional income of ₹12,054/- per farm family. In 2022, the farming community generated ₹118.75 lakhs from different enterprises. The programme also had a significant social impact, with seasonal migration from the adopted villages reduced by 26 and 34% of farm women and 20% of rural youth attracted to agricultural activities. The programme also resulted in a 24-30% knowledge gain among tribal farmers in the selected technologies through various Capacity Building Programmes (CBPs). A significant rate of skill acquisition was observed in the adopted technologies, such as scientific vegetable production, zero tillage, livestock production, and eco-friendly plant protection measures. Women farmers' drudgery was reduced through village-level CHCs, and tribal farm families' nutritional level was enhanced through nutritional home gardening with IIHR/TNAU seed kits. Overall, the programme introduced and sustained 54 agricultural interventions in the farmers' fields. Cropping intensity increased by 120% in the adopted villages, and backward and forward production linkages were established for crop, livestock, and horticulture enterprises. Market linkages were established for different commodities produced under this project to ensure the sustainability of the disseminated technologies. In total, 515 capacity-building programmes were organised, and 8417 tribal farmers benefitted from this initiative.

Keywords: Capacity building, Enterprise diversification, Farm income, FFP, Tribal farming

Phenolic antioxidant-linked health-promoting properties of tree bean (*Parkia roxburghii*) plant parts

Lokesh Kumar Mishra

Department of BPME, College of Agriculture, Central Agricultural University, Imphal– *795504, Manipur, India

*lkmishra2005@gmail.com

Tree bean (*Parkia roxburghii*) is an underutilised leguminous plant belonging to the family Fabaceae. It is highly valued as a delicacy among the people of Manipur, north-east India and south-east Asia. Being a well-adapted species to northeast India thriving on low agri-inputs, it can play an important role in promoting diet diversity that simultaneously addresses food security and climate resilience. The edible plant parts of Tree Bean include the pods, floral buds and seeds and are used to prepare several traditional dishes among different northeastern indigenous tribes. Its consumption has been claimed to have diverse medicinal properties. Many of these medicinal properties of edible parts of *P. roxburghii* have been attributed to their rich phenolic acid profiles with high antioxidant capacities. Therefore, this study aimed to screen the plant parts of *P. roxburghii* to determine phenolic antioxidant-linked anti-diabetic properties using rapid *in vitro* assay models. These can be targeted for use in ethnic foods of indigenous communities in the northeastern region of India and may potentially be promoted globally as a health-promoting vegetable. The edible plant parts were screened for total soluble phenolic content, phenolic acid profiles, total antioxidant activity, α-amylase and α-glucosidase inhibitory activities using *in vitro* assay models targeting their use for health diet design in type 2 diabetes. The highest total soluble phenolic content and high antioxidant activity were observed in the pods of the tree bean. Further high α-glucosidase inhibitory activity was also found in bark and leaves. Overall, high α-glucosidase and low α-amylase inhibitory activity was observed in all the plant parts evaluated in this study. Further positive and high correlations between total soluble phenolic content, antioxidant activity (based on DPPH free radical scavenging assay), and α-glucosidase inhibitory activity were observed, which indicated potential phenolic antioxidant-linked anti-hyperglycemic function in the edible plant parts. The major phenolic acids found in the plant parts in terms of quantity were Catechol and gallic acid. Low amounts of chlorogenic acid, salicylic acid, p-coumaric acid, syringic acid and vanillin were also detected in the edible plant parts. This *in vitro* study provides the biochemical rationale and scientific foundation to further target this underutilised legume of northeastern India for potential dietary and therapeutic uses in ethnic communities targeting the improvement of food systems for the early stages of type 2 diabetes and its associated complications.

Keywords: Antioxidant properties, Health diet design, *Parkia roxburghii*, Phenolic compounds

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Journey of Indian wheat and roadmap for improvement

Gyanendra Singh*
ICAR–Indian Institute of Wheat and Barley Research, Karnal-132 001, Haryana, India
*director.iiwbr@icar.gov.in

Wheat (*Triticum aestivum* L.) is the second most important cereal crop of India and plays a vital role in the food and nutritional security of the country. The diverse environmental conditions and food habits of people in India support the cultivation of three types of wheat (bread, durum and dicoccum). Among these, bread wheat is the major one, contributing approximately 95 per cent to total production. Wheat crop in India is grown across different agro-climatic zones based on climatic conditions, soil types and growing duration of wheat. To achieve sustained agricultural growth, India has established a wide network of agricultural research, one of the world's largest national agricultural systems. An important milestone in the history of wheat cultivation in India was establishing the All India Coordinated Wheat Improvement Project (AICWIP) in 1965 by the ICAR. Through coordinated research efforts made under AICRP, nearly 500 wheat varieties suited to different agroecological conditions and growing situations have been released so far. These genotypes are very successful in increasing wheat production from a mere 12.5 million t in 1964 to around 112.7 mt million t during 2022-23. Indian wheat has not witnessed any disease epidemic of rust or other disease pathogen during the past five decades. Besides, precision land levelling for efficient input usage, increasing the water use efficiency by adoption of micro-irrigation systems like drip and sprinkler, balanced fertilisation coupled with timely sowing, fine-tuning and location-specific conservation agriculture practices, residue management, appropriate mechanisation to adopt conservation agriculture practices. Climate change is the most serious constraint to wheat production in this region, which can significantly affect wheat production due to its sensitivity to temperature, precipitation, and other environmental factors. Extreme heat events during critical growth stages can also lead to heat stress and spikelet sterility, resulting in lower grain quality and yield losses. Besides, changes in precipitation patterns due to climate change can impact water availability for wheat cultivation. Shifts in the timing and intensity of rainfall can lead to water stress during crucial growth periods, affecting grain development and overall yields. Adaptation strategies are essential to mitigate the negative effects of climate change on wheat. These may include developing and adopting heat-tolerant and drought-resistant wheat varieties, implementing improved water management practices, promoting conservation agriculture techniques, investing in climate-resilient agricultural infrastructure and developing new varieties utilising cutting-edge technologies through implementing a science-led growth to enhance the water use efficiency, nutrient use efficiency and checking further soil degradation under high cropping intensity. Increased production is a prime concern for attaining sustainable food security and becoming the world leader in wheat production.

Keywords: Abiotic stresses, Climate change, Cutting edge technologies, Food Security. Wheat

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Identification of high-yielding biofortified wheat genotypes in advanced breeding lines

Mishra, C. N.*, Sushma Kumari Pawar, Swati Sharma, Mukesh Kumar, Tyagi, B. S., Satish Kumar, Ahlawat, O. P., and Gyanendra Singh

ICAR-Indian Institute of Wheat and Barley Research Karnal, India

*Chandra.Mishra@icar.gov.in

Zinc (Zn) deficiency poses a significant threat to human health, particularly in areas where wheat is the main dietary source because it is essentially low in bioavailable Zn. Recent studies have shown the value of biofortifying food crops to increase the Zn content of wheat grains, especially in areas with low phyto-available Zn levels in the soil. Foliar application of nutrients is an effective strategy to increase grain yield and nutritional content of wheat grains under field conditions. In an experiment, a set of fifty 13th HZWYT (High Zinc Wheat Yielding Trial) CIMMYT Wheat lines, including check variety (HD3086), was conducted in a randomised complete block design, with two conditions and in two replications at ICAR-IIWBR Karnal. One set of wheat lines under field conditions was grown as a control, and the other set was treated with Zinc oxide (ZnO- 39.5%) at the anthesis stage of the plant. Different traits, *viz.,* nutritional content (Fe/Zn content in grains), physiological parameters and quantitative traits, have been recorded to observe the effect of foliar spray application. Applying Zn as zinc oxide (Zn O) foliar spray in one set of the genotypes, an increment was observed in a few genotypes between the ranges of 51-60% and as in the check variety (HD3086), the increment of 28% was found. The mean sum of squares due to the interaction between genotype with the condition for five traits, viz., days to heading, grain yield, thousand kernel weight, NDVI and Zn content, were recorded as statistically significant and depicting the sufficient variability among the genotypes. Seventeen genotypes were significantly superior to the check variety for the grain Zn content; the range for the grain Zn content was recorded from a minimum of 24.6 to 54.9 ppm. To increase nutritional security, improve Zn biofortification and achieve higher wheat yields, particularly in soils with small phyto-available Zn pools, we recommend using foliar Zn fertiliser.

Keywords: Biofortification, Foliar application, Foliar spray, Wheat, Zn mainstreaming

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Landraces and wild species to widen the genetic pool for crop improvement

Divya Balakrishnan*, Pranay, G., Saitheja, D., Magudeeswari, P., Santosh Venna, Naresh Sahu, Saiprasanna, D., Neerja, C. N., Swamy, A. V. S. R., Subba Rao, L. V., Sarla, N. and Sundaram, R. M.

ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, India

*dbiirr23@gmail.com; Divya.Balakrishnan@icar.gov.in

Wild accessions and landraces are the potential genetic material which can bring back novel alleles for the food and nutritional security of the country. The majority of the popular Indian cultivars are derived from single cultivated species *Oryza sativa* and majorly from the *indica* subspecies group. Inbreeding within these cultivars resulted in a yield plateau and resulting in no further genetic improvement. Landraces are traditional or indigenous genotypes cultivated and grown for generations in specific regions or cultures. These native varieties often have unique characteristics such as flavour, aroma, texture, and adaptability to local environmental conditions. Many of these traditional varieties contribute to the regional culture and heritage by harbouring therapeutic or medicinal properties. Similarly, wild and related species contribute to several economically important genes that can improve yield, nutritional contents, stress tolerance, etc. At ICAR-IIRR, prebreeding studies are carried out to bring these long-lost related species into mainstream cultivation by transferring favourable traits into popular cultivated varieties. Molecular marker-defined introgression lines are developed as a national resource for basic and applied research. This prebreeding material would enable the identification of genotypes with favourable traits and rapid gene identification of any trait. CSSLs and introgression lines are developed in the study, which is a very useful genetic resource for mapping QTLs/genes for complex traits and accelerating gene discovery. Popular mid-early variety MTU1010 and late duration variety Swarna (MTU7029) were selected as recurrent parents and wild accession of *Oryza rufipogon*(IC309814) and one of *O. nivara* (IC283150) with high photosynthetic efficiency were used as donor parents to develop CSSLs. A set of 165 polymorphic SSRs and 1094 genome-wide SNPs were employed in detecting chromosome segments and ensuring that at least 90% of the genome of *O. rufipogon* is represented as overlapping small segments. These materials and several other crosses of elite varieties with landraces resulted in identifying high-yielding stress-tolerant genotypes with better nutritional and quality-related traits. QTLs for yield and biotic stresses like Blast, BLB, BPh, leaf folder and sheath blight were also identified from this population. Nutrition-rich genotypes with high Fe and Zinc and quality parameters were identified, and causative gene locus for the target traits were also detected from this study.

Keywords: Landraces, Nutrition, Preebreeding, Wild, Yield

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Growth and yield of quinoa as influenced by different dates of sowing, crop geometry and nitrogen levels under sodic wasteland condition

Devendra Singh*, Nainwal, Mohan Singh, R. C., Prem Kumar, Arun Kumar and Tewari, S. K.

CSIR-National Botanical Research Institute, Lucknow, Uttar Pradesh 226001 India

*singhdrdevendra@gmail.com

Climate change is rapidly degrading the conditions of crop production. For instance, increasing salinisation and aridity are forecasted to increase in most parts of the world. Consequently, new stress-tolerant species and genotypes must be identified and used for future agriculture. Stress-tolerant species exist but are underutilised and neglected. Many stress-tolerant species are indeed traditional crops that are only cultivated by farmers at a local scale. Quinoa (*Chenopodium quinoa* Willd.), a grain crop, has gained worldwide attention because of its ability to grow in various stress conditions like soil salinity, acidity, drought, frost, etc. (Jacobsen *et al.* 2003). Its grain is a rich source of a wide range of minerals, vitamins and high-quality protein containing ample amounts of sulphur-rich amino acids (Koziol 1992; Ruales and Nair 1992). The protein content of quinoa grains is higher than other cereals, and it has a better distribution of essential amino acids. Furthermore, the quinoa plant is resistant to cold, salt, and drought, which leaves no doubt why it has been called the "golden grain". On that account, the production of quinoa and its products followed an increasing trend that gained attraction in 2013, as it was proclaimed the international year of quinoa. The rationale for the revival of quinoa and its reintroduction into the diet is related to the epidemiological situation, which includes diseases that exhibit risk factors that may be reduced with a balanced nutritious diet, in which quinoa plays a major role, being considered a "superfood." Moreover, it is one of the crops selected by Food and Agriculture Organization (FAO) to offer food security. The field experiment was conducted at Banthra Research Centre, CSIR-National Botanical Research Institute, Lucknow, which is situated at an altitude of 120 m above sea level at 26°45' N latitude and 80°53' E longitude during rabi season to evaluate quinoa under the sodic wasteland condition at different dates of sowing, crop geometry and nitrogen levels (RDF:100 kg N, 50 kg P_2O_5, 50 kg K_2O ha^{-1})–three dates of sowing viz. i.e., D_1: 01st November, D_2: 15th November, D_3: 30th November and three spacing of sowing (S_1:30 cm, S_2: 45 cm, S_3: 60cm) and three nitrogen levels (N_1: RDF, N_2: 75% RDF, N_3: 125% RDF). The 15th November date of sowing, 30 cm spacing, and 75% RDF nitrogen level recorded the higher growth, yield and yield attributes of quinoa.

Keywords: *Chenopodium*, Crop geometry, Date of sowing, Nitrogen level, Quinoa and sodic

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Resistance prevalence and antioxidant enzyme alterations in *Tribolium castaneum* (Herbst) against phosphine toxicity

Satyapriya Singh[1,2]* and Sabtharishi Subramanian[2]

[1]Division of Crop Protection, Central Horticultural Experiment Station, ICAR-IIHR, Bhubaneswar-751 019, Odisha, India
[2]Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi-110012, India

*satyapriya.singh@icar.gov.in, satyaiari05@gmail.com

Food commodities are essential sources of nutrients and calories for living beings. However, it is much more prone to biotic stresses in stored conditions. In this context, insects cause a considerable loss, accounting for approximately 5-10% and 20-30% in temperate and tropical countries, respectively. Hence, its safeguarding is of utmost importance. Quick management exclusively relies on phosphine fumigation, which is used worldwide. But, the emergence of resistance to this chemical is a global concern. Herein, we evaluate the resistance level to phosphine toxicity in red flour beetle, *Tribolium castaneum* (Herbst), collected from six locations across India. One lab susceptible is included as a control. Further, the assessment of changes in antioxidant enzymes was conducted. The concentration-response mortality was determined and analysed using the probit model. The highest LC_{50} was observed in the Mirzapur population (1.277 mg l^{-1}) compared to the lab-susceptible strain (0.018 mg l^{-1}). Similarly, the LC_{90} value ranged between 0.230 to 27.546 mg/L. The least resistance ratio was observed in the Kailashahar population (2.11%). Our data elucidated that Mirzapur and Kailashahar exhibit the highest and lowest resistance levels, respectively. The activities of antioxidant enzymes in *T. castaneum* populations showed significant variation after exposure to phosphine. SOD activity levels varied from 8.77 to 18.82 U/mg protein, while POX and CAT activities ranged from 52.42 to 408.32 and 61.11 to 247.49 M H_2O_2 reduced/min/mg protein, respectively. The correlation analysis showed that SOD and POX had a significant positive association (r=0.89 and r=0.98, respectively) with an increased resistance ratio. On the contrary, CAT had a negative correlation (r=-0.98) with resistance to phosphine. Our study emphasises the variation in resistance within the population and the different associations of antioxidant enzyme activities in response to phosphine fumigation in field populations of *T. castaneum*. This study aims to establish a foundation for developing improved strategies for managing stored insects and boosting food safety and nutritional security.

Keywords: Antioxidant, Bioassay, Phosphine, Resistance Ratio, Stored Commodities

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Add-ons to coastal livelihoods: Does it bring home the bacon? Collations from Gujarat, India

Swathilekshmi, P. S.*, Narayanakumar, R., Vipinkumar, V. P., Divu Damodaran, N., Johnson, B., Suresh Kumar Mojjada, Jose Kingsly, H. and Leslie V. A.

ICAR-Veraval Regional station of CMFRI, Veraval, Matsya Bhavan, Veraval—362 269, Gujarat, India

*swathi.lekshmi263@gmail.com

Balancing risks and uncertainties are overarching realities in coastal livelihoods. Occupational diversification is a major strategy to address the aforesaid concerns and is not alien to the realm of marine fisheries. Income accruing from diversified livelihoods is a seminal variable influencing the fisher's decision to diversify. In the following study, we attempt to explore the livelihood landscape of marine fishers of the Porbandar district of coastal Gujarat and to capture the variables which best discriminate between low and high-income groups of fishers practising these livelihood portfolios using multivariate analysis. Among the diversified livelihoods studied, shrimp farming, combined with marine fishing, generated the highest mean annual income of INR 6,40,000 compared to others. The findings of our study imply that seven coefficients take higher values which were social, economic and institutional impact (0.805), followed by occupational status (0.699), family size (0.640), marital status (0.458), social participation (0.413), and marketing behaviour (0.361) and these possessed larger discriminatory ability in delineating between low and high-income levels. Overall, we infer that if livelihood diversification were successful in generating social, economic, and institutional impacts, they would have a greater probability of associating themselves with higher income levels. Fishers over the years have demonstrated their prowess to spread their risk across different occupational strategies, either in combination with marine fishing or standalone occupations, which would reduce the pressure on fishery resources.

Keywords: Diversification, Fishers, Livelihoods, Risks

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Curvularia leaf spot, re-emerging disease of maize: Status and perceptions

Khokhar, M. K.*, Mukesh Sehgal, Anoop Kumar and Acharya, L. K.
ICAR-National Research Centre for Integrated Pest Management, New Delhi 110012, India
*khokharmk3@gmail.com

Curvularia leaf spot of maize caused by *Curvularia lunata* (Wakker) Boedijn is an emerging disease and is considered a major threat to maize production, inflicting small losses to total wipe-out of the crop. It is more prevalent in areas where maize is cultivated in warm and humid climates with temperatures between 28-32°C at the flowering to grain filling stage. Owing to its seed and air-borne nature, there are several means to manage this disease. However, integrated disease management shall be the best choice among available management strategies. Information on disease distribution, symptoms, pathogen life cycle, yield loss, epidemiology, development of artificial diseases epiphytotics, and future research needs, especially biological control and sustainable integrated management strategies, are the need of the hour. The consolidated knowledge of pathogen biology and epidemiology shall help better manage the disease and reduce crop losses by the re-emergent Curvularia leaf spot.

Keywords: Biological control, *Curvularia lunata,* Host-pathogen interaction, Host plant resistance, Maize

Screening of potential biocontrol agents against important seed-borne plant pathogens of field crops

Gopi Kishan, Banoth Vinesh, Kuldip Jayaswall, and Sanjay Kumar

ICAR- Indian Institute of Seed Science, Kushmaur, Mau-275 103, Uttar Pradesh, India

*gopi.kishan1@icar.gov.in

Seed-borne diseases have been found to affect the growth and productivity of crop plants. Seeds are regarded as a highly effective means for transporting plant pathogens over long distances. Seed treatment with biocontrol agents along with priming agents may serve as an important means of managing many of the soil and seed-borne diseases, the process often known as biopriming. In the present study, surveys of different farmer's fields have been carried out, and rhizospheric soil samples were collected. Seven seed-borne pathogens–*Fusarium oxysporum* f.sp. *ciceri*, *Alternaria brassicicola*, *Rhizoctonia solani*, *Ustilaginoidea virens*, *Helminthosporium oryzae*, *Fusarium oxysporum* f.sp. *cumini* and *Neovossia indica* were isolated from different locations. Around 20 bacterial isolates of *Bacillus* and *Pseudomonas* have been collected from rice, wheat and chickpea fields of ICAR-IISS, Mau and adjoining farmer's fields. Five Biocontrol agents–*Trichoderma harzianum*, *Trichoderma viride*, *Trichoderma hamatum*, *Trichoderma asperellum* and *Pseudomonas fluorescens* were collected from NBAIM-NAIMCC, NBAIM, Mau. The radial growth measured in dual culture plates was used to select efficient *Trichoderma* spp. against different pathogens. Percent inhibition data shows that all the species of *Trichoderma* inhibited the growth of all the pathogens. *T. viride*, *T. harzianum*, and *T. hamatum* inhibited the growth up to 71.94, 80.23 and 71.99% respectively after seven days. *T. asperellum* was the least effective, with 56.79% mycelial growth inhibition.

Keywords: Biocontrol agents, Biopriming, Priming agents, Seed-borne pathogens, *Trichoderma*

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

New diseases in sugarcane germplasm at Kannur

Gopi, R., Chandran, K., Nisha, M., Mahendran, B. and Sony Jayaraman
ICAR-Sugarcane Breeding Institute, Research Centre, Kannur-670 002, Kerala, India
*ramaraj.muthu.gopi2@gmail.com

Sugarcane is one of the important cash crops cultivated in both tropic and subtropical parts of the world. The world's largest sugarcane germplasm is maintained at ICAR-Sugarcane Breeding Institute (SBIRC), Research Centre, Kannur, Kerala. Various diseases such as ring spot, smut, rust, wilt, pokkah boeng, yellow leaf disease, leaf fleck, and stalk rot have been recorded in sugarcane germplasm. During the survey and monitoring, some previously unrecorded diseases were found. The etiology of the diseases was studied, and pathogens were isolated, studied morphologically and identified through molecular methods. The new diseases recorded were brown spot, banded sclerotial disease, false floral smut, seedling and sett rot, red leaf disease, and red spot, etc. Brown spot is caused by *Cercoporas longipes* and found in hybrid and species clones. Banded sclerotial disease was caused by *Rhizoctonia solani*, first appearing in July at the grand growth phase stage. It caused symptoms such as short-of-wave pattern blightening symptoms on leaves and sheaths. Later, as the infection progressed, numerous sclerotial bodies were also seen. False floral smut is caused by the association of *Claviceps purpurea* and *Epicoccuma ndropogonis*, and a total of 24 clones were affected in the germplasm and appeared in December. Seedling and sett rot were found in clones such as 28 NG 36, IJ 76 560 of *S. officinarum*, LF 69-1080 and LF 70-920 of foreign hybrids and a few clones of waterlogging trials (WL-16-144, WL-16-116, WL-16-15) under field conditions at seedling stage. It is caused by *Athelia rolfsii,* and one or two-month-old plants were affected. Red leaf disease is caused by *Dimeriella sacchari* and appears as red spots or patches on the infected leaves. A total of 36 clones of hybrids and *Saccharum* species were affected. Red spot of varying lengths caused by *C. vaginae* was found only on the leaf sheath in many clones of germplasm throughout the season. Pathogen could not be isolated in the case of red leaf disease; however, the fruiting bodies and symptoms were confirmed through literature and by observing under a microscope. The diseases recorded in the study are minor; however, considering the change in climate scenario, any disease found to be insignificant at present may become a major one and hence needs continuous monitoring, epidemiological study and integrated disease management.

Keywords: Blightening, Epidemiological study, Integrated disease management, Pathogens, Sclerotial bodies

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Nutribars from nutricereals: A holistic approach to address malnutrition and promote sustainable nutrition

Beenu Tanwar*, Nistha Lamsal and Ankit Goyal

Mansinhbhai Institute of Dairy and Food Technology, Dudhsagar Dairy Campus, Mehsana-384 002, Gujarat, India

*beenutanwar@gmail.com

Malnutrition remains a critical global public health concern, with India grappling with significant portions of its population affected by various undernutrition and micronutrient deficiencies. This challenge is further exacerbated by the surge in fast food and snack consumption over the past decade, underscoring the imperative for accessible, nutritious, and functional food alternatives. In response, the development of nutribars using nutricereals emerges as a promising solution, providing a convenient and effective means to combat malnutrition while enhancing overall health and well-being. A blend of germinated and roasted Buckwheat and Finger Millet along with Wheat, Groundnuts, Oats, Quinoa, Chia seeds, and select ingredients was employed to create seven distinct variants of a novel nutrition bar alongside a control sample excluding Buckwheat and Finger Millet. These bars underwent comprehensive assessments encompassing proximate analysis, antioxidant capacity, total phenolic content, and sensory attributes. Bars enriched with buckwheat and finger millet exhibited a noteworthy increase in protein and fibre content, ranging from 10 to 60% and 15 to 81%, respectively, compared to the control sample. Moreover, they demonstrated significantly elevated levels of antioxidant potential and total phenolic content compared to the control sample, highlighting their nutritional superiority. The findings underscore the feasibility of incorporating various pseudocereals in crafting nutritionally enriched nutribars, poised to positively impact human health, fortify food security, and enhance economic efficiency. This innovative approach aligns seamlessly with the UN Sustainable Development Goals, particularly in the context of combatting malnutrition in India and as a model for global nutrition strategies.

Keywords: Buckwheat, Finger millet, Malnutrition, Millets, Nutribar, Nutricereals

Barley: A potent harbinger of good health

Singh, Omvir*, Kumar, L., Singh, J., Malik, R. and Lal, C.

ICAR-Indian Institute of Wheat and Barley, Karnal, Haryana, India

*omvir.singh2@icar.gov.in

Barley (*Hordeum vulgare* L.), one of the major cultivated cereals, had been domesticated about 10,000 years ago by Neolithic farmers. The Greek physician and probable father of medicine, Hippocrates, used to recommend barley gruel, a dish made by cooking barley in milk, as a nutritious food for mothers weaning infants and young children as it was easily digestible and provided essential nutrients and vitamins for their development. Ayurveda has mentioned barley as Yavam, which pacifies urinary tract diseases, corrects fat metabolism, and maintains *Pitta & Kapha dosha.* It reduces rhinitis, asthma, cough, pain in the thighs, and throat and skin diseases. Since ancient days, barley has been a common cereal consumed by people of all ages, providing them with essential nutrients, energy and sustenance. Barley is rich in natural and functional ingredients like soluble fibre -beta-glucan (5-10%) as compared to wheat (1.2%) and rice (0.82%), insoluble fibre, polyphenols, protein, minerals and vitamins, which render this wonder cereal as a functional food. Barley has low phytates (386 mg) compared to wheat (638 mg) per 100 gm of edible portion. Barley has resistant starch and a low glycemic index (28) as compared to wheat (>62), rice (>72), and millet (>55). Barley contains 50% less gluten than wheat. Beta-glucan is a favourite food of the friendly gut microbiome, which ferments beta-glucan in the gut and produces short-chain fatty acids like propionate, acetate and butyrate. These fatty acids prevent from occurring and/or cure some major chronic diseases like diabetes, bad cholesterol, heart and cardiovascular diseases, keep the brain healthy and improve cognitive functions, prevent certain types of cancers, keep the gut healthy and enhance the bioavailability of nutrients in the intestine. Hulless barley should be produced at farmers' fields and must be promoted as a healthy staple food. Scientists of the Barley Section of IIWBR developed pure hulless barley products like dalia, poori and parantha, which were adjudged better in taste than wheat. However, the taste of chapatis of barley flour was comparable to chapati made of wheat. There is a need to develop high-yielding hulless barley varieties to produce 35 million t of hulless barley to feed 250 million diabetic and other people suffering from chronic diseases in Bharat, which will save huge amounts of money for the government and people who are spending money on treatment on the chronic diseases.

Keywords: Barley, Beta-glucan, Chronic diseases, Food products, Gut microbiome

Double emulsion encapsulated *Emblica officinalis* extract reduces the high fructose diet-induced metabolic dysfunctions in rats

Neha Chaudhary, Savita Devi, Shaik Abdul Hussain*, Srinu Reddi, Suman Kapila, Satish Kumar and Latha Sabikhi, M. H.

Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India

*abdulndri2006@gmail.com

Emblica officinalis, also called Amla, is known for its bioactive principles. Amla extracts can be used as functional ingredients in health foods. However, the bioactivity of Amla extracts can be affected by food processing and storage conditions. Water-in-oil-in-water ($W_1/O/W_2$) double emulsion (DE) is regarded as a suitable encapsulating system for delivering bioactive molecules. In the present investigation, a DE matrix was optimised to encapsulate the Amla extract. The outer aqueous phase (W_2) was added with pectin, the middle oil phase (O) was added with PGPR, and the inner aqueous phase (W_1) was added with NaCl to prepare a stable DE matrix. Aqueous extract of 25% was encapsulated in DE. The confocal microscopy, particle size analysis, and sedimentation stability results revealed that the DE was stable for up to one month at refrigeration temperature. Amla extract encapsulated DE was fortified into mango-flavoured milk smoothie (ADEM) at 5, 10 and 15% levels. Based on the sensory and physico-chemical characteristics, 5% DE incorporation was finalised in mango flavoured milk smoothie. The ADEM had a proximate composition of 23.92 ± 0.24% total solids, 1.01 ± 0.01% protein, 0.78 ± 0.01% fat, 0.24 ± 0.01% ash, 0.67 ± 0.05% acidity, 4.2 ± 0.02 pH. The smoothie samples were analysed for physico-chemical, microbiological, and sensorial attributes for 42 days at 7-day intervals. No significant ($p>0.05$) changes were observed for the sensory attributes during the entire storage period. Non-significant ($p>0.05$) differences were observed in antioxidant activity and tannin content in ADE during 42 days of refrigerated storage. The overall bioaccessibility (after complete simulated digestion) of tannin from ADE and the optimised smoothie was 98.84 ± 0.41 and 89.47 ± 0.37%, respectively. The effect of feeding ADEM on high fructose diet (HfD) induced metabolic dysfunctions in rats was investigated. Physical and biological characteristics of animals, including stool weight, haematocrit status, cholesterol level, phenol levels and anti-oxidative status of rats, were evaluated after feeding experimental samples. ADEM feeding improved cardiovascular health in rats by enhancing the bioavailability of polyphenols. ADEM consumption also strengthened the anti-oxidative network by increasing the activity of superoxide dismutase and catalase enzymes and reduced lipid peroxidation in rats. It showed an antihypertensive effect by increasing HDL cholesterol and nitric oxide (NO) levels. ADE smoothie feeding reduced cardiac tissue degeneration, hepatic inflammation, and steatosis symptoms in HfD-fed rats. ADEM can be used as a functional beverage to meet the increasing consumer demand for health foods.

Keywords: Antioxidant, Cardiovascular disease, Double emulsion, *Emblica officinalis*, Smoothie

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Nutri-SMART Village by KVKs – A pathway for nutrition security in Central India

Singh, Shyam Ranjan K.[1]*, Shrivastava, V.[1], Raut, A. A.[1], Harish, M. N.[1] and Sharma, D. P.[2]

[1]ICAR-Agricultural Technology Application Research Institute, JNKVV Campus, Adhartal, Jabalpur-482 004, Madhya Pradesh, India
[2]Extension Services, JNKVV, Jabalpur, Madhya Pradesh, India

*srksingh.icar@gmail.com

The UN Sustainable Development Goal-2, aimed to end hunger by achieving food and nutrition security globally through sustainable agriculture by 2030. The worsening phase of malnutrition is hindering the growth of India into developed nation. Despite achieving food sufficiency, the problem of malnutrition is not solved, where about 70 per cent population of the country belongs to agriculture. Agriculture and nutrition are linked together as the outcome of agriculture is food and for nutrition, food is required. Nutrition-sensitive agriculture and nutrition-specific intervention will be helpful in achieving dietary diversity for the consumption of micronutrient-rich foods through nutrition garden, bio-fortified varieties, food fortification and value addition. The increased literacy and skills by extension activities and capacity development to combat the problem of malnutrition supported with water, sanitation, and hygiene (WASH) to ensure nutritional security in the country. The Krishi Vigyan Kendras (KVKs) of Madhya Pradesh and Chhattisgarh under the guidance of ICAR-ATARI Jabalpur and in convergence with Department of Women and Child Development, being conducted these activities in the rural village and transformed into Nutri-SMART Village (NSV). A total of 42 Nutri-SMART villages are functional in Madhya Pradesh, established by the KVKs functioning under this state. The present study was conducted in the three Nutri-SMART villages of the three KVKs viz., Morena, Chhindwara and Jabalpur. A total of 60 farm women to whom demonstrations on nutrition gardens (well-organized and nutri-dense crop plan was provided) were selected for the study. Nutrition gardens are targeted to supply micronutrients to reduce malnutrition especially hidden hunger in the rural area. Results showed that the demonstration of a nutrition garden increased the availability of vegetables and their consumption at the household level as yield (250 kg m^{-2} area) of vegetables enhanced by 25.00, 82.47 and 134.28 percent whereas consumption of vegetables (g day^{-1}) increased by 25.00, 58.23 and 104.99 percent in Nutri-SMART village of Jabalpur, Morena and Chhindwara KVKs, respectively; in comparison to farmers practice (unorganized and not following proper crop plan in scientific manner). Nutrition garden is also supplied micronutrients like iron, vitamin C, vitamin A and calcium to meet the nutritional requirement of all the family members especially women and children. Thus, nutrition gardens improve dietary diversity by increasing the availability of nutrient-rich foods in daily diets.

Keywords: Dietary diversity, Malnutrition, Nutrition garden, Nutrient supplementation

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Utilizing natural genetic diversity for micronutrient enhancement in nutri-cereal pearl millet

Nirupma Singh*, Singh, S. P., Chandan Kapoor, Bana, R. S.
ICAR-Indian Agricultural Research Institute, New Delhi110012, India
*nirupmasingh@rediffmail.com

Deficits in the micronutrients iron (Fe) and zinc (Zn) pose serious health risks, especially for those who are less fortunate and have fewer resources in the semi-arid tropical regions of the world. Pearl millet is typically grown in hot, dry semi-arid regions, where other crops typically fail. It uses little water and energy with high grain Fe and Zn content, metabolizable energy, high antioxidant, slowly digestible starches, dietary fibres, and favorable essential amino acid profile compared to many other cereals, therefore pearl millet is regarded as a nutri-cereal and climate-smart crop. A cost-effective and long-term solution to the problem of global micronutrient deficiency is biofortification. The issues of anaemia and stunted growth may be minimized by genetic enhancements of the iron (Fe) and zinc (Zn) content in pearl millet. For developing high-yielding cultivars' with high grain micronutrient content we need diverse breeding lines. In 253 advanced breeding lines and tested over two seasons the goal of the study was to ascertain the degree of variability, heritability, and diversity for grain Fe, Zn, productivity-related traits, oil, protein, and starch content. All of these variables showed considerable variation according to a pooled analysis of variance. The result revealed that Fe (30-101 mg kg^{-1}), Zn (24-76 mg kg^{-1}), protein (10-16%), fat (7.7-10.2 %) and starch (54–60.6%) content showed varied diversity.

Keywords: High-yielding cultivars, Micronutrient, Natural genetic diversity, Pearl millet, Zn and Fe

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Farm and Food-based Strategies for Combating Hidden Hunger

Exploring the economic viability of fishing crafts and gears: Essaying reflections from marine fisheries harvest from the south-east coast of India

Swathilekshmi, P. S*., Narayanakumar, R., Vipinkumar, V. P., Divu Damodaran, N., Johnson, B., Suresh Kumar Mojjada, Jose Kingsly, H. and Leslie, V. A.

ICAR-Central Marine Fisheries Research Institute, Kochi-682018, Kerala, India

*swathi.lekshmi263@gmail.com

Harvest fisheries remain the dominant source of supply of fish for answering the hunger pangs and catering to the nutritional security of the piscivorous population of the world. While the concern for overfishing of these resources causes an increasing cause of alarm for fishery managers, scholastic society, and government at large, knowledge of an interplay of the dynamics of costs and returns of such fisheries is of prime importance in enabling the fishers in placing a ceiling on fishing crafts which underperform, and which fail to yield tangible and remunerative outcome. Management of open-access water regimes is often shaped by the dynamics of capital investment, gross revenue, and other economic indicators at play, which are embedded in the social system in which fishery managers and resource harvesters operate. Our study is situated in the Kanyakumari district of Tamil Nadu, along the south-east coast of the Indian Peninsula, with its 63 km length of coastline and a history transgressed with political repercussions impacted by the artisanal and mechanized sectors, the state-run machinery as well as the ecclesiastical hegemony in influencing and coercing fisher behaviour. The economic performance of crafts and gears in the fishery deeply influences fisher behaviour in investing in this sector. To gain insights into this, data on mechanized crafts were collected from Chinnamuttom harbour and motorized units from Kanyakumari. Among the mechanized units, single-day gillnetter was found to have the highest capital productivity of 0.55. Among mechanized trawlers, mechanized single-day trawlers had the highest capital productivity of 0.60. The labour productivity was highest for mechanized multi-day trawlers (248.47 Kg/crew/trip). It was also observed that motorized single-day crafts had a high operating ratio of 0.71 and a low labour productivity of 14.37 Kg/Crew/trip. Our findings would be of help to fishery managers, resource users and governance for fishery management and for ensuring the conservation of fishery resources and sustaining the income of the fishers.

Keywords: Economics, Fisher behaviour, Management of fishery, Net operating income

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Impact of supplementation of an antioxidant-rich extract of seaweed *Eucheuma denticulatum* on feed efficiency, serum antioxidant status, immune response, gut pathogen count, and expression of intestinal and hepatic genes in broiler chickens

Shyam Paul [1]*, Kannaki Ramasamy [1], Hemanth Venkata[2], Savaram RamaRao[1], Mantena Raju[1], Sinduja Ramanan[2], SriSailaja Nori[2], Shrikumar Suryanarayan, Godumagadda Reddy[1], Prakki Kumar[1], Cadaba Prasad[2] and Rudra Chatterjee [1]

[1] ICAR-Directorate of Poultry Research, Hyderabad, India; pdpoult@nic.in
[2] Sea6 Energy Pvt Ltd, Centre for Cellular and Molecular Platforms, NCBS TIFR, Bangalore, India

* sspaulcirb@gmail.com.com

The plants rich in bio-actives and antioxidants are in focus for their immunity and health-stimulating potentials in different species of farm animals, but limited reports are available on the effects of antioxidant-rich seaweed extracts on feed efficiency, and other performance parameters, tissue antioxidant status, gut pathogen density, and potential to replace antibiotic growth promoters in broiler chickens or on their possible mechanism of action. The aim of the present study was to evaluate the effects of of antioxidant-rich dried aqueous extract of red seaweed *Eucheuma denticulatum* (referred to as PBD5) on above-mentioned parameters and their potential as an alternative to antibiotic growth promoter (AGP) in broiler chickens. *In vivo* feeding experiments were conducted on Vencobb 430Y chickens (1-42 days post-hatch). Each of the five diets (basal diet with three dosing regimes of PBD5 (0.25 g kg^{-1} for 6 weeks, 0.25 g kg^{-1} for 4 weeks or 1.0 g kg^{-1} for 2 weeks), a positive control [Virginiamycin (V), 0.04 g kg^{-1}] and a negative control (without any treatment) was fed to 13 pen replicates of five chicks in each. PBD5 at 1.0 g kg^{-1} diet for 2 weeks improved ($P < 0.05$) cumulative feed efficiency (4.65% improvement at 28 d, and 3.74% at 35 d) than the negative control (comparable to V) and the trend in improvement persisted up to 42 d. The group fed with PBD5 @ 1.0 g kg^{-1} for 2 weeks had significantly ($P < 0.05$) higher serum IgG level, glutathione peroxidise level, EE digestibility, expression of occludin and avian beta-defensin 4 gene in the gut and a trend of increased expression of growth hormone receptor gene in the liver as compared to the control with no significant effect on body weight, phytohaemagglutinin response or haemagglutination inhibition titer. At day 25 of age, fecal *E.coli* count was significantly ($P < 0.01$) lower in seaweed extract groups and the V group as compared to the negative control. Thus, it may be concluded that dried aqueous extract of *E. denticulatum* at 1.0 g kg^{-1} diet for 2 weeks can be used as an alternative to antibiotic growth promoter in broiler chickens to improve feed efficiency, reduce gut pathogen load and improved performance associated with increase in expression of gut immunity and growth hormone receptor genes.

Keywords: Alternative to antibiotic growth promoter, Broiler chicken, *Eucheuma denticulatum*, Seaweed

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Development of a core set from a large diverse rice (*Oryza sativa L.*) landraces population panel using agronomic data

Padma Thakur[1**], Vandana Sharma[1], Neha Sajwan[1], Devendra Pratap Singh[1], Shubham Kumar Singh[1], Rajneesh Kumar[1], Shashi Pandey[1], Ayush Raj Singh[1], Neha Sharma[1], Gopala Krishnan, S.[1*], Vinod, K. K.[1], Ranjith Ellur[1], Haritha Bollinedi[1], Prolay Bhowmick[1], Bashyal, B. M.[1], Akshay Singh[2], Nancy Sharma[2], Sabina Rana[2], Avantika Maurya[2], Rachael John[2], Praful Jayaswal[2], Rakesh Singh[2], Khan, Z.[2], Jameel Akhtar[2], Bhardwaj, R.[2], Sarika Jaiswal[3] and Singh, A. K.[1]

[1]ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi -110 012, India
[2]ICAR- National Bureau of Plant Genetic resources, Pusa Campus, New Delhi-110 012, India
[3]ICAR-Indian Agricultural Statistics Research Institute, Pusa, New Delhi -110 012, India

*gopal_icar@yahoo.co.in

**padma.13291@gmail.com

A population size of 13,517 rice genotypes comprising traditional landraces and five checks (Pusa 44, IR 64, Jaya, Swarna and Pusa Sambha 1850) were grown in augmented design at ICAR- IARI, Farm, New Delhi. A total of 3,639 landraces along with checks were harvested which were photo-insensitive in the New Delhi region. These genotypes are being evaluated for seven biotic stresses (Bacterial leaf blast, Rice blast, Bakanae, Sheath blight, False smut, Brown plant hopper and Nematode), six abiotic stresses (Drought, Submergence, Anaerobic germination, Nitrogen use efficiency, Phosphorus use efficiency and Photosynthesis) and quality parameters over 11 locations throughout the country. A sample population of 1,317 rice landraces was evaluated for 6 agro–morphological traits [plant height (PH), panicle length (PL), number of panicles per plant (NPPP), number of tillers per plant (NTPP), panicle exertion (PE) and yield per plant (YPP)] by principal component analysis (PCA) to determine the pattern of genetic diversity and relationship among the individuals. K-means clustering was done to identify the sample population structure. The traits NPPP, NTPP and YPP showed the highest variability in the population. The PCA revealed that the first three principal components (PC) were significant and explained 76.4% of the total variability. The percent variance accounted by the PC1, PC2 and PC3 were 34.7%, 23.15% and 18.54% respectively. The largest contribution to PC1 was from NPPP (43.69%) followed by NTPP (42.16%) and YPP (11.00%). The largest contributor to PC2 was from PH (44.68%) followed by PL (45.46%) and PE (6.70%). Similarly, PC3 had contributions from PE (56.25%), YPP (29.26%) and NTPP (4.97%). The clustering process grouped the experimental population into four groups. Totally 405 genotypes (30.8%) are grouped in group 1, the second group comprised 407 genotypes (30.9%), group 3 included 295 landraces (22.4%) and group 4 comprised 210 genotypes (15.9%). A core set of 132 genotypes were drawn from the population with 40 genotypes representing group 1, while 41 genotypes representing group 2, 30 and 21 genotypes representing group 3 and 4, respectively. The centroid of different traits of each core was at par with the corresponding group mean. The core sets had a cumulative correspondence of 0.999 with the base population for all the traits evaluated. The core set can be further used for the selection of diverse genotypes for downstream plant breeding applications. The identified core set can also be used for GWAS analysis.

Keywords: Core set, GWAS, PCA, Rice landraces

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Evaluation of BNI introgressed lines and trait incorporation in Indian wheats

Mishra, C. N. *, Swati Sharma, Sushma Kumari Pawar, Disha Kamboj, Mukesh, Amit Kumar[1], Satish Kumar, Tyagi, B. S. and Gyanendra Singh

ICAR-Indian Institute of Wheat and Barley Research, Karnal -132 001, Haryana, India
ICAR-North Eastern Hill Region, Umiam-793 103, Meghalaya, India

*Chandra.Mishra@icar.gov.in

The Biological Nitrification Inhibitor (BNI) trait increases nitrogen uptake and improves ammonium assimilation by suppressing nitrification activity in wheat cultivars. The BNI trait has been introgressed into the wheat genotypes in Mexican wheats. These introgressed lines along with their recipient parents (Munal, Rolfs and Vorobey) and check varieties DBW187, DBW303, and DBW371 were evaluated under four different nitrogen management levels viz., 0%, 50%, 75% and 100% of recommended nitrogen dose at ICAR-IIWBR, Karnal for the sixteen agro-morphological, physiological and quality attributes. The data was subjected to following SAS 9.3. Analysis of Variance revealed that the mean sum of squares due to genotype and management were highly significant for all studied traits except peduncle length, biomass, CT and iron content. The Normalized Difference Vegetation Index (NDVI) data was recorded at 16 phenological stages throughout the crop season. The Multivariate Analysis of Variance for the dependent variable NDVI suggested that the variation due to Time×Genotype and Genotype×Management was significant. The significant improvement among traits was observed for plant height, spike length, number of spikes, flag leaf length, flag leaf width, biomass, protein content and grain yield on increasing the nitrogen level from 75 to 100%. On comparing BNI wheat with recipient parent using Tukey's Grouping for Means of Genotype, the genotypes BNI-Munal and Munal differ significantly for days to heading, spike length, flag leaf length, peduncle length, 1000-grain weight and harvest index. The PCA revealed that the first five main components account for 90.66% of the total variation, with PC1 having the highest contribution (37.05%) among all. The major contributing traits for diversity in PC1 were flag leaf width and harvest index followed by spike length in PC2. The polygonal view of the genotype by trait biplot showed a positive association between grain yield and 1000-grain weight and harvest index but low magnitude and negative association with days to heading and biomass across genotypes. The study indicated that 25% of urea as fertilizer in the field can be saved when adopting BNI-derived wheat genotypes. For incorporation of this trait in Indian wheat varieties, different crosses have been made by using donor BNI Munal and recipients DBW327, DBW370, DBW71, DBW72, DBW187, DBW222, DBW252, PBW703, PBW698, PBW765, DBW332, DBW110, DBW90 and DBW303. A tightly linked molecular marker 24-s81287 with BNI trait localized on 3B chromosomes has been validated and will be used for MAS and further incorporation process.

Keywords: BNI, Grain yield, Nitrogen, Wheat

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Assessing peroxide levels and oxidative stress induced by fish oil supplements: Implications for product quality and cellular health

Vishnu Kalladathvalappil Venugopalan and Mohamed Hatha Abdulla

Department of Marine Biology, Microbiology and Biochemistry, School of Marine Sciences, Cochin University of Science and Technology (CUSAT), Ernakulam, Kerala, India

*vishnukalladath@gmail.com

Fish oil supplements have gained wide acceptance as a nutritional source of omega-3 fatty acids, which are known to confer numerous health benefits, particularly in cardiovascular health. However, the oxidative stability and peroxide nature of these supplements have not been extensively investigated. In this study, we aimed to evaluate the oxidative stability of commercially available fish oil supplements and assess their impact on cardiomyoblast cell lines. Using established methods, we measured the peroxide values (PV) of a range of fish oil supplements currently marketed. Surprisingly, our results revealed that a significant proportion of these supplements exhibited elevated peroxide levels (5 to 10 meq L^{-1}), indicating a state of oxidation. Furthermore, we investigated the effects of oxidized fish oil supplements on cardiomyoblast cell lines *in vitro*. We found that exposure to oxidized fish oil supplements resulted in a marked decrease in the activity of antioxidant enzymes, including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), in the cardiomyoblast cell lines. This suggests a compromised antioxidant defence system in response to the oxidative stress imposed by the supplements. Moreover, the opposite effect was observed in these cells, with a decrease in cell viability and an increase in oxidative damage markers. These findings highlight a potential concern regarding the quality and efficacy of fish oil supplements available in the market. The observed oxidation of these supplements and the subsequent detrimental effects on cardiomyoblast cell lines raise questions about their utility in promoting cardiovascular health. Given the widespread use of fish oil supplements and their perceived benefits, further investigations are warranted to elucidate the underlying mechanisms responsible for the observed effects. Moreover, efforts should be made to enhance the oxidative stability of fish oil supplements and develop standardized methods for evaluating their quality.

Keywords: Antioxidant enzymes, Cardiovascular health, Fish oil supplements, Oxidative stability, Oxidative damage, Peroxide values.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Hybrid wheat development: Progress and challenges

Vishnu Kumar*, Tyagi, B. S., Vikas Gupta and Gyanendra Singh
ICAR-Indian Institute of Wheat & Barley Research, Karnal, Haryana, India
*vishnupbg@gmail.com

India witnessed an all-time high wheat production of 112.74 Mt during the year 2022-23, which accounted for 34.10 % of the total food grain. Concurrently, India also surpassed China and ranked first in the world's human population of 1.42 bn (UN, DESA). To feed 17.76 % global population, combating climate change, ensuring nutritional security and for maintaining agri-export some new frontier avenues are required in staple food crops like wheat. Hybrid development is one of the key areas to break yield plateau and to manifest the heterosis for production and productivity enhancement. After utilizing different nuclear and cytoplasmic interactions, the *Triticum timopheevii* Zhuk. based T-CMS male sterility and fertility system was adopted by wheat breeders for developing wheat hybrids. Though the T-CMS derived lines are stable for male sterility but effective fertility restoration is not satisfactory. In this direction, transfer of male sterility in novel high yielding genetic backgrounds, conversion of new restorer lines, heterotic pool development, hybrid development and evaluation are essentially required. To overcome the adverse environmental effects of CHA, the cytoplasmic male sterility system was explored and significant progress has been made. At ICAR-IIWBR, the male sterility transfer is underway into the high yielding and rust resistant newly released bread wheat varieties, namely DBW222, DBW187, DBW296, DBW303, DBW327, PBW826 and WH1270. The restorer lines were genetically enriched for incorporation of rust resistance gene(s). The developed hybrids were evaluated in multi-location trials and average yield above 57 q ha^{-1} and 48 q ha^{-1} were observed under timely and late sown conditions, respectively. However, the yield levels were lower than the released best check varieties but were still larger than the previous year trials. The developing hybrids in the combination of recently released wheat varieties will further improve the genetic gain.

Keywords: CMS, Hybrid, Rust resistance, Wheat

Influence of foliar application of 'PGR's and nutrients for enhancing the productivity of soybean under rainfed condition

Pawar, K. N.

University of Agricultural Sciences, Dharwad, Karntaka, India

kasu_pawar@rediffmail.com

Soybean (*Glycine max*) is a predominant edible plant and a major supply of plant protein and oil worldwide. Global demand for soybeans keeps increasing as its seeds provide essential protein, oil and nutraceuticals. In a quest to meet high demands for soybean, it has become essential to introduce agro-technical methods that promote adaptability to complex environments, improve soybean resistance to biotic stress, and increase productivity. Plant growth regulators are mainly exploited to achieve this due to their crucial role in plant growth and development. The present study was conducted at Agricultural Research Station, Dharwad Farm, University of Agricultural Sciences, Dharwad, India during the years 2020-21 and 2021-22 to investigate the influence of foliar application of plant growth regulators (PGR's) and nutrients for enhancing the productivity of soybean under rainfed conditions. The experiments consist of nine treatments viz., NAA 20 ppm NAA 30 ppm, GA 30 ppm, GA 40 ppm, GA 50 ppm urea 2%, KNO_3 1%, pulse magic 1% and control. Among all the treatments foliar application of GA 40 ppm at flowering and pod formation stage recorded a higher yield (2158 kg ha^{-1}) compared to control (1595 kg ha^{-1}) and also recorded a higher photosynthetic rate (29.35 µmol CO_2 m^{-2} s^{-1}), proline content (3.05 µmol g^{-1}), oil content (18.93%), protein content (39.10%), chlorophyll content (3.21 mg g^{-1} fresh weight) and also recorded higher relative water content in GA 40 ppm (82%) compared to control (73%).

Keywords: Chlorophyll content, GA, Oil, Photosynthetic rate, Protein, Soybean, Yield.

Optimum soil moisture regime during different phenological growth stages of Thompson Seedless (*Vitis vinifera*) grape

Shikhamany, S. D.* and Sumit Rameshraddy

R&D Unit, Agrihawk Technologies Private Limited, 523, 24th Main Rd, Sector 2, HSR Layout, Bengaluru 560102, INDIA

*surupa@fyllo.in

Grape cultivation in India is concentrated in the tropical region, where irrigation is indispensable because of scanty rainfall and high evaporation. Hence, the present investigation was carried out to determine the optimum soil moisture regime during different phenological growth stages in sandy loam soils for Thompson Seedless grape on Dog Ridge rootstock. The stages after back pruning were S1(1-40 days), S2 (41-70 days), S3 (71-120 days), and S4 (121 days–fruit pruning) corresponding respectively to the active shoot growth period, fruit bud differentiation, fruit bud development and shoot maturity. Similarly, the four stages after fruit pruning were S5 (1-40 Days), S6 (41-70 Days), S7 (71-110 days), and S8 (111- harvest), respectively corresponding to active shoot growth, flowering and berry set, berry growth, and berry ripening. Soil moisture levels in kPa were recorded daily by the moisture probe, "nero" of <fyllo.in>, with dual sensors at 30 and 60 cm depth in the feeder root zone. Vines were spaced at 2.75 × 1.5 m in all the vineyards. Soil moisture levels were averaged for each stage and depth. Regression analysis determined the optimum soil moisture levels during the eight stages at each depth. Soil moisture at 30 cm depth correlated with yield better as compared to 60 cm during all stages except Stage 4. Soil moisture levels of 31.3 and 33.1 kPa during Stage 7 at 30 and 60 cm depth respectively accounted for 62 and 61.1 per cent variation in yield. The optimum soil moisture was 41.6 kPa during Stage 2 at 60 cm depth corresponding to a yield of 6.08 t ha^{-1}. This stage being the period of fruit bud differentiation, low soil moisture levels are essential to promote it in Thompson Seedless, particularly on vigour imparting rootstock Dog Ridge. Similarly, the optimum soil moisture level of 33.1 kPa during Stage 7 at 60 cm depth was associated with a yield of 6.44 t ha^{-1}. Stage 7 being the stage of berry growth, yield response to water was high. On the other hand, the yield response to water during Stage 8 at 30 cm depth was low as evidenced by the soil moisture level of 13.5 kPa corresponding to a yield of 4.09 t ha^{-1} Stage 8 is the period of berry ripening, but not of berry growth. The optimum soil moisture regime at different depths during different stages was determined based on the lower and upper critical limits of soil moisture corresponding to 90% of the maximum yield.

Keywords: Berry ripening, Grape yield, Soil moisture regime, Stages and depths, Thompson Seedless

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Mass seed production and rearing of small indigenous fish mola carplet (*Amblypharyngodon mola*) to promote nutrition-sensitive aquaculture

Rashmi Ranjan Das*, Kalpajit Gogoi, Saurava Kumar Biswal, Francois Rajts and Sourabh Kumar Dubey

WorldFish, New Delhi 110008, India

*r.ranjandas@cgiar.org

Nutrition-sensitive aquaculture is a transformative approach that aims to enhance nutritional outcomes by promoting nutrient-rich small fish alongside traditional carp polyculture. Integrating small indigenous fish species (SIS) into conventional carp farming is seen as a promising solution to address micronutrient deficiencies, especially among women and children. At the forefront of this promotion is the introduction of the mola carplet (*Amblypharyngodon mola*), a remarkable SIS boasting elevated levels of vital micronutrients such as calcium, iron, vitamin A, and vitamin B12. The research commenced with successful mass seed production of mola and its subsequent culture in carp polyculture ponds at a farmer's field in Jagatsinghpur district, Odisha. Pioneering techniques combining hormone administration, using a Synthetic GnRH analogue, and environmental manipulation were employed to stimulate seed production. The inducing hormone was administered at 0.25 and 0.5 mL kg^{-1} of body weight for males and females, respectively. Breeding was facilitated in specially designed tanks with a double hapa arrangement, while an aeration tower ensured a continuous supply of oxygen-rich water to enhance breeding performance and larval survival. Depending on seasons, temperature and maturity status of brooders, the protocol allowed 1.5-3.0 kg of matured female mola to produce roughly 1 million spawns. Furthermore, a successful nursery-rearing protocol for mola seed was developed, with a stocking density of 500 m^{-2} yielding higher fry harvests after 21 days with a survival rate of over 50%. In 2022, more than 30 farmers received mola spawn and fry from the partner hatchery. The stocking densities were recommended at 50 numbers m^{-2} for spawn and 5-10 numbers m^{-2} for fry in carp polyculture ponds. Stocking hatchery-produced mola seed in dried and newly water-filled ponds was found to be ideal to avoid predation. After 3-4 months of stocking, mola was ready for consumption or sale, and frequent partial harvesting was recommended to increase household consumption and manage overpopulation by auto recruitment. Although not all ponds were fully harvested, mola production in carp polyculture ponds ranged from 500-550 kg ha^{-1} y^{-1} without additional management. While mola can breed naturally in the ponds and continue to produce, the research recommends stocking hatchery-produced uniform-sized mola seed annually for several advantages. It is recommended to stock the mola seeds in a carp polyculture pond well before the carp fingerlings for better survival. This research presents a significant contribution to scaling nutrition-sensitive carp-mola polyculture by developing mass seed production and rearing technology of mola.

Keywords: Mass seed production, Mola carplet, Nutrition-sensitive aquaculture, Polyculture, Small indigenous fish species (SIS).

Induced breeding and mass seed production of pool barb (*Puntius sophore*) – A nutrient-dense small indigenous fish species in Assam

Kalpajit Gogoi*, Ruhul Amin, Biswajyoti Sarma, Francois Rajts, Sourabh Kumar Dubey and Arun Padiyar

WorldFish, New Delhi-110 008, India

*Kalpajit.gogoi@cgiar.org

Integrating small indigenous fish species (SIS) into conventional carp polyculture systems holds great promise for addressing micronutrient deficiencies in nutritionally disadvantaged human landscapes. Among the diverse SIS in Assam, the pool barb (*Puntius sophore*) stands out as an exceptional candidate, abundant in vital micronutrients such as calcium and vitamin B12. Previous studies have already demonstrated the successful incorporation of pool barb into composite culture with carps, making it an ideal species for promoting nutrition-sensitive aquaculture approaches in the region. This research presents successful captive breeding and seed production of pool barb conducted at a farmer's field in the Darrang, Assam. The study utilized pioneering techniques that combined hormone administration, using a Synthetic GnRH analogue, and environmental manipulation to stimulate seed production. For females, the diluted inducing agent was administered through the peritoneal cavity at two different doses of 0.3 and 0.5 mL kg^{-1} body weight, while males received a single hormone dose of 0.2 mL kg^{-1} body weight. The sex ratio was maintained at 1:1. The brooders' average length and weight were recorded at 6.25±0.35 cm and 7.34±0.42 g for males, and 10±0.54 cm and 12.15±1.32 g for females, respectively. Breeding was conducted in rectangular cement tanks, featuring a double hapa arrangement (10 mm inner hapa and 250-µ outer hapa) and continuous oxygen-rich water showering. To facilitate egg-laying, an artificial grass substratum was provided at the bottom of the inner hapa. Latency periods for breeding ranged from 8-10 h, with a temperature of 26.5 °C. Fertilized eggs, displaying adhesive light brownish coloration, hatched after 13-15 h of fertilization at 26.5-27.8°C. Notably, breeding performances were significantly enhanced ($P<0.05$) with the inducing agent administered at 0.5 mL kg^{-1} body weight for females, resulting in the highest number of egg output (3,690 eggs), fertilization rate (84.36%), and hatching rate (88.75%). The research protocol facilitated the production of approximately 1 million spawns from a total of 2.5-3.0 kg matured female pool barb, with the yield varying based on seasonal, temperature, and maturity factors of the brooders. Through the successful development of mass seed production and rearing technology of pool barb at the farmer's field, offers a significant contribution to accelerate ongoing efforts in scaling nutrition-sensitive carp-SIS polyculture in Assam. These findings underscore the potential of sustainable aquaculture practices to combat nutritional challenges and herald a promising food secured future.

Keywords: Mass seed production, Nutrition-sensitive aquaculture, Pool barb, *Puntius sophore*, Small indigenous fish species (SIS).

Elucidating the genetic variability for grain zinc and iron content among indigenous wheat germplasm

Sawan Kumar, Ravish Chatrath*, Satish Kumar, Mishra, C. N., Arun Gupta and Gyanendra Singh

ICAR- Indian Institute of Wheat and Barley Research, Karnal-132001, Haryana, India

*r.chatrath@gmail.com

Biofortification of staple crops with key micronutrients is a sustainable, cost-effective and vital strategy for decreasing malnutrition and alleviating nutritional security. Identification of wheat accessions with high nutritive value is a necessary step to develop nutritionally enriched varieties in near future. A total of 215 wheat germplasm lines were selected from 2309 lines based on high grain iron (Fe) and zinc (Zn) content, and evaluated along with four commercial high yielding checks for various grain yield attributes and quality traits at ICAR-IIWBR, Karnal during *Rabi*, 2022-23. Grain Zn and Fe content were determined using Non-destructive, Energy Dispersive X-Ray Fluorescence Spectrophotometer (ED-XRF). Data was subjected to variability analysis, Pearson's correlation and Non-hierarchical clustering. Significant heritable variation observed among the genotypes for grain yield, plant height, effective tillers per plant, test weight, grain Zn and Fe content. Grain Zn ranged from 28.30 to 58.40 mg kg^{-1} with an average of 45.34 mg kg^{-1} whereas grain Fe content ranged from 30.60 to 64.90 mg kg^{-1} with an average value of 44.78 mg kg^{-1}. A total of 157 accessions had high grain Zn (>40 mg kg^{-1}) coupled with high Fe (>40 mg kg^{-1}) content. These lines are being further subjected to validation of known quantitative trait locus (QTLs) associated with high grain Zn and Fe in wheat using SSR markers. High heritability coupled with high genetic advance was observed for grain yield (q ha^{-1}) and days to 50 percent flowering, whereas high genotypic coefficient of variation (GCV) with phenotypic coefficient of variation (PCV) was recorded for grain yield (q ha^{-1}), effective tillers/plant and spike length. None of the germplasm lines exhibited significantly high grain yield (q ha^{-1}) than the best check DBW-187. However, 21 had high Fe and Zn content as compared to best quality check WB-2. Correlation studies depicted a strong positive correlation of grain iron with zinc content (0.46). The negative correlation of Zn content was observed with grain yield (-0.26) and spike length (-0.18). Furthermore, the studied germplasm was grouped using Euclidean distance with complete linkage method. The non-hierarchical clustering categorized the germplasm into six clusters at 33% similarity level. The highest inter-cluster distance was found between cluster V and VI, followed by cluster II and VI, propounding that genotypes included in these clusters possesses wide genetic diversity for studied traits. Therefore, a wide range of variability for both agronomic traits and micronutrient content validated the scope of improving for Fe- and Zn-rich high yielding wheat cultivars.

Keywords: Biofortification, Germplasm lines, Grain iron and zinc, Quantitative trait locusts, Wheat

Tropical Chlorophytan seaweeds as potential storehouse of nutritional and bioactive properties

Shilpa Kamalakar Pai *, Kajal Chakraborty and Ashwin Ashok Pai

ICAR-Central Marine Fisheries Research Institute, Ernakulam North P.O., P.B. No. 1603, Cochin-682018, Kerala, India

**shilpa170398@gmail.com*

Edible seaweeds, also known as sea-vegetables are highly regarded as delicacies in Asian countries such as Japan, Korea, and China. They offer numerous nutritional benefits and are often favored over pulses like soybeans due to their high protein content. Notably, red algae varieties like *Porphyra tenera* (nori) and *Palmaria palmata* (dulse) have even higher protein levels. The primary objective of this study is to assess the nutritional aspects of seaweeds belonging to the family Chlorophyceae, encompassing analyses of amino acids, lipids, fatty acids, and mineral compositions. The seaweeds under consideration include *Ulva linza*, *U. fasciata*, *U. lactuca*, *Halimeda macroloba*, *H. gracilis*, *Chaetomorpha antennina*, and *C. linum*. Additionally, the study aims to evaluate the anti-inflammatory properties of these seaweeds. The results of the analysis revealed a significantly higher n-3/n-6 polyunsaturated fatty acid ratio in *U. lactuca* (2.14 ± 0.22), as well as a greater percentage of total polyunsaturated fatty acids (19.11 ± 0.01%). This suggests that including *U. lactuca* in the diet could have substantial health benefits. *C. linum* exhibited higher anti-inflammatory activity (IC_{50} 1.60 ± 0.10 mg mL^{-1}) compared to other seaweeds. The *U. linza* demonstrated higher protein content (10.5 mg g^{-1}) along with elevated levels of essential amino acids like methionine (6.37 ± 0.02 mg mL^{-1}), which are comparable to those found in leguminous plants. This highlights its potential as an alternative food source to combat malnutrition among coastal populations. Additionally, *C. linum* showed a considerable proportion of minerals such as calcium, magnesium, and phosphorous, which could be beneficial for bone mineralization. Furthermore, the organic extract of *H. macroloba* exhibited greater anti-inflammatory potential with a lower IC_{50} value (1.51 ± 0.10 mg mL^{-1}) compared to other seaweeds considered in this study. Overall, these seaweed species demonstrated promising nutritional and bioactive properties, positioning them as potential high-health food options. Consequently, it opens new avenues for developing novel functional food compositions that harness the benefits of these seaweeds.

Keywords: Anti-inflammatory, Chlorophytan seaweeds, Essential amino acids, Nutritional sources. Polyunsaturated fatty acid

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Climate resilient sugarcane production for sustaining food and energy security in India: Future road map and policies

Gangwar, L. S., Sharma, A. K., Viswanathan, R. and Rajesh Kumar
Indian Institute of Sugarcane Research, Lucknow-226 002, Uttar Pradesh
* lalscari@gmail.com

Sugarcane cultivation and processing for food and energy security has concerns to conserve nature resources, enhance per unit productivity of irrigation water as it is called a water guzzler crop. This paper has examine comparative economics of organic sugarcane (OS) and inorganic (IS) farming system. It provides livelihood to 7.5-8.0 million farmers and 1.4 million workers in sugar mills and ancillary industries. The sugarcane cultivation area is hovering 5.15 million ha, annual production 439.42 million tons with 83.9 tons productivity per ha. The mono sugarcane cultivation over the years have reduces Soil Organic Corban (SOC), micro-organism, depletes micronutrients and soil fertility. The natural/organic sugarcane farming (NSF) is a system of crop production without chemical fertilizers and pesticides, works on principal of agro-waste recycling, reproductive and regenerative capacity. It has indigenous traditional knowledge (ITKs) and tradition of natural farming to tap organic products market. It has implemented a National Programme on Organic Production (NPOP) for accreditation of certification bodies, standards for organic production to promote organic farming and products marketing. This accreditation system and standards have been recognised by the European Union and Switzerland for unprocessed plant products equivalent to their standards. The aggregate area under organic certified farms registered under NPOP was 10.17 million ha, produced 2.9 million tons of certified organic products such as cereals, millets, sugarcane, pulses, fruits and vegetables etc. Keeping in view, significance of organic sugarcane farming (OSF) in enhancing farmers' income and sustainability of production ecosystem, present study is designed (i.). To assess input use, cost, yield, return, land and water conservation on organic sugarcane (OS) vis-à-vis inorganic sugarcane (IS) farms. (ii.) To identify socio-economic constraints faced by farmers, relevant issues and way forward to enhance profitability. The results revealed that OS is labour-intensive and cost of cultivation was less on account of chemical fertilizers, irrigation, seeds and agrochemicals savings. The application of organic inputs was more on OS as compared to IS farms. The inputs demand may increase with area expansion under OS. The involvement of self-help groups for production of certified inputs could be beneficial for supply of organic inputs. The OS cost of cultivation was ₹ 162,866 as compared to ₹239,658 per ha on IS, reveals 32.04 % cost saving. The cane yield on OS farms was 16.40 % less as compared to IS farms. The economic benefits and social costs involved in OS should be quantified to suggest policies.

Keywords: Low input, Organic farming, Sugarcane, Sustainable production, Yield.

Development and quality assessment of millet-legume based vermicelli

Durga Priyadarshini. R.* and Annette Beatrice, D.

Department of Home Science, Women's Christian College, Affiliated to the University of Madras, Chennai, Tamil Nadu, India.

*durgapriyadarshinir@gmail.com

Vermicelli is a traditional Indian food product commonly consumed by all age groups in the form of upma, kheer, noodles. Vermicelli is made using refined cereals which lack essential nutrients. Millets and legumes are excellent sources of nutrients, especially protein and micronutrients. Incorporation of these in vermicelli offers a more balanced and nourishing dietary option. Furthermore, utilizing locally available millets and legumes will support local agriculture and enhance food sovereignty. Hence, the aim of the study was to develop value-added vermicelli by incorporating barnyard millet and legume flour. Refined wheat flour, barnyard millet flour (*Echinochloa frumentacea*) and legume flour (*Phaseolus vulgaris* L.) in the ratio of 80:10:10, were homogenized with salt and water, and extruded using single screw extruder. Sensory attributes, the nutritional profile, texture, cooking quality and shelf life were assessed using standard methods. The mean overall acceptability score of the millet-legume based vermicelli was found to be 7.25 ± 0.68. Analysis of the nutrient profile revealed the following (per 100g): energy (374.04 ± 0.69 kcal), carbohydrate (77.92 ± 0.16 g), protein (13.88 ± 0.04 g), fat (0.76 ± 0.02 g), crude fiber (<0.1 g), ash (1.29 ± 0.04 g), calcium (38.93 ± 0.16 mg), potassium (244 ± 1.56 mg), iron (1.77 ± 0.14 mg) and magnesium (52.64 ± 0.01 mg). Textural analysis of value-added vermicelli demonstrated a hardness of 341.88 ± 0.30 g and adhesiveness of 0.14 ± 0.02 g sec^{-1}. The water absorption index was 296.66 ± 15.27 g $100g^{-1}$ and the optimal cooking time was found to be 4.15 ± 0.03 minutes. Shelf life analysis of this vermicelli, evaluating key parameters at day 1, 30, and 60 revealed that water activity (0.331 ± 0.01, 0.359 ± 0.01, 0.372 ± 0.01), moisture content (6.61 ± 0.07%, 6.57 ± 0.14%, 6.1 ± 0.4%), and total plate count (12×10^1 CFU g^{-1}, 24×10^1 CFU g^{-1}, 39×10^1 CFU g^{-1}) increased gradually and were within limits, while pH (6.28 ± 0.06, 6.18 ± 0.11, 5.85 ± 0.11) decreased thereby enhancing stability. Yeast and mould count remained below detectable limits (<10 CFU g^{-1}). The *Escherichia coli* was not detected. These findings confirm that the newly developed vermicelli was microbiologically safe and shelf stable upto 60 days of storage at room temperature. Value-addition of vermicelli using millet and legume flour enhanced the nutritional content while preserving its desirable qualities, thus contributing to healthier dietary options and improved consumer well-being.

Keywords: Barnyard millet, Legume, Nutrient dense, Value-addition, Vermicelli.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Comparative advantage of zero tillage over conventional tillage for potato in rice-potato cropping system

Shiv Pratap Singh*, Sadawarti, M. J., Rawal, S., Dua, V. K., Sharma, S. K. and Singh, Y. P.
ICAR-Central Potato Research Institute, Shimla-171 001, Himachal Pradesh, India
*drshivpratapsingh@yahoo.co.in

Potato production is associated with different practices such as planting, hilling, and harvest that significantly disturb the soil environment with heavy machinery. A field study was conducted at ICAR-Central Potato Research Institute RS, Gwalior (M.P.) during the Rabi season of 2020–21 with nine treatment combinations having three rice cuttings i.e. ground level, at 30 cm height and 60 cm height and three tillage *i.e.* tuber zone tillage, tuber row zone tillage and normal tillage. Treatments were replicated thrice. Highest tuber emergence (98.3%) was recorded with Ground level rice harvest + tuber row zone tillage. Rice harvest at 60 cm height + tuber row zone tillage recorded highest plant height (41.3 cm). Highest fresh haulm weight/plant was recorded with rice harvest at 30 cm height + normal tillage (173.7 g). Highest tuber yield/plant was recorded with rice harvest at 30 cm height + normal tillage (144.9 g). Highest total tuber was recorded with ground level rice harvest + tuber row zone tillage (575.7 thousand ha^{-1}). Highest total tuber yield was recorded with rice harvest at 30 cm height + normal tillage (16.5 t ha^{-1}) which was significantly higher than Ground level rice harvest + normal tillage but statistically same with all other treatments. Highest net return was recorded with rice harvest at 30 cm height + normal tillage (Rs. 27.3 thousand ha^{1}). Highest number (31.3%) and yield (28.9%) of green tuber was recorded with rice harvest at 30 cm height + tuber zone tillage. Adoption of conservation tillage may enhance crop productivity and environmental quality.

Keywords: Normal tillage, Tuber row zone, Tuber zone, Zero tillage.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Comparative advantage of soil test based NPK applications over their recommended doses in potato under rice-potato cropping system

Singh, R. K,*, Shiv Pratap Singh, Sadawarti, M. J., Sarla Yadav, Vinod Kumar and Brajesh Singh

ICAR-Central Potato Research Institute, Shimla 171 001, Himachal Pradesh, India

*rksingh.cprs@gmail.com

A sufficient supply of mineral nutrients can fortify the potato plant against adverse growth conditions, is crucial for achieving high yield and is essential for producing potatoes that meet the desired quality requirements. Nitrogen (N), phosphorous (P) and potassium (K) are the nutrients which are most commonly fertilised in potato production. A field study was conducted at ICAR-Central Potato Research Institute RS, Patna (Bihar) during the Rabi season of 2022–23 with eight treatment combinations having recommended and soil test-based NPK applications. The treatments consisted of T1-recommended NPK, T2-recommended NP and soil test-based K, T3- recommended NK and soil test-based P, T4- recommended N and soil test based PK, T5- recommended PK and soil test-based N, T6-recommended K and soil test based NP, T7- recommended P and soil test-based NK and T8- soil test-based NPK. Treatments were replicated thrice. Highest tuber emergence (95.4%) was recorded with recommended NK and soil test-based P which was statistically same compared to other treatments. Grade wise tuber yields of <25g, 26-50g, 51-75 g and >76 g were statistically same under different treatments. Similarly highest total tuber yield was statistically same under different treatments although it was highest under treatment recommended NP and soil test-based K (25.3 t ha^{-1}) application. Hence, it is concluded that application of NPK on general recommendation and soil test basis was found equally effective.

Keywords: NPK, Potato, Recommended dose, Soil test-based application.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Augmenting production potential and profitability of pulses through cluster frontline demonstrations in North-east Region, India

Rajesh Kumar*, Bagish Kumar, Thoi Thoi Devi, M., Munmi Boruah, Abul K. Azad, Purnima Saikia, Musliha Nasrin, and Kadirvel, G.

ICAR-Agricultural Technology Application Research Institute, Zone-VI, Guwahati

*rajeshk3022@gmail.com, atariguwahati@gmail.com

Pulses provide nutritional and environmental security in bringing income and employment opportunity through various improved technological interventions. To make India self-sufficient in pulses production through productivity enhancement, availability of quality seed needs special attention and it's encouraging that new programs, government support, and collaborations between research institutes, farmers and various other stakeholders are boosting the production of pulses and helping the farmers immensely. However, non-availability of quality seed, and area specific technology demonstration is a major constraint in enhancing production and productivity of these crops. Cluster Front Line Demonstration (CFLD) is an appropriate approach for demonstration of improved technology and innovations in agriculture for large scale popularization among the farming community. To evaluate the impact of improved technology on productivity and profitability of pulses, a five years study was carried out by conducting CFLDs at farmers' fields in various KVKs of Assam, Arunachal Pradesh and Sikkim from 2016-17 to 2020-21. The study revealed that a total of 13842 demonstrations were conducted in 4919 ha area in Assam, 1782 demonstrations were conducted in 635 ha area in Arunachal Pradesh and 1594 demonstrations were conducted in 582 ha area in Sikkim through improved production technology. The average grain yield in demonstration fields of all selected pulses crops namely; Black gram, Green gram, Field pea, Lentil, Rajmah and Lathyrus were higher than farmers traditionally practice. Highest demonstration yield was recorded in Rajmah *i.e.* 1476 kg ha^{-1} as compared to farmers' practices 1062 kg ha^{-1} with 38.95 % increase in yield followed by Field pea *i.e.* 982 kg ha^{-1} and Black gram 854 kg ha^{-1} compared to farmers' practices. The highest additional income (₹. 86051 ha^{-1}) was recorded in Rajmah followed by (₹. 61245 ha^{-1}) in Field pea and (₹. 49350 ha^{-1}) in Green gram over farmers' practices which is highly encouraging and it is suggested to adopt these technologies for sustainable production of pulses in North-east India. This is due to multiple factors such as institutional support, introduction of new varieties, better technology, and production systems and even government policies like seed hub and minimum support price that supported the production, productivity and profitability of pulses in the region under cluster frontline demonstration. It can be concluded that, there is a need of more area expansion and technology dissemination under pulses, farmers should be encouraged for pulse-based cropping system for better income generation and environment.

Keywords: CFLD, Minimum support price, Pulse-based cropping system, Technology demonstration.

Single and multi-nutrient deficiencies of sulphur and micronutrients in soils of India

Behera, S. K. [1*], Shukla, A. K.[2], Rahul Mishra[1] and Datta, S. P.[1]

[1]ICAR-Indian Institute of Soil Science, Bhopal-462 038, Madhya Pradesh, India
[2]Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior-474 002, Uttar Pradesh, India

* sanjibkumarbehera123@gmail.com

The deficiencies of nutrient elements and inappropriate nutrient management practices in agricultural soils of the world is one of the reasons for low crop productivity, reduced nutritional quality of agricultural produce, and animal/human malnutrition. The present study was carried out to evaluate the single and multi-nutrient deficiencies of sulfur (S) and micronutrients [zinc (Zn), boron (B), iron (Fe), copper (Cu) and manganese (Mn)] in agricultural soils of India for their effective management to achieve sustainable crop production, improved nutritional quality in crops and better animal/human health. Altogether, 24,2827 surface soil samples (0 to 15 cm depth) were collected from the agriculture fields of 615 districts in 28 states of India and were analyzed for available S and micronutrient concentration. The concentration of available S and micronutrients varied widely. The distribution of single and multi-nutrient deficiencies of S and micronutrients in different districts, states and agro-ecological regions (AERs) of India was different. The deficiencies of S, Zn and B were higher compared to the deficiencies of Fe, Cu and Mn. There were occurrences of two-nutrient (namely S + Zn, Zn + B, S + B, Zn + Fe Zn + Mn, S + Fe, Zn + Cu and Fe + B), three-nutrient (namely S + Zn + B, S + Zn + B and Zn + Fe + B) and four-nutrient (namely Zn + Fe + Cu + Mn) and five-nutrient (Zn + Fe + Cu + Mn + B) deficiencies in different extents. There is a need for S and micronutrient application based on the soil deficiency status in various districts, states and AERs of India, as well as crop requirements for sustainable crop production, enrichment of nutrients in crops and better animal and human health. Based on multi-nutrient deficiency, the right kind of S and micronutrients-based customized fertilizers may be developed and supplied for use in different regions of India. This type of study needs to be carried out periodically to obtain precise information pertaining to exact levels of S and micronutrient deficiencies to achieve strategic planning of balanced and site-specific nutrient management.

Keywwords: Deficiency, India, Multielement deficiency, Phytoavailable micronutrient, Soil.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Host preference of shoot fly on different minor millets: A way for management through crop diversification

Gouri Shankar Giri[1*], Kaushal Kishor[2] and Sweta Mishra[2]

[1]Tirhut College of Agriculture, Dholi, Bihar, India
[2]PG College of Agriculture, Pusa, Bihar, India
Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur -848 125, Bihar, India

*gsgiri@rpcau.ac.in

Minor millets are high energy, nutritious food compared to other cereals, and India is considered as the largest producer of minor millets. Though millets are known for their capability to resist different kinds of biotic and abiotic stress, under changing climate scenario, these crops harbour several insect pests from germination to harvesting. The shoot fly is one of the major biotic constraints in achieving the target production and productivity in millet culture. The pest is known to affect all kinds of millets as well as maize to some extent including some weed species also. These crops serve as its alternate host and help to complete its lifecycle during the off-season. Crop diversification is one of the ancient practices for disease and pest management. Hence it is important to study the most preferred host of shoot fly in order to manage it through diversification of agro-ecosystems. The present study was carried out in the research farm of Tirhut College of Agriculture, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. Observations regarding per cent dead heart formation, number of larvae or pupa as well as population of shoot fly adults through sweep net were recorded at weekly intervals on finger millet, foxtail millet, proso millet, barnyard millet, and brown top millet. All the crops were grown in an area of 20 m^2 and replicated four times. It was observed that per cent dead heart formed due to shoot fly was maximum in brown top millet (21.30%) followed by proso millet (20.15%) and finger millet (16.75%). Barnyard millet and foxtail millet recorded the lowest dead heart formation (6.70 and 9.95%) due to infestation of shoot fly. Similarly, when the dead hearts were split open, maximum number of larvae and pupa per plant were observed in brown top millet followed by proso millet and finger millet. During the cropping period, maximum number of shoot fly adults per sweep was observed on brown top millet (6.8) followed by proso millet (6.4). Fewer numbers of shoot fly adults per sweep was observed in finger millet, foxtail millet and barnyard millet. On the basis of these findings, it may be concluded that brown top millet and proso millets are the most preferred host for shoot fly and may be utilized as border crop for its management.

Keywords: Crop diversification, Dead heart, Minor millets, Shoot fly

Maize as ethanol feedstock: Prospects and strategies in India

Jat, H. S.*, Jat, S. L. and Bhupender Kumar

ICAR-Indian Institute of Maize Research, Ludhiana-141 004, Punjab, India

*pdmaize@gmail.com

Maize has recently become an important industrial raw material in India. The Indian Government revised its target of 20% ethanol blending into petrol (EBP) by 2025-26. Presently, 11.7% of EBP comes from broken rice, molasses, etc., but scope of further expansion in this is limited. As a result, from 2023, maize has been identified as an important feedstock for ethanol production in the country. As per the current trend, maize production is expected to surpass 43 million tonnes by 2030, which would only meet the current industries' requirements other than ethanol. However, there is a requirement of over 12 million tonnes additional maize feedstock for ethanol production to meet 20% blending targets. Currently, ethanol industries are spreading across the country, especially in western, eastern IGP and central India. There is no correlation between ethanol installation capacity and maize production, as Punjab, Haryana, and Odisha are already net importers of maize to sustain their feed/starch industries. Other major states do not produce surplus maize for ethanol and hence, the country needs to enhance its maize production. The on-farm demonstration showed maize had a kharif yield potential of over 60 q ha^{-1} in northwest India, however, pricing and marketing are the major challenges which can be addressed by linking maize growers with densely established distilleries. Similarly, in eastern India, maize had a higher return (₹18-52 thousands ha^{-1}) over upland rice. Rapid growth can be achieved by expanding acreage in nearly 50 high-yielding districts of the country. In the northwestern, eastern IGP and central India there is a potential of increasing maize acreage by 10 lakh hectares in kharif season with productivity of over 40 q//ha. Maize can also be expanded in high potential ecology of the *rabi* season in eastern, central and peninsular India on about 5 lakh ha with over 50 q/ha yield. On-station establishment of maize agri-innovation platforms and living laboratories need to be the targets to provide stakeholders with information on best management practices to enhance maize yields in low productivity areas. In over 95 districts (each with >20,000 ha), targeting climate-resilient maize hybrids with best management practices could increase production by 6.0 million t. Research on better ethanol content and recovery, and establishment of new seed hubs etc., will further boost this segment of maize for ethanol. Market linkages with ethanol industries and government support for the above initiatives of acreage-productivity enhancement will be helpful.

Keywords: Acreage expansion, Agri-innovation platform, Climate resilient maize, Crop diversification, Ethanol blending petrol, Seed hubs

Nutri cookies and cakes sweetened with sugarcane raw sugar (jaggery)

Chandran, K*., PK. Hasnath[2], C. Keerthi [1], M. Nisha[1], B. Mahendran[1] and R Gopi[1]

[1]ICAR- Sugarcane Breeding Institute Research Centre, Kannur, Kerala–670002
[2] CUAUMFT034, Department of food science and Technology, University of Calicut, Kerala–673635

*email: k.chandran@icar.gov.in

Jaggery is a natural sweetener made by the concentration of sugarcane juice, and is available in solid, liquid, and powder form. All forms contain all the vitamins and minerals present in sugarcane juice; jaggery is thus one of the most wholesome and healthy sugars. Jaggery is loaded with antioxidants, minerals, and vitamins that can boost the immune system. Liquid jaggery is a thick syrup obtained from sugarcane juice without adding any chemical reagents and the processing of powder jaggery is similar to liquid jaggery but with slight adjustments in the pH of the juice. The concentrated slurry was then rubbed with a wooden scrapper, for the formation of grains. Refined sugars are linked with many lifestyle diseases and hence more nutritious and healthy sweetener is in demand in the confectionery industry. Hence, this study aimed to develop sugarcane raw sugar-based cakes and cookies fortified with edible fiber from rice bran and flour of millets. Rice bran is highly nutritious and known to have good nutritive value, high fiber content, and therapeutic use. Millets have become an integral part of the food system in view of their high nutritive and fiber value. The development of different value-added products from raw sugar and their commercial availability become the need of the hour to sustain it as a healthy sweetener and for future profitability in the value-added products of sugarcane. The present study was conducted to standardize the composition of different ingredients for cakes and cookies based on heat-processed sugarcane juice instead of refined sugar and nutritional enrichment using flour of different millets and wheat flours fortified with rice bran. The physicochemical methods for sugarcane juice processing, chemical analysis for moisture content of cookies and cakes, and organoleptic evaluation of both were carried out. It can be concluded that most cereal-based baked products can be developed by replacing refined sugar with jaggery as a sweetener which reduces the ill effects of refined sugar on health. Sensory evaluation done on a 5-point hedonic scale showed that cake and cookies made with liquid jaggery as a sweetener were better on taste but powder jaggery was better for maintaining low moisture content, texture, and keeping quality. Rice bran incorporated in cookies up to 5% level had better acceptance. The lack of fiber content and the use of refined white sugar are the main drawbacks of cookies and cakes made out of "Maida" (refined floor). Since cereals-based baked products are part of our daily diet the nutri cookies and cakes will be an excellent vehicle for a balanced diet, especially when raw sugar and ingredients like millets and rice bran are used. Nutri cookies can be recommended in the daily diet for children and also to prevent malnourishment or undernourishment in children.

Keywords: Flour, Jaggery, Millets, Sugarcane, Value addition

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Effect of biofertilizers and levels of lime on linseed (*Linum usitatissimum L.*) under custard apple (*Annona squamosa L.*) based agri-horti system on Vindhyan soil

Singh, J. K.* and Devu Sumasri

Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh 221 005, India
*jksinghbhu3@gmail.com

Agroforestry encompasses a range of land-use systems in which perennial woody plants are intentionally cultivated alongside agricultural crops and/or livestock, organized either through spatial arrangements or temporal sequences. Through the integration of trees into agricultural environments and farming practices, agroforestry aims to enrich and maintain yields, resulting in improved social, economic, and environmental advantages for land users on various levels. An experiment was conducted during the winter (*Rabi*) season of 2022-2023 in the Vindhyan region at Rajiv Gandhi South Campus, Barkachha, Banaras Hindu University, Mirzapur, Uttar Pradesh, which aimed to assess the effect of biofertilizer and levels of lime on growth and yields of linseed (cultivar 'Neelam') under custard apple-based agri-horti system. The study employed a factorial randomized block design that incorporated three different types of biofertilizers (*Azotobacter*, Phosphate solubilizing bacteria and Sulphur solubilizing bacteria) and three levels of lime application (125, 250 and 375 kg ha^{-1}). Additionally, three separate plots were set up near the experimental field. These plots were fertilized with 40,40,40,30 kg ha^{-1} of NPKS, 250 kg lime ha^{-1}, and 5 tonnes of FYM ha^{-1}. These plots were used for comparison with the rest of the treatment combinations. The application of PSB for seed inoculation led to improved growth parameters, along with higher counts of balls plant^{-1}, seeds ball^{-1}, and 1000-grain weight over *Azotobacter* or SDB and the control (no biofertilizers and no lime). Similarly, the application of 375 kg lime ha^{-1} also had a positive influence on these growth parameters. The combined impact revealed that the highest grain yield (838 kg ha^{-1}) and stover yield (1731 kg ha^{-1}) were achieved when PSB seed inoculation was combined with lime application of 375 kg ha^{-1}. The maximum oil yield was also found in cases of PSB inoculation (39.06%) and the application of 375 kg lime ha^{-1} (41.27%). The application of these treatments demonstrated that there was a higher yield under custard apple-based agroforestry system plots than in the open plots.

Keywords: Agri-horti system, Biofertilizers, Lime Levels, Linseed, Yield

Response of liquid biofertilizer and their mode of application on yield and economics of finger millet (*Eleusine coracana L.*)

Kaushal Kishor[1*], Gouri Shankar Giri[2], Sweta Mishra[1] and Bharati Upadhaya[3]

[1]Post- Graduate college of Agriculture, Dr Rajendra Prasad Central Agricultural University, Pusa , Bihar, India
[2]Tirhut College of Agriculture, Muzaffarpur-843 105, Bihar, India
[3]Krishi Vigyan Kendra, Birauli, Dr Rajendra Prasad Central Agricultural University, Pusa , Bihar, India-

*Kaushal.kishor@rpcau.ac.in

Finger millet is one of the important millet crops in India as well as Bihar. Chemical fertilizers applied on a regular basis have negative impact on soil physical and chemical qualities, as well as crop yields. Conjunctive use of organic manures, biofertilizers and fertilizers is critical to maintain yield and reduce reliance on chemical fertilizers. An experiment was carried out during *Kharif* 2021 at Research Farm of Tirhut College of Agriculture, Dholi, RPCAU, Pusa, Bihar in randomized block design with 3 replications involving 11 treatments *viz*., T_1–100% RDF + seed treatment with liquid biofertilizer (5 ml kg^{-1} seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg ha^{-1} FYM and applied in furrow), T_2 -100%RDF + seed treatment with liquid biofertilizer. T_3 -100% RDF + soil application of liquid biofertilizer, T_4–85% RDF + seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer, T_5–85% RDF + seed treatment with liquid biofertilizer, T_6–85% RDF + soil application of liquid biofertilizer, T_7–70% RDF + seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer, T_8–70% RDF + seed treatment with liquid biofertilizer, T_9–70% RDF + soil application of liquid biofertilizer, T_{10}–RDF, T_{11}–Control. The RAU-8 variety of finger millet was used. Grain yield (24.15 q ha^{-1}) and straw yield (49.22 q ha^{-1}) were significantly higher with T_1 which was statistically at par with T_3 and T_4. Net returns (₹55,817/ha) and Benefit cost ratio (2.09) were significantly higher in T_4. Application of 85% RDF + seed treatment with liquid biofertilizer (5 ml kg^{-1} seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg ha^{-1} FYM and applied in furrow) was found best for higher productivity and profitability in finger millet cultivation.

Keywords: Biofertilizers, Economics, Finger millet, Yield

Enhancing chickpea productivity through post-emergence herbicides for comprehensive weed management

Choudhary, V. K.*, Dubey, R. P. and Mishra, J. S.

ICAR-Directorate of Weed Research, Jabalpur-482 004, Madhya Pradesh, India

*ind_vc@rediffmail.com

Chickpea cultivation faces significant challenges from both abiotic and biotic stresses. Among the biotic stressors, weeds are particularly notorious for causing substantial yield reductions. The initially slow growth and limited competitive ability of chickpea (*Cicer arietinum* L.) create an opportunity for weeds to inflict yield losses of up to 94%. Notably, grasses and broadleaved weeds (BLWs) are the predominant weed species in chickpea fields, with BLWs posing a particularly significant threat to chickpea production. The scarcity of labour, rising labour costs, and the unavailability of selective post-emergence herbicides tailored for control of BLWs compound these concerns. To address these challenges, a series of field experiments were conducted at ICAR-Directorate of Weed Research in Jabalpur, Madhya Pradesh, India, during 2017-2023. The primary objectives of this study were to assess both pre-emergence (PE) and post-emergence (PoE) herbicides, determine the optimal dosage for effective herbicides, identify the ideal timing for herbicide application, evaluate varietal tolerance to promising herbicides, and assess herbicide compatibility. These objectives aimed to establish a comprehensive weed management strategy that would ensure broad-spectrum weed control in chickpea, thereby enhancing yields and overall profitability. Over the course of this study, numerous PE and PoE herbicides were tested in chickpea cultivation. Among the PE herbicides, pendimethalin+imazethapyr at a rate of 1.0 kg ha^{-1} and pendimethalin at 678 g ha^{-1} demonstrated effectiveness. However, they exhibited reduced efficacy against certain BLW species. In the case of PoE herbicides, topramezone at rates of 20 and 30 g ha^{-1} (an inhibitor of a p-hydroxyphenylpyruvate dioxygenase enzyme) emerged as equally effective options, although it showed mild and recoverable phytotoxicity and somewhat lower efficacy against grassy weeds. The dose-response study determined that topramezone at a rate of 20.16 g ha^{-1} delivered effective weed control, increased seed yields, and proved economically viable. Furthermore, the application of topramezone at 20.16 g ha^{-1}, performed 20 days after sowing, exhibited superior efficacy compared to later application timings. Among the tested chickpea cultivars, JG 14, 16, and 36 exhibited less phytotoxicity to herbicides. Additionally, compatibility studies indicated that topramezone is compatible with quizalofop at 50 g ha^{-1}. Consequently, the tank mixture of topramezone at 20.16 g ha^{-1} and quizalofop at 50 g ha^{-1} emerged as a promising option for achieving comprehensive weed control, increased productivity, and enhanced profitability in chickpea cultivation.

Keywords: Chickpea, Dose-response, Herbicide compatibility, Topramezone, Varietal selectivity

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Integrated farming system approaches for sustainable intensification, livelihood security and diversification of coastal agriculture

Parveen Kumar*, Venkatesh Paramesh and Solomon Rajkumar
ICAR-Central Coastal Agricultural Research Institute, Ela, Goa, India
*pkumarcssri@gmail.com

Currently, intensive agriculture system are characterized by specialized, simplified, and concentrated systems for cultivating crops and raising animals to meet the increasing demands for food, feed, and fibre. However, this approach often relies on external inputs like irrigation, synthetic fertilizers, chemical pesticides, and growth hormones, leading to environmental degradation and reduced ecosystem services. In contrast, the integrated farming system (IFS) is a complex interrelated matrix of soil, plants, animals, implements, power, labour, capital, and other inputs controlled in parts by farming families and influenced to varying degrees by economic, institutional, and social forces that operate at many levels. This approach aims to fulfil multiple objectives, including supporting livelihoods, biodiversity conservation, emission reduction, climate change adaptation, and the provision of ecosystem services. The structure and components of an IFS vary based on the local agro-climatic conditions, influencing its overall performance. To gain insights into IFS performance, a comprehensive analysis of different IFS models across the country was conducted. The results of the analysis indicated significant advantages of IFS adoption. IFS exhibited improvements in crop equivalent yield (CEY), net returns, and employment potential by 247%, 223%, and 193%, respectively compared to monoculture cropping. Notably, IFS emerged as a crucial method for conserving biodiversity with a Shannon diversity index of 2.6, as it accommodates diverse crops and livestock, fostering multi-enterprise systems that enhance the livelihood security of small-scale farmers. Further, IFS enhance nutrient recycling through composting, mulching, and residue incorporation, and as a consequence have the capacity to reduce the external purchase of inputs. The nutrient recycling in turn helps to increase the soil quality indicators such as soil nutrient availability, soil organic carbon and also improves soil microbial activity. By recycling by-products and residues from one enterprise as inputs for others, IFS establishes a linked and self-sustaining system that is resilient to climate change.

Keywords: Biodiversity conservation, Cropping system, Farming system, Productivity

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Technological developments in sugarcane for value addition and product diversification

Suresha, G. S*, Hari, K. and Murali, P.

ICAR-Sugarcane Breeding Institute, Coimbatore-641 007, Tamil Nadu, India

*gs.suresha@icar.gov.in; sureshgiriyapur@gmail.com

Sugarcane is one of the most important agro-based industrial crops and the primary source of sugar and jaggery. Although sugarcane production has been increasing for several decades, it gained importance only recently for sugarcane product diversification and bioenergy applications. Since many dominant sugar producing countries are producing surplus sugar, it is the need of the hour to diversify sugarcane for the production of value-added food products, fuels, and feed to sustain the crop, farmers, and industries. In this direction, ICAR-Sugarcane Breeding Institute, Coimbatore has expanded its research activities and developed new processes and technologies for the production of value-added products from sugarcane. Cane jam is a unique novel value-added product from sugarcane juice which is a rich source of minerals and vitamins compared to commercial fruit jams available in the market. It is prepared purely with sugarcane juice without additives and free from man-made sugars. Dietary fibre technology aimed to explore sugarcane bagasse as a source of dietary fibre. Sugarcane bagasse is known to have cellulosic fibre which is grouped under insoluble or bulking fibres. This group of fibres are advantageous to human health as they add bulking effect to the food, which relieves constipation, improves gut health, and cures inflammatory bowel diseases (IBD). Sugarcane juice is highly perishable and cannot be stored under room conditions for long periods but can be stored in frozen condition at -20°C for about 6-8 months or more.m Imediately after extraction, the colour tends to change from green to greyish or brownish due to enzymatic browning reaction. Therefore, ICAR-SBI has developed an improved novel process for extracting juice from sugarcane without removing rind and storing the juice under frozen condition for longer periods without much change in colour, flavour, and physical, biological, and nutritional qualities. Frozen juice was used for development of novel value-added products such as sugarcane juice powder through spray and freeze-drying process, liquid jaggery or cane syrup, kulfi, and high- and low-fat and soft-serve ice cream. These processes were developed by optimizing the processing parameters such as boiling temperature, optimizing the brix levels for pre- and final settling point, physico-mechanical separation of suspended solids from sugar syrup, prevention of crystallization, use of stabilizers, anti-browning agents, consumer acceptability and shelf-life studies. The technologies developed were licensed to different stakeholders for commercial production. This would provide new avenues to farmers, rural youth, women and small-scale entrepreneurs for increasing their revenue and employment opportunities.

Keywords: Bagasse, Byproducts, Diversification, Sugarcane juice, Value addition.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Antimicrobial effects of chitosan-henna leaf extract on selected plant pathogens

Nayana, A[1]*., Sabu, S[1] and Sainamole Kurian, P[2].

[1]School of Industrial Fisheries, Lakeside Campus, Cochin University of Science and Technology, Ernakulam, Kerala, India
[2]Department of Plant Pathology, College of Agriculture, Kerala Agriculture University, Trissur, Kerala, India

*nayanapanambil@gmail.com

Plant diseases cause a decrease in crop yield and quality, which leads to economic loss for the farmers. To control the attack of pathogens in crops, chemical pesticides are primarily used. The continuous use of chemical pesticides may cause long-term effects on human health and the environment. In this study, the antimicrobial efficacy of chitosan-henna leaf extracts (*Lawsonia inermis*) *in vitro* and *in vivo* against selected plant pathogens (*Colletotrichum gloeosporioides, Pythium aphanidermatum, Ralstonia solanacearum* and *Xanthomonas* sp.) was investigated. The antimicrobial properties of chitosan (CH) and henna leaf extract (HNE) were determined at different concentrations (750 ppm, 1000 ppm, 1250 ppm, and 1500 ppm). Mycelial growth of *C. goleosporum* and *P. aphanidermatum* was inhibited (up to 100%) at 750 ppm of 1% chitosan and 1000 ppm of 1% Henna extract solution. The same concentrations also inhibited (up to 85%) the growth of *R. solanacearum* and *Xanthomonas* sp. The combination of chitosan-henna leaf extracts (750 ppm CH+1000 ppm HNE) showed complete inhibition against all the pathogens at 75% of the combination. The promising results obtained in this investigation advocate its use in plant crops and as a natural alternative to reduce the use of chemical pesticide for sustainable organic farming in India.

Keywords: Antimicrobial effects, Chitosan, Henna leaf, Mycelial growth, Natural alternative

Millet, a potential crop of organic farming for climate resilience and nutritional security in Himalayan Ecosystem

Jayanta Layek[1,2]*, Krishnappa[2], R., Kartik Sharma[1]

[1]ICAR-Indian Institute of Agricultural Biotechnology, Ranchi, Bihar, India
[2]ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya, India

*jayanta.icar@gmail.com

Organic farming is a promising solution for mitigating environmental burdens and it combines tradition, innovation, and science to benefit the environment and quality of life. Due to nutritional superiority, climate resilience and low input demand, millets get prominent place in organic cropping sequence. There is less knowledge about millets in the North Eastern Hill (NEH) region but it has been traditionally cultivated and consumed. However, scientific cultivation of millets as a potential crop in the degraded and acidic soils of the region should be promoted. An experiment was conducted under an organic production system in NEH region for three consecutive years by evaluating high-yielding varieties (HYVs) of different millets, viz., finger millet, foxtail millet, little millet, barnyard millet, proso millet, and browntop millet, along with local germplasms of finger millets from Himalayan foothills (*Sikkim-1* and *-2*, *Nagaland-1* and *-2*) to identify the stable, high-yielding and nutritionally superior genotypes suited for the region. Among the various millets evaluated, finger millet, little millet and foxtail millet proved their superiority in terms of productivity. Among different germplasms of finger millets, the HYV *VL-Mandua 352* recorded the highest average grain yield (1.73 Mg ha^{-1}) followed by local landraces *Nagaland-2* (1.61 Mg ha^{-1}) and *Sikkim-1* (1.55 Mg ha^{-1}). Root traits like total root length, root volume, the average diameter of roots, and root surface area were significantly higher in finger millet genotypes (*Nagaland-1*, 2, and *Sikkim-1)* as compared to the rest of the millet lines. Finger millet landrace, *Sikkim-2* recorded the highest omega-6 content (1.16%), followed by barnyard millet, VL-207 (1.09%). Barnyard millet recorded the highest polyunsaturated fatty acid (PUFA) content (1.23%), followed by foxtail millet variety *SiA-3088* (1.09%). While, the local finger millet genotypes, *Sikkim-1* and *-2* recorded the highest histidine (0.41%) and tryptophan (0.12%) content, respectively, *Sikkim-1* and *Nagaland-2* recorded the highest thiamine (0.32%) as compared to the HYVs. These findings indicated that finger millet has great potential in this Himalayan ecosystem under an organic production system, and apart from HYVs like *VL Mandua-352*, local germplasms, viz., *Nagaland-2* and *Sikkim-1*, should also be promoted and used in breeding programme for ensuring food and nutritional security in the fragile Himalayan ecosystem and elsewhere.

Keywords: Millets, Nutritional security, Organic farming, Physio-chemical traits, Root architecture

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

From Nuisance to Nutrition: Unmasking the seed-specific genes contributing to Raffinose Family Oligosaccharides accumulation in peanuts (*Arachis hypogaea* L.) via transcriptomic-based approach

Bishi, S. K.[1]*, Sanyal, R.[1,2], Jawed, Danish., Tribhuvan, K. and Kumar, M.

[1]ICAR-Indian Institute of Agricultural Biotechnology, Ranchi-834003, Jharkhand, India
[2]National Institute of Plant Genome Research, Aruna Asaf Ali Marg, New Delhi 110067, India

*sujitbishi@gmail.com

Plants have been using carbohydrates and their derivatives as signalling molecules in response to stress throughout their evolutionary history. One particular type of metabolite, known as Raffinose family oligosaccharides (RFOs), often considered antinutrients, actually plays a crucial role in plant physiology. To reduce RFOs in plants without hindering normal growth and functioning, it is essential to identify the genes responsible for RFO biosynthesis and understand how they are expressed in different plant tissues and at different stages of development. In this study, we aimed to pinpoint these genes in peanuts by conducting RNA-seq analysis at two key seed stages: maturing seed stage (S1) and matured seed stage (S2) across three distinct peanut varieties: TG37A (high RFOs) and GG7 (low RFOs) from the Spanish group, and Girnar 2 (high RFOs) from the Virginia group. Our transcriptomic data confirmed that various families of RFOs biosynthetic genes are expressed in a time- and tissue-specific manner. While stachyose emerged as the primary RFOs component, Raffinose Synthase (*RS*) exhibited varying contributions to RFOs accumulation. Notably, significant differential expression of *AhRS14* and *AhRS6* in seeds indicated their roles as regulatory genes. The exclusive expression of *AhRSV* in Girnar-2 suggests its potential use as a marker for identifying peanut groups. Additionally, the consistently high transcript density of *AhGolS6* and *AhSS7* at all seed stages implies their continuous expression in seeds. The selective expression of homologous genes underscores their importance in plant evolution during allopolyploidization. These identified genes hold promise as potential targets for developing peanut varieties with lower RFO content. This research has the potential to enhance the nutritional quality of peanuts and mitigate any discomfort associated with consuming legumes.

Keywords: Antinutritional factor, Discomfort, Groundnut, Regulatory genes, RFOs

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Insecticidal and repellent activities of essential oil from the leaves of *Callistemon lanceolatus* to control pulse beetle, *Callasobruchus chinensis*

Ankitha, T. A., Visakh, N. U. and Berin Pathrose*

Department of Agricultural Entomology, College of Agriculture, Kerala Agricultural University, Thrissur 680656, Kerala, India

*berin.pathrose@kau.in

Callistemon lanceolatus, commonly known as the crimson bottle brush, is a flowering plant that belongs to the family Myrtaceae. The pulse beetle, *Callosobruchus chinensis* is a primary pest of stored pulses causing about 32-64% weight loss in cowpea. Essential oils are a natural eco-friendly and sustainable alternative to synthetic chemical insecticides for controlling storage pests like pulse beetles. This research study aims to extract and chemically characterize the essential oil from the leaves of *C. lanceolatus* using hydrodistillation and to evaluate its insecticidal and repellent activities against *C. chinensis*. Hydrodistillation of dried leaves from the C. *lanceolatus* yielded essential oil of 1.02±0.01%. The chemical composition of volatile oil was analyzed through GC-MS. The major components of the oil include 1,8-cineole and α-pinene. Subsequently, the contact toxicity, fumigant toxicity, and repellent activity were evaluated against *C. chinensis*. The essential oil from the dried leaves of *C. lanceolatus* showed significant fumigant and contact activities against adult insects. LC_{50} values were 1.368 mg/L air and 1.045 mg/L air in 24 h and 48 h in fumigation assays, respectively. The contact toxicity of *Callistemon* leaf essential oil varied from 0.747% to 0.278% after 24 and 48 hours of exposure, respectively. The area preference method was used to measure the repellent activity at various concentrations (0.05%, 0.06%, 0.07%, 0.08%, and 0.09%), and the results showed 36.66%, 40.00%, 55.00%, 55.83% and 61.66% repellency. These results suggest that essential oils from the leaves of *C. lanceolatus* can be used as a fumigant and as a contact insecticide with repellent activity against *C. chinensis*. Hence, the essential oil extracted from bottle brush leaves can be a potential botanical insecticide against *C. chinensis*.

Keywords: *Callosobruchus chinensis*, Contact toxicity, Essential oils, Fumigant toxicity, Repellent activity.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Bioefficacy of essential oil extracted from wild turmeric (*Curcuma aromatica* Salisb) leaves waste against a major secondary storage pest, *Tribolium castaneum*

Aminu Sulhath, T. A., Visakh, N. U. and Berin Pathrose*

Department of Agricultural Entomology, College of Agriculture, Kerala Agricultural University, Thrissur 680656, Kerala, India

*berin.pathrose@kau.in

Pest management is facing significant economic and environmental challenges due to the extensive use and excessive dependence on pesticides. Botanicals can be utilised as an economic and eco-friendly substitute for synthetic pesticides. It helps in resolving issues arising from synthetic pesticides like non-target toxicity, residual consequences, and challenging biodegradability. Wild turmeric, *Curcuma aromatica*, is an important herbal plant that has been extensively used by the medicinal industries. The rhizome is the economically important plant part used for oil extraction. The leaves left over after the harvest of rhizomes are considered waste. This research aims to extract and chemically characterize the essential oil from the leaf waste of wild turmeric and evaluate its insecticidal properties. Essential oil is extracted via the hydro-distillation method, yielding about 0.51% of essential oil. The results of the gas chromatography-mass spectrometry (GC-MS) characterization revealed that the major chemical components of the essential oil were camphor (19.82%), curdione (15.31%), and 2-bornanone (12.25%). The insecticidal activity of the oil was assessed using a key storage pest, the red flour beetle (*Tribolium castaneum*), as the test insect. The contact, fumigant, and repellent activities of the essential oil against red flour beetles were evaluated. The study revealed that the oil exhibits remarkable repellent activity, ranging from 85.55% to 97.77% at concentrations of 0.1% to 0.5%, respectively. It has excellent contact toxicity (at 24 h, LC_{50} = 1.04% and at 48 h, LC_{50} = 0.86%) against the test insect. It also shows notable fumigant toxicity (at 24 h, LC_{50} = 18.18 mg/L air and at 48 h, LC_{50} = 16.57 mg/L air). Hence, the essential oil extracted from the waste leaves of wild turmeric can serve as a potential botanical pesticide against the storage pest, *T. castaneum.*

Keywords: Contact toxicity, *Curcuma aromatica,* Essential oils, Repellent activity, *Tribolium castaneum*

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Effect of polyhalite application on maize yield, nutrient use efficiency and soil properties in semiarid Alfisols

Sumanta Kundu[1*], Singh, V. K. [1], Jami Naveen[1], Vipin Kumar Mishra[2], Sanneganti Sai Prasad[2], Neeraj Kumar Awasthi[2], Indoria, A. K.[1], Gopinath, K. A.[1], Pratibha, G. [1], Jvns Prasad[1] and Shanker, A. K.[1]

[1]ICAR- Central Research Institute for Dryland Agriculture, Santhoshnagar, Hyderabad, Telangana, India
[2]Anglo American Crop Nutrients

*Sumanta.K@icar.gov.in

In India, rainfed agriculture accounts for 52% of net sown area, contributing around 44% of food grain production and supporting 40% of the population. Productivity of rainfed areas is low because of frequent droughts, low and erratic rainfall, soil degradation, low nutrient use efficiency, low level of input, and limited adoption of recommended technologies. In most cases, farmers apply only Nitrogen (N) and Phosphorus (P) via DAP, or only N via urea, omitting the application of Potassium (K). K application is critical in rainfed condition to cope with water stress circumstances. Many farmers apply more nitrogen than suggested when using HYV or hybrid maize or cotton with increased yield potential in rainfed areas. At the same time improving nutrient use efficiency and maintaining soil health is one of the major challenges under semiarid alfisols. As polyhalite is a natural fertilizer material, it has very low carbon footprint compared to synthetic materials. Though the impact of polyhalite application on crop productivity has been studied in many European, Latin American, and African countries, it has not been thoroughly studied in Indian semi-arid Alfisols where soils are degraded, light textured, and low to medium in both exchangeable and non-exchangeable K. In this background, a field experiment was initiated in 2021 in Gunegal Research Farm (GRF), ICAR-CRIDA, Hyderabad in Alfisol under rainfed condition to study the effect of polyhalite application on maize yield, fertiliser use efficiency, and soil properties. Significantly higher grain yield (4240 kg ha^{-1}) and harvest index (42.03%) was observed in NPK (75%polyhalite + 25%muriate of potash, MOP) + 25%S treatment which were at par with NPK (100%K polyhalite). K use efficiency increased by 21.39% with application of K through polyhalite compared to MOP application. N use efficiency also increased by 2.5 kg grain/kg N applied when K source is polyhalite compared to MOP. There is slight build-up of K and S with application of polyhalite. Higher maize yield can be obtained with the application of NPK (75%Polyhalite + 25%MOP) + 25%S. Application of polyhalite improved N and K use efficiency. Therefore, application of polyhalite as partial replacement of MOP can increase maize yield and use efficiency of applied nutrients.

Keywords: MOP, Muriate of potash, N use efficiency, Productivity, Rainfed condition, Soil health

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Flavoured RTS Beverage from coconut haustorium

[1]Radhakrishnan N. V.*, [2]Aparna Nath S. S.,[3] Sujatha R. and [2]Joy M.

[1]Kerala Agricultural University-College of Agriculture, Vellayani, Vellayani P. O., Thiruvananthapuram- 695522, Kerala, India
[2]Kerala Agricultural University -Coconut Research Station, Kattachalkuzhi, Kattachalkuzhi P. O., Balaramapuram, Thiruvananthapuram-695501, Kerala, India
[3]Kerala Agricultural University- College of Agriculture, Padannakad, Padannakad P. O., Kasaragod- 671314, Kerala, India

*radhakrishnan.nv@kau.in

Coconut haustorium is a spongy structure produced when the basal portion of the coconut embryo close to the germinating pore enlarges during germination. Despite being a rich source of nutrients and minerals, coconut haustorium is currently underutilised and is seen as a huge waste in the coconut business. A study was carried out to develop a ready-to-serve (RTS) beverage from coconut haustorium pulp blended with pineapple juice as per the standards of FSSAI and assess its nutritional and biochemical properties under refrigerated storage conditions. Coconut haustorium pulp was blended with pineapple in five different ratios and the most acceptable ratio was recorded to be 80:20 for RTS preparation. The best blended beverage selected was analysed for nutritional and biochemical properties. A gradual increase was observed in TSS, total sugars and reducing sugars while there was a decrease in β-carotene, antioxidant activity and ascorbic acid in storage. The shelf-life of the product was recorded to be 45±2 days under refrigeration. Based on the results, it was found that preparation of RTS by blending coconut haustorium with pineapple juice is a viable option.

Keywords: Biochemical properties, Coconut haustorium, Nutritional properties, RTS

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Chemical composition and insecticidal activities of essential oil of *Alpinia calcarata* (Haw.) Roscoe rhizome against Red flour beetle, *Tribolium castaneum*

Pathikalayil, R. Anuranj, Visakh, N. U. and Berin Pathrose*
Department of Agricultural Entomology, College of Agriculture, Kerala Agricultural University, Thrissur 680 656, Kerala, India
*berin.pathrose@kau.in

Alpinia calcarata (Family: Zingiberaceae) commonly known as lesser galangal or snap ginger, is widely cultivated in tropical countries. It is a rapidly spreading plant with profound medicinal properties like anti-inflammatory, antinociceptive, analgesic, reproductive, anti-cancerous, gastro-protective, and other biological activities. Most of the storage pests have acquired resistance to conventional chemical pesticides. Replacing conventional chemical pesticides with organic ones would be ideal and sustainable in nature. This study was done to assess the potential of essential oil isolated from the rhizomes of *A. calcarata*. Hydro-distillation of the dry rhizome was done followed by the chemical analysis of the extracted essential oil. The contact and fumigant toxicity, and the repellent activity of the extracted essential oil were evaluated against a major storage pest species *Tribolium castaneum*. The *A. calcarata* rhizome yielded 0.4 ± 0.02% essential oil and the principal chemical ingredients were identified by Gas Chromatography-Mass Spectrometry (GC-MS) characterization as 1,8-cineole, eucalyptol, and α- fenchyl acetate. The results of the study revealed notable contact (LC50 at 24 h and 48 h were 1.089 and 0.964%, respectively) and fumigant toxicity (LC50 at 24 h and 48 h were 4.047 and 2.307 mgL-1 air, respectively). The repellent activity was assessed using an area preference test which exhibited a strong repellent activity at different concentrations (0.1%, 0.3%, 0.5%, 0.7% and 0.9%, which showed 76.66, 83.32, 87.77, 87.77, 84.44% repellency, respectively). It can be concluded that the essential oil isolated from the rhizome of *A. calcarata* could be a promising organic pesticide that is safe for the management of storage pests.

Keywords: Contact toxicity, Essential oils, Fumigant toxicity, GC-MS, *Tribolium castaneum*

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Molecular mapping of nutritional traits in synthetic hexaploid wheat (*Triticum aestivum L.*) population using a high-density SNP-based linkage map

Vasudha Jadon [1,2,*], Jyoti Kumari [1], Sundeep Kumar [1], Amit Kumar [1], Hari Krishna [2], Gopalareddy Krishnappa [3,4], Neelu Jain [2], Pradeep Kumar Singh[2] and Gyanendra Pratap Singh [1,2]

[1]National Bureau of Plant Genetic Resources, New Delhi 110012, India
[2]Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India
[3]ICAR-Sugarcane Breeding Institute, Coimbatore 641007, India
[4]ICAR-Indian Institute of Wheat and Barley Research, Karnal 132001, India

*vasudhajadonbio@gmail.com

Malnutrition caused by micronutrient and protein deficiency is one of the important public health issues across the globe. Wheat breeding programs must be re-oriented to broaden the genetic base using landraces and crop wild relatives to effectively dissect the genetic basis of nutritional quality traits, and to develop wheat varieties with enhanced micronutrients and protein content. Genomic regions governing grain iron concentration (GFeC), grain zinc concentration (GZnC), grain protein content (GPC), and thousand kernel weight (TKW) were investigated in a set of 188 RILs derived from a cross between a high-yielding Indian bread wheat cultivar (HD2932) and a synthetic hexaploid wheat (Synthetic 46) derived from tetraploid *Triticum turgidum* (AA, BB 2n = 28) and *Triticum tauschii* (DD, 2n =14). The RIL population was genotyped using a set of 802 high-quality SNPs from 35K Axiom® Wheat Breeder's Array and 34 SSRs and phenotyped in two environments. The constructed genetic map had a total genetic length of 10913 cM. A total of nine QTLs including five for GPC (*QGpc.iari_1B, QGpc.iari_4A, QGpc.iari_4B, QGpc.iari_5D,* and *QGpc.iari_6B*), two for GFeC (*QGfec.iari_5B* and *QGfec.iari_6B*), and one each for GZnC (*QGznc.iari_7A*) and TKW (*QTkw.iari_4B*) were identified. Two stable and co-localized QTLs (*QGpc.iari_4B* and *QTkw.iari_4B*) were identified on the 4B chromosome between the flanking region of *Xgwm149–AX-94559916. In silico* analysis revealed that the QTLs were located on important putative candidate genes such as *P-loop containing nucleoside triphosphatehydrolase*, *Nodulin-like protein, NAC domain, Purine permease, Zinc-binding ribosomal protein*, *Cytochrome P450*, *Protein phosphatase 2A,Zinc finger CCCH-type*, and *Kinesin motor domain* involved in the regulation of iron homeostasis, zinc transportation, Zn, Fe, and protein remobilization to the developing grain, regulation of grain size and shape, and increased nitrogen use efficiency. The identified novel QTLs, particularly stable and co-localized QTLs will be validated to estimate their effects in different genetic backgrounds for subsequent use in marker-assisted selection (MAS).

Keywords: Candidate genes, Mapping, QTLs, SNPs, SSRs, Wheat.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Low protein and high lipid diet: Effect on nitrogenous waste production of GIFT fingerlings reared in recirculatory aquaculture system

Vijayakumar Sidramappa Mannur*, Sikendra Kumar**, Tincy Verghese, Ashutosh D Deo and Akhila, S.

ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra, India

*vijayakumar.fntpb005@cife.edu.in

**sikendra@cife.edu.in

Recirculatory Aquaculture System (RAS) is an emerging intensive type of aquaculture system that achieves high rates of water re-use with reliably effective use of land. Inbuilt mechanical and biological filtration helps to maintain the water quality in RAS. But the high stocking density in RAS results in higher ammonia release and accumulation in the culture water, which affects the growth and health of fish by causing stress to them. With a view to combating this issue, an experiment was conducted to investigate the effect of low protein and high lipid diets on nitrogenous waste production of genetically improved farmed tilapia (GIFT) fingerlings reared in RAS. Sixty GIFT fingerlings of initial size 5.05±0.1 g were stocked in each experimental tank of 50 L capacity, maintaining the stocking density of 6000 g/m^3. Six practical diets were formulated with varying protein levels (40% to 30%) and lipid levels (7% to 12%) for six different treatment groups *viz.* $P_{40}L_7$, $P_{38}L_8$, $P_{36}L_9$, $P_{34}L_{10}$, $P_{32}L_{11}$ and $P_{30}L_{12}$. The NH_3-N, NO_2-N and NO_3-N levels of culture water varied significantly ($p<0.05$) with varying levels of dietary protein and lipid. The NH_3-N level decreased from T1 (0.22 ppm) to T6 (0.08 ppm) with decreasing dietary protein and increasing dietary lipid levels. The highest levels of NH_3-N and NO_2-N were observed in the T1 group as the fish of that group were fed with higher dietary protein. A similar trend was also observed in the results of NO_2-N (0.29 to 0.13 ppm) and NO_3-N levels (1.08 to 0.7 ppm). As the highest growth was observed in fish fed with dietary protein and lipid level of 34% and 10% respectively, with significantly lower levels of NH_3-N and NO_2-N excretion into the culture water, it feed containing 34% dietary protein and 10% dietary lipid can be recommended for the culture of GIFT fingerlings in RAS.

Keywords: Ammonia-N, Dietary intervention, GIFT, Low-protein high-lipid diet, Nitrogenous waste

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Integrated Farming System: Way for nutritional and economic security of small farmers

Sunil Kumar*, Bhambri, M. C., Vinay Samadiya and Porte, S. S.
Department of Agronomy, College of Agriculture, IGKV, Raipur (C.G.) , India
*hellosonu2001@gmail.com

The human population of India has increased to 140.76 crores at a growth rate of 0.81 per cent in 2021 and is estimated to increase further to 167.49 corers by 2050. On the other hand, our national food grain production for past 3-4 years is hovering around 315.7 million tonnes. This means that per capita food grain production is only about 187.8 kg per year. Simultaneously, the demand for high-value commodities such as fruits, vegetables, livestock products, fish, poultry etc. is increasing faster than food grains. The average size of operational holdings has decreased from 2.28 hectares in 1970-71 to 1.08 hectares in 2015-16. If this trend continues, the average size of holdings in India would be further reduced to a low of 0.32 ha in 2030. Declining size of landholdings without any alternative income augmenting opportunity is resulting in fall of farm income, causing agrarian distress. In view of serious limitations of horizontal expansion of land for agriculture, the only alternative left is vertical expansion through various farm enterprises requiring less space and time but giving high productivity and ensuring periodic income especially for the small and marginal farmers. Integrated farming system model (1.0 ha) at IGKV under AICRP-IFS project was started from the year 2010-11 with cropping system, horticultural system, fishery, and poultry enterprises. From the year 2012-13, dairy component, vermicompost units, biogas units have also been added to the operations. A gross income of Rs 512014/- per ha and net income of Rs 267968/- per ha was generated from the entire IFS Research model area from different components/enterprises. Gross total of Rs 176078/- was obtained from cropping system, Rs 33076/- from kitchen garden, boundary plantation etc., Rs 112138/- from dairy unit, Rs 18975/- from fisheries-cum-duckery, Rs 46020/- from poultry unit Rs 21480/ from vermicompost unit, Rs 88520/- from goatery and Rs 15727/- from biogas. Overall net return from the cropping system was Rs 99581/-, dairy Rs 53953/-, poultry Rs 18142/-, fisheries-cum-duckery Rs 12359/-, goatery Rs 48826/-, vermicompost unit Rs 11584/-, biogas/compost pit Rs 12055/-, and horticulture (kitchen garden + boundary plantation) Rs 11469/-. From the employment generation point of view total 413 mandays was the generation from 1.0 ha IFS model during 2020-21 and residue recycled worth Rs 88370.00 within the IFS model to reduce the input cost. Sustainable value index, energy output: input ratio and water productivity were 0.74, 1.42 and 25.35 Rs m^{-3} respectively during 2020-21.

Keywords: Cropping system, Food grain production, Horizontal expansion, Operational holdings, Sustainable value index.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Preliminary assessment of yield and nutritional properties of coconut cabbage (heart of palm) in selected coconut (*Cocos nucifera* l.) accessions

Ranjini, T. N.*, Niral, V., Samsudeen, K. and Selvamani, V.

Division of Crop Improvement, ICAR- CPCRI, Kasaragod.

*ranjini.tantry@icar.gov.in; ranjini.tantry@gmail.com

The coconut palm, known as the 'Kalpavriksha,' is renowned for its multifaceted utility, from its roots to its crown. While numerous value-added products are derived from the coconut, one lesser-known and underutilized edible product is the palm "cabbage" or "heart-of-palm." Recognizing the gap in the study of its nutritional value and its potential as an alternative food source, the present study was conducted to evaluate the cabbage extracted from coconut seedlings, for yield and nutritional properties by quantitative determination of proximate composition, including moisture, total sugar, reducing sugar, total protein, free amino acids, lipids, total phenols, and ascorbic acid content, using standard analytical techniques.

Eight coconut accessions, comprising of six tall (Andaman Giant Tall, Java Tall, Philippines Lono Tall, Strait Settlement Apricot Tall, BARI Narikel Tall 1, and Klapawangi Tall) and two dwarfs (Malayan Green Dwarf and Niu Leka Green Dwarf), were screened to assess cabbage yield and quality parameters. The results demonstrated significant variation in cabbage yield among the studied accessions. The average cabbage yield (core portion) from four-year-old seedlings ranged from 81 g to 202 g. Strait Settlement Apricot Tall exhibited the highest mean cabbage yield (202 g), followed by Philippines Lono Tall (181.30 g). The lowest cabbage yield was recorded in the dwarf accession Malayan Green Dwarf (81 g). Seedling characteristics, such as the number of leaves and seedling girth, showed a significant positive correlation with cabbage yield.

Biochemical analysis revealed variations in moisture content (ranging from 82.5% to 87.25%), total sugar (6.68% to 10.81%), reducing sugar (2.07 to 3.3%), starch content (15.85% to 21.96%), crude protein content (10.07% to 13.14%), free amino acids (0.63% to 1.3%), crude lipid (3.5 to 4.9%), total phenol content (48.63 to 69.01 mg GAE/100g), and ascorbic acid content (6.5 to 10 mg/100g), among the studied accessions. The palm heart of the coconut also boasts a high energy value, ranging from 114.00 to 125.22 kcal/100g.

These findings reveal that coconut palm heart is a valuable nutrient source, rich in carbohydrates, crude protein, and Vitamin C. It can serve as an excellent alternative vegetable source to combat malnutrition.

Keywords: Accessions, Coconut cabbage, *Cocos nucifera*, Heart of palm.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Technological interventions for enhancing farmers' income and productivity: A case study in Bihar

Rohan K. Raman*[1], Abhay Kumar[1], Dhiraj K. Singh[1], Ujjwal Kumar[1], Md. Monobrullah[1], Rakesh Kumar[1], P. K. Sundaram[1], Sudip Sarkar[1], Tej Pratap[2], and Anup Das[1]

[1] ICAR Research Complex for Eastern Region, Patna-800014
[2] Krishi Vigyan Kendra, Manpur, Gaya-823003

*rohan.raman@icar.gov.in

Bihar is predominantly an agrarian state having more than 75% agricultural farmers, but their average annual income is very low. Improved agricultural technologies are the need of the hour to increase farmers' income. This study was conducted to assess the impact of agricultural technologies on net income and productivity of farmers of Gaya district, Bihar in Eastern India. Rice varieties like *Rajendra Sweta* (RAU 710-99-22), a high-yielding variety along with recommended herbicides and pesticides were distributed among more than 200 farmers in five villages of Gaya during kharif season in 2021-22. A sample of 75 farmers were randomly selected from among them for economic assessment. The parameters such as yield (t/ha), gross income (INR), net income (INR), benefit-cost (B:C) ratio and other variables were measured before and after technological intervention provided to the farmers. The significant ($p<0.05$) difference in selected parameters was analyzed through Z-test and regression analysis. Results showed that there is a significant ($p<0.05$) increase in yield, net income, gross income and B:C ratio to the extent of 23.9%, 93%, 37.01% and 58% respectively. Simultaneously, significant ($p<0.05$) decrease in cost of cultivation, land preparation, plant protection, weed control, family labour and hired labour were observed to the extent of 18, 17.31, 12.59, 23.33, 24.61 and 20% respectively. Hence, technological interventions in the field were found to be helpful in enhancing productivity and income of farmers. Therefore, such technological interventions should be adopted by farmers in order to supplement their livelihood.

Keywords: Climate, Food security, Regression analysis, Technology, Yield, Z-test

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Blending millets and legumes with wheat for food products with enhanced nutritional potential

Anuj Kumar*, Sewa Ram, Abhishek, Sunil Kumar, O. P. Gupta, Vanita Pandey and Gyanendra Singh
ICAR-Indian Institute of Wheat and Barley Research, Karnal
*anuj19ak@gmail.com

Legumes and millets hold special significance and are called smart foods. These dryland and climate-smart crops grow in semi-arid and tropical regions and are considered salubrious. Legumes and millets are known to be good sources of protein, micronutrients and various bioactive compounds. The present study evaluated the effect of legume flour (chickpea, green gram) and millet flour (finger millet, pearl millet, sorghum) addition on the spread quality of NIAW 3170 flour collected from Hisar and Pantnagar centres according to international protocol AACC 10-52. NIAW is a soft wheat variety suited for biscuit manufacture. The softness of the grain is 30-45%. It is recommended for peninsular and north-western plain zones under restricted irrigation conditions. The spread factor for NIAW 3170 grown at the Hisar and Pantnagar locations was observed to be 10.46 and 10.34, respectively. The addition of chickpea and green gram (0-40%) in Hisar and Pantnagar-grown varieties led to a slight reduction of spread ratio from 10.46 to 9.06, 9.70 and 10.34 to 8.53, 9.47, respectively. The mean spread factor for chickpea and green gram meal biscuits was 6.15 and 5.87, respectively. The addition of pearl millet and sorghum reduced the spread factor from 10.46 to 6.5, 7.29 and from 10.34 to 8.12, 8.61 for Hisar and Pantnagar varieties, respectively. The addition of finger millet flour in the varieties did not cause an appreciable reduction in spread factor except at 40% level in the Hisar variety where the spread factor fell to 8.42. The results of the study implied that chickpea, green gram, and finger millet can be incorporated into flour up to 40% level while pearl millet and sorghum can be incorporated up to 30% level without considerably reducing the spread ratio. The addition is expected to enhance the nutritional profile of the biscuits.

Keywords: Chickpea, Finger millet, Green gram, Legume flour, Millet flour, Spread factor

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Banana biodiversity for food and nutritional security

Selvarajan, R.*
ICAR-National Research Centre for Banana, Tiruchirappalli-620 102, Tamil Nadu, India
*selvarajanr@gmail.com; director.nrcb@icar.gov.in

India, being one of the centres of origin of banana, encompasses a rich spectrum of cultivars, wild relatives, indigenous and traditional varieties which harbor diverse genetic traits that influence fruit quality, resistance to pathogens, insect pests, nematodes, and adaptation to varying agro-ecological conditions. In the past three decades, ICAR-NRCB in collaboration with other institutes has been instrumental in collection, conservation, evaluation and utilization of *Musa* germplasm in India. This collection has led to the establishment of Asia's largest field gene bank with 374 indigenous and 125 exotic accessions that have been systematically characterized. The evaluation of this genetic diversity is pivotal for breeding programs aiming towards the development of nutritionally fortified cultivars, addressing micronutrient deficiencies and promoting good health, particularly in regions heavily reliant on bananas as their staple food. In India, almost 120 banana varieties are cultivated which are very diverse in their taste, nutritional richness and utility. Of this, only eight varieties have been elevated as GI tagged bananas, fetching a better price in the market. However, there are many more varieties which are unique and specific to a particular location whose potential remains untapped. Indian bananas possess substantial genetic variability for all the micronutrients besides Ca and Mg, which could fairly contribute to the RDA of Indians, and almost 20 commercial cultivars have been placed in the top 10 positions. Bananas are diabetic-friendly if consumed at just ripe stage (stage 4 or 5) because they will have a moderate GI of 60, especially in commercial varieties like red banana, Nendran and Neypoovan. Culinary bananas contain fairly good amounts of starch which are resistant in nature and thus could be utilized in food industries and pharmaceuticals. Dehydrated ripe banana powder, a fruit sugar serves as a versatile ingredient in food industries. Moreover, the extraction of non-starch polysaccharides from ripe banana puree and pomace offers potential applications in the food industry as a probiotic supplement. Besides, food applications, pseudostem could be potentially used in non-food industries for the extraction of cellulose and fibres. However, the maintenance of banana biodiversity faces numerous challenges, including the threat of emerging pests and diseases, habitat destruction, and climate change. Therefore, harnessing the genetic potential of diverse banana varieties through scientific research, breeding efforts, and sustainable agricultural practices is crucial to ensure a resilient and nutritious future for communities dependent on this essential crop.

Keywords: Conservation, Food security, Nutritional enhancement, Sustainable agriculture, Utilization.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Soil test based balanced nutrient application in little millet (*Panicum sumatrense*) for lateritic soils of Tamil Nadu

Balamurugan, J.[1], R. Santhi[1], M. Gopalakrishnan[1], S. Maragatham[1], Immanuel Chongboi Haokip[2] and Sanjay Srivastava[2]*

[1]Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu
[2]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

*sanjaysrivastava238@gmail.com

Little millet is a coarse cereal providing nutraceutical components such as phenols, tannins and phytates along with other nutrients. A field experiment was conducted at Coimbatore to develop soil test-based balanced fertilizer recommendations for little millet (*var.* CO 4). The experiment comprised 24 treatments with four levels each of N (0, 40, 80 and 120 kg ha^{-1}), P_2O_5 (0, 20, 40 and 60 kg ha^{-1}) and K_2O (0, 25, 50 and 75 kg ha^{-1}) and three levels of FYM (0, 6.25 and 12.5 t ha^{-1}) applied to three strips of varying fertility gradient in fractional factorial design. The nutrient requirement for producing one quintal of grain was 1.96 kg of N, 1.44 kg of P_2O_5 and 2.39 kg of K_2O. The per cent nutrient contribution from the soil, fertilizer and organic manure (FYM) was 9.02, 22.2 and 12.3 for N; 18.4, 38.3 and 10.4 for P_2O_5 and 6.41, 52.2 and 20.7 for K_2O, respectively with a response ratio of 5.83. Fertilizer prescription equation as well as ready reckoner for a definite yield goal was developed for balanced nutrient management using these basic parameters. Verification of the result showed that target grain yield of 2 t ha^{-1} was achievable with both chemical and integrated modes of nutrient management with an acceptable ±10% deviation. The soil test-based balanced nutrient application also enhanced the response ratio and farmers profit (higher benefit:cost ratio) compared with farmers' practice and general recommendation. Thus a farmer can set his yield goals depending upon resources available at his end.

Keywords: Balanced nutrition, Fertilizer recommendation, Nutrient management, Soil test,

Evaluation of various insecticides against mustard aphid, *Lipaphis erysimi* (Kaltenbach) in mustard crop

Bajya, D. R.*, Harphool Singh and Jat, L. K.

Sri Karan Narendra Agricultural University, Jobner, 303 329, Jaipur, Rajasthan (India)

*drbajya.ento@sknau.ac.in

Field experiments were conducted to evaluate the efficacy of various insecticides against mustard aphid, *Lipaphis erysimi* (Kalt) on mustard crop during *Rabi* season 2020-21 and 2021-22. The results on the field efficacy of insecticide against *L. erysimi* revealed that treatment performance is in the order of imidacloprid 17.8 SL > thiamethoxam 25%WG > acetamiprid 20%SP > dimethoate 30%EC > malathion 50%EC > fipronil 5%EC > profenofos 50%EC > buprofezin 25%EC. The least population was obtained with most effective imidacloprid 17.8%SL (5.40 per plant) at 7 days after sowing (DAS) and (6.67 per plant) at 10 DAS during 2020-21 and 2021-22 respectively. The same trend was observed till 28th day in comparison to rest of the treatments and untreated control. Significant reduction in population was observed with imidacloprid 17.8% SL @ 27.0 g a.i. ha^{-1} followed by thiamethoxam 25%WG @ 25 g a.i. ha^{-1} and dimethoate 30%EC @ 200 g a.i. ha^{-1}. Imidacloprid 17.8% SL @ 27 g a.i. ha^{-1} was significantly superior in comparison to the rest of the treatments as well as at par with thiamethoxam 25%WG@25 g a.i. ha^{-1} up to 28 days of spray. The maximum yield was obtained with imidacloprid 17.8% SL (17.99 and 18.22 q ha^{-1}) followed by thiamethoxam 25%WG (16.62 & 17.37q ha^{-1}) during 2020-21 and 2021-22 respectively.

Keywords: Evaluation, Imidacloprid 17.8 SL, Insecticides, *Lipaphis erysimi*, Mustard, Sucking pests.

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Cold anaesthetization of *Penaeus vannamei* for waterless transportation

Parvathy, U.*., Vishnu R. Nair, Jithin, T. J., Madhusudhana Rao, B., Binsi, P. K., Sathish Kumar, K. and Murali, S.
ICAR-Central Institute of Fisheries Technology, Matsyapuri P.O., Willingdon Island, Kochi–682029, India
*p.pillai2012@gmail.com

The Pacific white shrimp (*Penaeus vannamei*), a globally significant shrimp species, has experienced increasing popularity for live transport and storage due to technological advancements, in specially designed tanks, containers, and transport vehicles equipped with aeration or oxygenation facilities. Waterless transportation method is one of the marketing methods adopted, where the shrimps are maintained in a cool and moist environment using materials like sawdust, cotton etc. The present study focused on optimizing key parameters, such as target temperature (transportation temperature) and cooling rate, to achieve the desired cold anaesthetization of shrimp prior to waterless transportation. Marketable size *P. vannamei* with an average weight of 25 g were collected from local aquaculture farms of Kerala. The shrimp underwent various treatment combinations of cooling rates (CR) and target temperatures (TT) for anaesthetization and subsequent simulated transportation studies. The treatments also included a control group for reference. The survival rate and physical activity of the shrimps were evaluated during their revitalization period, which extended up to 24 h after each treatment. The results showed that a cooling rate of 6 °C h^{-1} and a transportation temperature of 12 °C yielded the highest survival rate of 98.83%. This optimized cold anaesthetization and transportation method can be recommended for efficient waterless transport of shrimp of marketable size.

Keywords: Cold anaesthetization, *Penaeus vannamei*, Pacific white shrimp, Waterless transport

Theme: Ensuring Food & Nutritional Security: Production, consumption and value addition
Sub theme: Resource Efficient, Environment Friendly Production of Nutrient-dense Farm Foods in India

Deciphering the regulation of nutritive value and drought stress response in *Moringa oleifera* through genomic approach

Sushree Shyamli, P [1,2], Mitrabinda Panda [1,2], Seema Pradhan[1] and Ajay K Parida[1]

[1] *Institute of Life Sciences, NALCO Square, Chandrasekharpur, Bhubaneswar, Odisha-751023*

[2] *Regional Centre for Biotechnology (RCB), Faridabad, Haryana-121001*

*shyamlyc21@gmail.com

Moringa oleifera (drumstick tree), is a tropical multipurpose plant with medicinal and nutritional properties and with an ability to grow in low water conditions. This makes the species an ideal candidate to study the regulatory mechanisms that modulate abiotic stress tolerance and its possible use in agroforestry systems. It is a well-recognized member of the Moringaceae family and is thought to be originated in the sub-Himalayan forests of the Indian subcontinent. Moringa leaves are an excellent source of protein. It has 13 known species mostly possessing nutritional, phytochemical and pharmacological properties. All parts of the plant have been used for a number of health benefits and play a distinct role in treating several health conditions. However, abiotic stress factors have an adverse impact on the nutritional quality. The present study is therefore, designed to determine the effect of abiotic stress on gene expression in the plant with focus on transcription factors. We generated and assembled a draft genome sequence of *M. oleifera* (var. Bhagya) into 915 contigs with a N50 value of 4.7 Mb and predicted 32,062 putative protein-coding genes using Next Seq platforms. The DNA libraries were prepared for sequencing on PacBio Sequel and Illumina HiSeq 2500 platforms to generate long and short reads respectively. RNA Seq was carried out with control and drought-stressed samples. We predicted a total of 21 Heat shock factors (HSFs) in the *M. oleifera* genome and carried out phylogenetic analyses, motif identification, analysis of gene duplication events, and differential expression of the HSF-coding genes in *M. oleifera*. Analyzing the effect of abiotic stress on nutritional value as well as deciphering the genomics of nutrient assimilation will enable us to correlate and study the interaction of the genes responsible for nutrigenetics and the regulation by HSFs in presence or absence of abiotic stress.

Keywords: Abiotic stress, Genome assembly, HSFs, Nutrigenetics

XII AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 2

Climate Action for Sustainable Agri-food Systems

Impact of climate change on food and nutrition security: Evidence and research gaps

Rama Rao, C. A.*, Raju, B. M. K., Samuel, J., Nagarjuna Kumar, R. and Singh, V. K.

ICAR – Central Research Institute for Dryland Agriculture, Hyderabad – 500 059, Telangana, India

*car.rao@icar.gov.in

Climate change is no longer a perception and is now a reality posing a formidable challenge to sustainable food security, agriculture and livelihoods. Long term analysis of climate, expressed in terms of moisture index, showed shifts from semi-arid to arid and moist sub-humid to dry sub-humid climate in a few districts in India which has implications to agricultural research and development planning. Most of the climate projections show a warmer and wetter climate for mid 21st century with steeper rise in both temperature and rainfall towards the end of the century. A more important aspect of climate change is the projected rise in incidence of extreme events in terms of frequency and intensity. However, the projections show a considerable spatial variability. This, together with the diversity in agro-climatic and socio-economic setting in the country, makes adaptation a greater challenge. Climate change vulnerability assessments identified districts with relatively high vulnerability and risk and thus are helpful in prioritizing investments. Climate change affects all aspects of agriculture by affecting crop growth and development directly and indirectly through its effects on water availability, incidence of insect pest and disease incidence. Changing temperature and atmospheric carbon dioxide levels were also shown to alter nutrient uptake and composition of crop plants. Climate change can lead to lowered food production, rise in food prices, increased incidence of human diseases and dampened food demand through falling crop incomes and thus affects all the four dimensions of food security: production, access, utilization and stability. With its diluting effects on nutritional composition of food crops, climate change also has implications to nutrition security too. An association between climate change vulnerability and incidence of child malnutrition expressed in terms of prevalence of stunting, wasting, underweight and anaemia was observed. Similarly, incidence of child malnutrition was also observed to be higher in households affected by extreme events such as floods. However, the causal links between climate change and nutrition related outcomes are still to be better understood given the role of various socioeconomic factors in determining the impacts of climate change. In order to minimize the impact, a coordinated approach consisting of policy and institutional interventions for enhancing technology adoption, altering production and consumption behaviour of producers and consumers, and improving marketing and trade environment is needed.

Keywords: Agriculture, Climate change, Food security, Nutrition security

Integrated Multi-Trophic Aquaculture (IMTA): Economic prosperity and environmental sustainability through the integration of cage fish farming and seaweed mariculture

Johnson, B.*, Tamilmani, G., Sakthivel, M., Ramesh Kumar, P., Anikuttan, K. K., Ranjith, L., Divu, D., Suresh Kumar Mojjada, Sekar Megarajan, Shubhadeep Ghosh, Boby Ignatius, Grinson George, Vinod, K. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Mandapam Camp–623 520, Tamil Nadu, India

*jsfaith@gmail.com

Intense fishing pressure along the coastal waters, coupled with negative impacts of climate change has lately started impacting the livelihoods of fishers. While harvests are dwindling, the demand for marine fish is increasing steadily owing to its crucial role in ensuring food and nutritional security of the population. This necessitates augmenting marine fish production through farming of promising commercial species of fish in the sea. Realizing this important priority, the ICAR-CMFRI has developed and standardized the technologies for seed production and farming of marine finfish and shellfish in open sea cages. One of the anticipated issues while expanding the sea cage farming is the increased organic and inorganic load in the water and consequent disease problems. In this context, the idea of bio-mitigation along with increased biomass production can be achieved by integrating different groups of commercially important aquatic species which are having varied feeding habits. This concept is known as Integrated Multi-Trophic Aquaculture (IMTA). To achieve environmental sustainability and economic stability, an innovative idea of integration of seaweed with sea cage farming of cobia was demonstrated during 2014-17 at Munaikadu, Palk Bay, Tamil Nadu.

A total of 16 bamboo rafts (12 x 12 feet) with 60 kg of seaweed per raft was integrated for a span of 4 cycles (45 days cycle^{-1}) along with one of the cobia farming cages. The rafts were placed 15 feet away from the cage in a semi-circular manner, so as to enable the seaweed to absorb the dissolved inorganic and organic nutrients generated at the cage site. Currently through IMTA, seaweed rafts integrated with cobia farming cages had a better average yield of 390 kg raft^{-1}, while in the non-integrated raft, the yield was 250 kg raft^{-1}. An additional yield of 140 kg of seaweed per raft (56% additional yield) was achieved through the integration with the cage farming of cobia. An additional net income of ₹85,120/- (896 kg x ₹95 kg^{-1} of dry weight) was realized through integration of seaweed rafts with cobia cages. Carbon dioxide sequestration (per unit mass of seaweed per day per 16 rafts per 4 crops) into the cultivated seaweed in the integrated and non-integrated rafts was = 47.4 kg CO_2 day^{-1} t^{-1} dry weight of *K. alvarezii* vs 30.4 kg CO_2 day^{-1} t^{-1} dry weight. Through IMTA there was a 25% increase in cobia fish production. IMTA is an eco-friendly option ensuring sustainable income to the coastal fishers. It is also one of the significant mitigating measures for reducing the adverse impact of climate change and also earns carbon credit to our country.

Keywords: Bio-mitigation, Cage farming, Seaweed mariculture

Low-salinity induced alterations in transcriptome of Indian white shrimp (*Penaeus indicus*)

Raymond, J. A. J.*, Vinaya, K. K., Ashok, K. J., Kumaravel, J., Karthic, K., Sudheesh, K. P. and Shekhar, M. S.

ICAR-Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R A Puram, Chennai-600 028, Tamil Nadu, India

*raymond.angel@icar.gov.in

Abiotic stress refers to non-living factors in the environment that can negatively impact the growth, development, and overall health of organisms. Shrimps are highly sensitive to changes in salinity levels. Sudden increases or decreases in salinity can cause osmotic stress, affecting their ability to regulate water and salt balance within their bodies. To understand the molecular mechanisms regulating the salinity stress, transcriptome and gene expression profiles under low salinity condition were compared. In this study, juvenile Indian white shrimp *Penaeus indicus* were acclimated to 5 ppt salinity, cultivated for three weeks at this salinity, and compared with a control group reared at 30 ppt. High-throughput RNA sequencing was used to analyze and compare the changes in gene expression patterns in the gills of both the control group and the treatment group of shrimps. The results revealed that 5351 genes were significantly differentially expressed in the gills at the end of third week. It was also observed that the osmoregulation of *P. indicus* is primarily regulated by lipid and amino acid metabolism, amongst others. Several important genes have been identified to be associated with salinity responses in shrimps. This study provides a better understanding of the genes involved and molecular mechanisms underlying low-salinity adaptation in *P. indicus*.

Keywords: Gene expression, *Penaeus indicus*, RNA sequencing, Salinity stress, Transcriptome

Utilisation of forecasts for enhanced preparedness and suitable crop planning

Rao, K. V.*, Singh, V. K., Prasad, J. V. N. S., Subba Rao, A. V. M., Ravindra Chary, G. and Bal, S. K.

ICAR-Central Research Institute for Dryland Agriculture, Santosh Nagar, Saidabad, Hyderabad.

*kv.rao@icar.gov.in

With increasing changes in patterns of rainfall and temperature, a need has arisen to take cognizance of seasonal forecasts of monsoon for both kharif and rabi seasons to appropriately plan for suitable crops to be grown, area coverage, production targets across different districts/states. The availability of seasonal forecasts at spatial scales facilitated to account for the variability in forecasts for better planning. In the last two years, the India Meteorological Department also started providing seasonal forecasts at spatial scales. ICAR-CRIDA has been making use of these seasonal forecasts provided by national and international agencies and conducting interface meetings with various state governments, and advising the state governments to enhance their preparedness to meet weather aberrations during the main cropping season. This process also facilitated the action plan for implementation of district agriculture contingency plans (DACPs) by suitably planning various technological interventions and keeping the need-based inputs at the disposal of field functionaries. Interventions (both preparatory mechanisms and real-time interventions through advisories) have also been demonstrated in farmer fields to cope with variable weather conditions. It is reported that by appropriately planning for technological interventions and suitable crops, minimisation of losses, changes in cropped areas and enhanced use of natural resource management options are achieved. Changes are more visible at the micro level such as district rather than state or national level. Similarly, protocols are developed to advise district authorities for growing suitable crops based on groundwater recharge (which depends on rainfall during the kharif season) and seasonal forecast for the rabi season especially for groundwater irrigated regions. Currently, available forecasts at the seasonal, monthly and medium ranges have become immensely helpful in better planning, so that appropriate crops can be grown and weather aberrations can be addressed in a meaningful way. Though efforts are being made to utilise the forecasts, there is a need for the involvement of development departments such as agriculture and irrigation, so that forecasts potential can be realised.

Keywords: District Agriculture Contingency plans, Interface meetings, Seasonal forecasts

Mapping the climate change-induced physical hazards along the coastal districts of India

Reshma Gills*, Shelton Padua, Ramachandran, C., Eldho Varghese, Ratheesh Kumar, R., Grinson George, Rose P. Bright, Vivekanandan, E., Jayasankar, J. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Kochi – 682 018, Kerala, India

*reshma1818@gmail.com; Reshma.Gills@icar.gov.in

Climate change is extensively recognized as a significant and multifaceted threat to the environment, ecosystems, economies, and societies around the world. Rising temperature, more frequent extreme weather events, sea-level rise, and shifts in ecosystems can lead to the loss of biodiversity, endangering countless plant and animal species. It also intensifies the frequency and severity of natural disasters such as storms, wildfires, floods, and droughts and can have significant economic consequences due to disruption of supply chains, damages to infrastructure, reduction of agricultural yields, and increase in cost of insurance and disaster recovery. Coastal areas and fishing communities are particularly susceptible to the effects of climate change because of their geographic location near the ocean and other distinctive features. Climate-responsive or climate-resilient spatial planning is a critical aspect of addressing the challenges posed by climate change. It is essential to understand the hazard proneness of a particular region to develop a climate-responsive spatial plan to reduce the likelihood and impact of these disasters, protecting lives and property. The study thus aimed to assess the hazard proneness of the coastal districts of India, taking five different hazards, i.e., sea level rise, flood proneness, shoreline change, heatwave and cyclone proneness, into consideration. Baleshwar District of Odisha, Mumbai City District of Maharashtra State, North 24 Parganas District of West Bengal, and Vizhianagaram and West Godavari districts of Andhra Pradesh showed the highest index values, respectively for cyclone proneness, flood proneness, shoreline change and heatwave. The composite multi-hazards index developed in the study showed that Krishna District of Andhra Pradesh has the highest proneness to the physical hazards due to climate change.

Keywords: Cyclone proneness, Flood proneness, Heatwave, Multi-hazards index, Sea level rise

Harnessing *Asparagopsis taxiformis*: A promising red macroalga for methane mitigation and its prospects for seaweed farming to reduce dairy farm carbon footprints

Aju, K. R*., Sobhana, K. S.**, Sreesanth, L., Alvin Anto, Priyanka Poulose, Reena V Joseph, Reeta Jayasankar, Grinson George and Gopalakrishnan, A.

ICAR-Central Marine Research Institute, Ernakulam North P. O., Kochi–682 018, Kerala, India

**sobhanapradeep11@gmail.com, sobhana.ks@icar.gov.in

Asparagopsis taxiformis, a red macroalgal species, has established a global presence primarily through deliberate introductions. Researchers have devoted considerable attention over the past five decades to uncover the diverse array of bioactive compounds found within this species. Notably, it possesses a remarkable ability to reduce methane emissions from ruminant animals, a significant contributor to short-term global warming. This unique trait has prompted extensive experimentation with *A. taxiformis* in recent years, elevating it to a prominent position among potential seaweed farming candidates. Despite its global importance, *A. taxiformis* has a limited known distribution in Indian waters. Therefore, further investigations and ongoing monitoring are crucial to comprehensively understand its prevalence in the region. Alternatively, strategic introductions of the species to suitable locations beyond its current range could be considered. In this context, our present study represents a significant milestone by confirming the presence of both the gametophyte and tetrasporophyte forms of *A. taxiformis* along the Thirumullavaram coast in southern Kerala, India. To validate our findings, we have conducted genetic analyses to authenticate the species' identity. We have also undertaken experimental laboratory culture and tissue culture for micropropagation of the species. Considering India's evolving developmental goals, which prioritize inclusiveness, self-reliance, sustainability, and green and blue economic growth for a healthier future, the widespread adoption of seaweed farming across suitable locations becomes imperative. *A. taxiformis* emerges as a crucial candidate in this context, offering not only medicinal and dietary benefits but also a means to mitigate methane emissions. The animal husbandry sector in India annually emits approximately 9.25 Tg of enteric methane, posing a significant environmental challenge. Addressing this issue requires the introduction of affordable and sustainable technologies. Seaweed farming, with a particular focus on species like *A. taxiformis*, presents a highly promising and environmentally sound solution for reducing methane emissions from livestock. Renowned for its high content of anti-methanogenic compounds, *A. taxiformis* is an ideal candidate for dietary interventions aimed at sustainably curbing methane emissions from ruminant animals. To effectively combat the pressing problem of methane emissions from livestock and their significant contribution to climate change, it is imperative that we must conduct thorough and sustainable investigations into the farming of such species.

Keywords: Anti-methanogenic compounds, Gametophyte, Genetic analysis, Global warming, Ruminant methanogenesis, Tetrasporophyte

In vitro characterization and functional validation of plant-growth-promoting and stress-tolerant soil bacteria to improve the yield and salt resistance of rice

Ajit Ghosh*, Mahmuda Begum, Papon Chandra Paul and Ronjon Chandra Paul

Department of Biochemistry and Molecular Biology, Shahjalal University of Science and Technology, Sylhet 3114, Bangladesh

*aghosh-bmb@sust.edu

The growing danger of soil salinity and the increasing use of chemical fertilizers has increased the necessity of searching for alternative options. The salt-tolerant and plant growth-promoting bacteria (PGPB) play an important role in overcoming this danger. In this study, we have screened, isolated, and characterized salt-tolerant plant growth-promoting microbes from the soil. A total of 22 strains were screened from the soil of different regions of Sylhet, Bangladesh. Among them, Five strains have shown better results in different biochemical tests, including phytohormone production, ammonia production, exopolysaccharide production, biofilm production, and salt-tolerant test. *In vitro* screening of these strains with rice was performed by measuring different parameters, including chlorophyll production, shoot length, root length, and dry weight under normal and saline conditions. One of the rice seeds (BARI-29), was chosen to be tested under normal and saline conditions. The maximum effect was found with strains A-15, F-6, and W-9, and the minimal effect was observed for the strains AW-2 and AT-2. The 16S rRNA sequencing identified the most effective strains as *Staphylococcus haemolyticus* for AT2, *Micrococcus* sp. DS4. pah.1 for "A-2", and *Staphylococcus* sp. for F6. The results strongly suggest that salt-tolerant and growth-promoting bacteria in soil can be an effective and environmentally friendly strategy to enhance crop yield and salinity tolerance of plants.

Keywords: Phytohormone, Plant growth-promoting bacteria, Salinity, Soil bacteria, Yield

Resilience index of Vembanad Lake fishery

Thankam Theresa Paul*, Deepa Sudheesan, Albin Albert, C. and Das, B. K.

ICAR-Central Inland Fisheries Research Institute, Kochi Centre, CMFRI Campus, Ernakulam – 682 018, Kerala, India

*thankamtheresa@gmail.com

The fishery of Vembanad Lake which is affected by climate change can be managed by many adaptation strategies, and the resilience of the fishery by itself is one among them. The paper assesses the resilience index of Vembanad fishery with the help of ecological (trophic level, dietary plasticity, temperature tolerance range), life history (spawning duration, relative fecundity, generation time), behavioural (parental care, egg buoyancy, egg adhesiveness) and biological (relative fecundity, ratio of mean length to length at maximum age, growth co-efficient) traits. The Kruskal-Wallis test was used to find significant differences between these variables in fishes. The study indicated that there is a significant difference in temperature tolerance range (TTR), trophic level (TRL), relative fecundity (RF), Mean length/ Length at maximum age, generation time (GT) and K (growth co-efficient) with each variable scoring a mean rank of 423.5. The random forest method has been used to identify the most contributing factor to the resilience of the fishery. The analysis indicated that TTR (IncNodePurity at 2822.753) followed by DP (dietary plasticity with incNodePurity at 617.58). Thirty five (35) fishes are found to have narrow thermal window (0-6^{0}C) compared to others indicating very low resilience. The study indicated that species with narrow dietary window is highly vulnerable. This study provides a self-assessment tool for stakeholders, prior to harvesting the fishery in the lake.

Keywords: Fishery resilience index, IncNodePurity, Random forest method, Temperature tolerance range, Vembanad,

Effects of high water temperature stress on physiological profiles of *Labeo rohita, Labeo calbasu* and *Labeo bata* in context of global warming

Satish Kumar Srivastava*, Poonam J, Singh and Akhilesh Kumar Mishra

ICAR- National Bureau of Fish Genetic Resources, Genomics and Computational Resources Division, Lucknow, Uttar Pradesh- 226 002, India

*srivastavask100@gmail.com

Water temperature is the most vital parameter for the survival of the fisheries sector. Studies pertaining to the effect of temperature increase on fishes to see the physiological changes occurring in their body might be helpful in planning conservation measures for important food fishes. *Labeo* species are one of the most common freshwater cultivable fishes having great economic potential in the aquaculture sector. They are abundantly found in rivers and ponds of tropical and temperate climatic areas of South-east Asian countries, including India. Temperature is an important factor which affects their immunological response and changes in blood factors. A study was undertaken to work out comparative changes in blood parameters on exposure to sublethal temperatures to have some idea about adaptability among rohu, calbasu and bata under the global warming scenario. The critical high temperature tolerance of the three *Labeo* species viz. *L. rohita, L. calbasu* and *L. bata* were estimated to be 41, 40 and 39°C, respectively. The effect of temperature on various blood parameters like blood haemoglobin, urea, serum protein, cholesterol and glucose were studied in control and experimental groups at 0, 15, 30, 45 and 60 days time intervals. The results suggest that temperature and duration of exposure, influence certain blood parameters significantly among these *Labeo* species.

Keywords: Bata, Blood sugar, Blood urea, Calbasu, Fish, Haemoglobin, *Labeo rohita*, Serum protein, Temperature stress

Can fishing holidays be part of just transition in marine fisheries? An exploratory study across coastal states in India

Shyam S. Salim*, Anuja A. R., Akhila Kumaran, Narayanakumar, R., Steny Rebello and Athira, N. R.

ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*shyam.icar@gmail.com

Marine fisheries sector has earned the adjective of being a sunrise sector in the Indian economy owing to its contribution to the Agricultural GDP in particular and the national GDP overall. Owing to this rapid growth rate, there has also been subsequent interest in the nature of growth, especially in the context of Sustainable Development Goals, especially SDG 14, which speaks about preserving the blue *i.e.*, our oceans. Given that there has been increasing focus on the use of marine fisheries resources with equity as the leading principle. This paper intends to analyze the macroeconomic impact of the COVID-19 pandemic on the marine fisheries sector in India, and suggest possible policy interventions that can aid in recovery. First, the loss due to the pandemic-induced lockdown is estimated across four components–landings, employment/wage, marketing and export/trade across all nine major coastal states in the country, namely, Gujarat, Karnataka, Kerala, Andhra Pradesh, Goa, Maharashtra, Tamil Nadu, Odisha and West Bengal. The loss was assessed across three periods: pre-COVID, during COVID and post-COVID taking the data for 2015-19, 2020 and 2021-22 for the pre, during and post COVID periods respectively. Our findings point out that irrespective of state-wise differences in loss, the recovery in the fisheries sector has been due to increased landing and/or higher prices of certain fish species in the market. Important externalities and innovations comprising marketing channels, including online avenues, also contributed to the sector's recovery. Subsequently, the paper also evaluated, where within the four components there has been slow, medium and fast recovery and the reasons for the same. Following this, we appraised what existing policies aided in the recovery of each component measured, and suggested measures as to how the ideal recovery would look like. Following the conceptual framework of just transition, the paper explores the possibility of institutionalizing fishing holidays in order to ensure that there is a minimum impact on the livelihoods of those who depend on marine fisheries. The paper concludes by focusing on stakeholder perspectives on fishing holidays and the inter-state differences in knowledge and attitude within the framework of the Knowledge-Attitude-Practice (KAP) model.

Keywords: Employment, Export, Fish landings, Marketing, Recovery

Impacts of ENSO events on ocean-atmospheric parameters and selected marine fish resources along the Gujarat coast

Arya S. Jagadan, Shelton Padua*, Prema, D., Ratheesh Kumar, R. and Nameer, P. O.

ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*sheltonpadua@gmail.com

ENSO events exert an enormous impact on the global weather pattern and are a dominant source of interannual climate variability around the world influencing human populations and ecosystems. ENSO episodes are also known to change the environmental characteristics of coastal waters which are the major habitats for fish resources that are harvested all along the Indian coasts. The effects of various ENSO episodes from 2007-2020 on marine fish resources of Gujarat were studied. The monthly catch of major pelagic fish resources like Gold spotted grenadier anchovy (*Coilia dussumieri*), Bombay duck (*Harpadon nehereus*), ribbon fish, torpedo scad (*Megalaspis cordyla*), long tail tuna (*Thunnus tonggol),* kawakawa *(Euthynnus affinis),* yellowfin tuna (*Thunnus albacares*); demersal fishes like croakers, threadfin breams, and greater lizard fish (*Saurida tumbil);* crustaceans like crabs, stomatopods, lobsters and *Penaeus* spp.*;* and molluscs like *Sepia pharaonis*, *Octopus* spp., *Sepia* spp. and squids by major gears for the period 2017-2020 were collected and its catch per unit effort were estimated. ENSO indices like Nino 1+2, Nino 4, Nino 3.4, ONI, MEI, SOI, EMI, DMI, TNI, and ocean-atmospheric parameters such as Chlorophyll a (CHL_A), Salinity (SALT), Sea Surface Height (SSH), Sea Surface Temperature (SST), Local Temperature Anomaly (LTA), Rainfall (RF), Ocean Current Direction (OCD) and Ocean Current Velocity (OCV) were analyzed. GAM modelling was used to study the influence of the ENSO phenomenon on different ocean-atmospheric parameters. GAM model results indicated that the ENSO could explain 47.5% deviance in LTA, 45.6% deviance in SALT, 45.5% deviance in SST, 41.8% deviance in RF, 35.5% deviance in SSH and 31.2 % deviance in CHL_A. The ENSO episodes could explain 39.6% deviance in the abundance of ribbon fish, 33.3%, 22.9%, and 21.8 % deviance in the abundance of tuna species such as *T. tonggol*, *E. affinis*, and *T. albacares* respectively, 34.6% deviance in the abundance of croakers, 26.6% deviance in the abundance of threadfin breams, 53.8% deviance in the abundance of stomatopods and 29.9% deviance in the abundance of *S. pharonis.* The combined model using ENSO indices and ocean-atmospheric parameters as predictors explained 66.6% deviance of ribbon fish, 74.1% deviance of *S. tumbil*, 79% deviance of stomatopods and 75.1% deviance of *Sepia* spp. The ENSO episodes alone could explain 32.8% deviance and a combination of ENSO and ocean-atmospheric parameters could explain 76.3% deviance in the abundance of total fish resources of the Gujarat coast.

Keywords: ENSO, GAM, Gujarat coast, Marine fish resources, Ocean-atmospheric parameters

Breeding durable root and stem rot (*Macrophomina phaseolina*) resistant sesame genotypes

Gupta, K. N.*, Rajni Bisen and Vishwakarma, A. K.

Project Coordinating Unit (Sesame &Niger), ICAR-Jawaharlal Nehru Krishi Viswa Vidyalaya (ICAR-JNKVV) Campus, Jabalpur-482 004, Madhya Pradesh, India

*kngupta1@rediffmail.com

Developing and deploying resistant varieties is an economic, eco-friendly and hassle-free tool to manage diseases. However, resistance does not last long and frequently succumbs to the changes and shifts in pathogens. The plant pathogens and pests are dynamic and keep on changing to counter the introgressed resistance. Host and pathogen evolve hand in hand and results in boom-and-bust cycle followed by susceptibility of a plant variety. Therefore, breeding for resistance has to be a continuous process. In this context, we have identified resistant sesame genotypes against Root and stem rot (*Macrophomina phaseolina).* Sesame (*Sesamum indicum* L.) is one of the world's oldest oilseed crops and has been cultivated in Asia since ancient times and largely produced for its oil and is also used as a flavouring agent. The seeds of sesame contain 40 to 53% oil, which contains a significant amount of oleic and linoleic acids. It plays an important role in the oil seed economy throughout the world. The fungal disease Root and stem rot caused by *Macrophomina phaseolina* (Tassi) Goid, is the most important disease and is widely, distributed in sesame growing region. The pathogen attacks plants at all growth stages. Due to soil borne nature, practically no effective field control and no source of resistance is available. 189 genotypes of sesame accessions were sown during *kharif* 2022 along with susceptible check VRI-1 and resistance check GT-10 in augmented plot design in two rows of 3 m length to screen for root and stem rot disease under sick plot conditions. Among the 189 accessions, 15 lines were found resistant, and disease incidence was less than 10%. The resistance line was used for further breeding programs.

Keywords: Fungal disease, Resistance, Root and stem rot, *Sesamum indicum*,

Phenotypic evaluation of traditional rice landraces for root traits

Abijith Kumar, V. S., Sahara Panta, Monika Reddy, Suresh Kumar, R., Reena, Sellamuthu* and Sudheesh Manalil

Amrita School of Agricultural Sciences, Amrita Vishwa Vidhyapeetham, JP Nagar, Arasampalayam, Coimbatore – 642 109, Tamil Nadu, India

*s_reena@cb.amrita.edu

Traditional landraces are a great source of genetic variability. India had more than one lakh rice landraces, but the number has gone down tremendously due to the introduction of new varieties. Some of the traditional landraces have been collected and evaluated for various characteristics, and few of the landraces have been identified for various useful traits, and even fewer are utilised directly as variety or indirectly in crop improvement programs. Still, many of the landraces are under the verge of extinction. Collecting and conserving them is essential as their genetic variability can be utilised for sustainable development in the climate change scenario. Many of these landraces are yet to be characterised. In this study, the farmers from different regions of Kerala and Tamil Nadu holding some of these traditional landraces were identified, and the landraces were collected from them. More than 50 landraces collected from them were multiplied and evaluated for various traits. Evaluating root traits is important to understand the drought tolerance potential of the varieties. Vigorous root growth is a drought adaptive trait. Hence, in this study, 44 landraces were evaluated for early stage root growth. Initially, root length at 3, 5 and 7 days after sowing were measured. At 5 days after sowing, the landraces had a root length ranging from 0.5 cm to 4.5 cm when they were germinated in petriplates at room temperature. At 7 days after sowing, the root length ranged from 0.7 to 6.2 cm. The landrace Chomala had the longest root length among the landraces evaluated. Other landraces such as Thondi, Navara, Salem Samba also had longer roots. Such wide variation among the landraces suggests that further in-depth evaluation will be required to identify and understand the drought tolerance traits. Hence, these landraces are raised in greenhouse conditions to evaluate root traits in detail and other drought tolerance traits. Maximum root length will be measured at different growth periods. Further, general morphological characters of the landraces will also be recorded. The landraces possessing drought tolerance traits will be identified and utilised in crop improvement programmes.

Keywords: Drought, Rice, Root, Traditional landraces

Weather based technological interventions in integrated farming system for reducing cost of cultivation and climate risk

Shamim M.*, Ravisankar N., Poonam Kashyap, Sunil Kumar, Prusty, A. K., Meraj Alam Ansari, Ragahvendra K. J., Raghuveer Singh, Abhishek Painkra and Sunil Kumar

ICAR-Indian Institute of Farming Systems Research, Modipuram-250 110, Uttar Pradesh, India

*shamimagrimet@gmail.com

Weather based Agro-advisories services for farmers of Uttar Pradesh emphasizing the latest technological interventions were started during 2018 using the Mobile Seva platform of C-DAC, Mumbai. Four districts such as Meerut, Muzaffarnagar, Baghpat and Varanasi covering two Agroclimatic zones of Uttar Pradesh namely Western Plain Zone and Eastern Plain Zone, respectively. District level anticipated weather condition predicted by India Meteorological Department, New Delhi, using Numerical Weather Prediction (NWP) models were used to prepare technological interventions based Agro-advisory and disseminated on a real time basis. The dissemination of Agro-advisory was carried out using Push SMS services by creating groups of farmers and other stakeholders of respective districts. The disseminated agro-advisories have covered all the major aspects of predominant integrated farming system components of the respective districts. Accuracy level of prediction of rainfall events or number of rainy days as well as intensity of rainfall in terms of low rainfall (<10.0 mm), medium rainfall (10.0-35.5 mm), heavy rainfall (35.5-64.4 mm) and very heavy rainfall (>64.4 mm) were analyzed for agro-advisories disseminated for Meerut Districts using the actual rainfall data recorded at Agromet Observatory located at ICAR-IIFSR, Modipuram, Meerut. Results revealed that out of the predicted 74 rainy days, 34 times it has turned to happen with 45.9% accuracy level of the forecast during the reporting period *i.e.*, January to December 2020. During Monsoon (July to September) and Post-Monsoon (October to June), the accuracy level was found to be reduced to 44.7% and 0.0% respectively of the prediction in terms of rainy days. Intensity-wise accuracy level was also calculated and 100% match between occurrence and prediction of very heavy rainfall was found which may serve the purpose of the project in risk management related to extreme weather, particularly in case of heavy downpours. Accuracy level has been drastically reduced up to 39.0% in case of prediction of low rainfall and it was found good enough in occurrence of rainfall between 35.5 to 64.4 mm (medium rainfall) with 50.0% prediction accuracy which may drastically reduce the cost of cultivation on irrigation and in enhancing the resource/input use efficiency in terms of fertilizer application, pesticide application and interculture operations.

Keywords: Accuracy, Extreme weather, Prediction, Rainfall, Rainy days

Symbiotic associations in diatoms and dinoflagellates in oligotrophic waters along the inshore waters off Kochi and Dakshina Kannada, South-west coast of India

Lavanya Ratheesh*, Reena V. Joseph, Pratibha Rohit, Bindu Sulochanan, Shelton Padua, Prema, D., Ratheesh Kumar, R., Vineetha Gopinath, Parvathy Rajeev and Grinson George

ICAR-Central Marine Fisheries Research Institute, Ernakulam North P. O, Kochi – 682 018, Kerala, India

*lavanyacmfri2010@gmail.com

Along the inshore waters of the south-west coast of India from 2015-2021, frequent occurrences of symbiotic associations of diatoms *Pleurosigma* sp. and *Rhizosolenia* sp, as well as dinoflagellates *Ornithocercus* sp. and *Noctiluca scintillans* with cyanobacteria and green algae were observed. So far, symbiotic associations between phytoplankton and cyanobacteria has been reported more from the Bay of Bengal. The present observations are based on monthly water and plankton sampling carried out along four near-shore stations off Dakshina Kannada and 5 inshore stations, off Kochi (7 m, 10 m, 20 m, 30 m and 40 m depths). The surface water was analysed for all the physiochemical parameters and phytoplankton diversity studies following standard procedures. During the pre-monsoon season of 2015, a bloom of dinoflagellate *Ornithocercus magnificus* (1.65 X 10^6 cells l^{-1}) was observed to harbour ectosymbiont cyanobacteria in their cingulum along the coastal waters of Dakshina Kannada, characterized by higher saline (35.2±0.91 PSU; $p<0.05$) nutrient-poor waters with low nitrate and nitrite concentrations (0.003±0.01 mg l^{-1} and 0.005±0.01 mg l^{-1} respectively) indicating an oligotrophic and nitrogen limited condition. Similar associations were observed off Kochi at 20 m depth surface waters with low nitrite (0.003±0.001 mg l^{-1}) and low chlorophyll a (0.63 ±0.37 mg m^{-3}) concentrations during the pre-monsoon season of 2020 (1.2 x 10^4 cells l^{-1}). Diatom (*Rhizosolenia* sp.) cyanobacterial *(Richella* sp.) symbiotic associations were observed in the surface waters of 20 m depth station in the inshore waters off Kochi, characterized by low nitrite (0 – 0.002 ±0.0006 mg l^{-1}) and nitrate (0.002 – 0.038 ±0.01mg l^{-1}) waters. *Pleurosigma* sp. was also observed with endosymbiont cyanobacteria during the same period but in low abundance. Frequent blooms of *Noctiluca scintillans* (2.4 x 10^5 cells l^{-1}) with endosymbionts *Pedinomonas noctilucae* were observed during the pre-monsoon season of 2021 and 2022 and post-monsoon seasons of 2016, 2017, 2019, and 2020 characterized by low chlorophyll concentration ranging 0.46–2.3± 0.2 mg m^{-3}. Phytoplankton communities are highly sensitive to sudden changes occurring in their habitat corresponding to environmental conditions such as wind velocity, rainfall, temperature and nutrient shifts. The prolonged oligotrophic conditions of the pre-monsoon seasons might have made the diatoms/dinoflagellates depend on these ecto/endosymbionts for their nutritional requirements which help them to thrive well during adverse environmental conditions to maintain productivity. Hence, more extensive investigations must be made on these mutualistic associations sustaining pelagic productivity as they form an early responder to ecological changes predicted in the marine ecosystems corresponding to climate change.

Keywords: Cyanobacteria, Diatoms, Dinoflagellates, Symbiotic associations

Soil microbial community and potential methane production under various vegetations of coastal area of Gujarat

Doongar R Chaudhary* and Madhav Kumar

CSIR-Central Salt and Marine Chemicals Research Institute, G. B. Marg, Bhavnagar-364 002, Gujarat, India

*drchaudhary@csmcri.res.in

The Gujarat State has the longest coastal line in India and experiences semi-diurnal tide with a large diurnal inequality and varying amplitude. Extensive mudflats about 6-8 km wide are distributed all along the coast. Mangroves and halophytes thrive well in tidal zones. High flooding condition retards organic matter decomposition, creates an anaerobic condition which favours methanogenesis. Therefore, the present study was carried out to determine the depth-wise distribution of functional genes *mcrA*, *pmoA* and *dsrA* in coastal wetlands (mangroves, halophytes and mudflats), potential methane production and correlated them with soil characteristics. In comparison to halophyte soils, mangrove soils had higher *pmoA* copy numbers, similarly, the copy number of *mcrA* was significantly higher in mangrove soils at all depths, while barren and halophyte soils contained similar numbers. The abundance of *dsrA* was also observed to be highest in mangrove soil while lower in barren and halophyte soils. The *pmoA*/*mcrA* ratio was significantly higher in barren and halophyte soil at all depths compared to mangrove soils. The ratio of *dsrA*/*mcrA* was significantly higher at 0-20 and 80-100 cm in the mangrove soils, however, at other depths all soil samples were non-significantly differed. Averaged over soil depth, the highest potential methane production was observed in mangrove (1512.52 µg C kg^{-1} day^{-1}) followed by halophytes (1235.65 µg C kg^{-1} day^{-1}) and mudflat (574.31 µg C kg^{-1} day^{-1}) soils. The abundances of bacterial and archaeal 16S rRNA, *pmoA*, *mcrA* and *dsrA* were positively and significantly correlated with moisture, electrical conductivity, organic carbon, dissolved organic carbon, NH_4^+, P, K, Na and SO_4^- while negatively correlated with pH of the soil.

Keywords: CH_4 emission, Coastal ecosystem, Intertidal zone, Soil microbial community

Climate smart technologies to enhance water productivity in wheat at farm level

Raj Pal Meena*, Tripathi, S. C. and Gyanendra Singh

ICAR-Indian Institute of Wheat and Barley Research, Karnal-132 001, Haryana, India

*rp.meena1@icar.gov.in

Under the pressure of population and food production, excessive exploitation of water resources clubbed with climate change has resulted in the continuous depletion of water resources. It has posed serious challenges to sustain life and produce enough food to feed the burgeoning population. Therefore, there is an urgent need to adopt climate-smart technologies to reduce the water footprint, and enhance water use efficiency (WUE) and agriculture productivity under stressed conditions. The role and percent water saving from innovative irrigation techniques such as micro-irrigation (25-70%), automation in irrigation and regulated deficit irrigation (5-50%), associated agronomic measures like precision land levelling (13-40%), modern methods of tillage (15-%), improved planting methods (20-50%), mulching (5-25%) have been studied. The high water use efficient genotypes as technological intervention is urgently required to further improve the water productivity of the wheat and sustain the profitability of farmers. Experiments were conducted to evaluate the wheat genotypes for higher water use efficiency under two soil moisture levels *viz*, 80 and 60% of ETo. Thirty genotypes were studied and it was found that genotypes 40 ESWYT33 (5213 kg ha^{-1}), DBW 360 (5063 kg ha^{-1}), DBW 243 (4662 kg ha^{-1}), DBW 313 (4826 kg ha^{-1}), 40 ESWYT 21 (4578 kg ha^{-1}) and DBW 325 (4638 kg ha^{-1}) produced desirable yield with water productivity ranging from 2.12 to 2.42 kg m^{-3} under soil moisture regimes of 80% of ETo. The same set of genotypes sown under higher soil moisture stress *viz*, 60% of ETo and it was found that DBW 243 (4260 kg ha^{-1}), RWP-2018-32 (4336 kg ha^{-1}), 40 ESWYT 39 (4208 kg ha^{-1}), DBW 322 (4047 kg ha^{-1}), DBW 313 (4438 kg ha^{-1}), DBW 369 (4060 kg ha^{-1}), RWP-2018-223 (4398 kg ha^{-1}), DBW 166 (4076 kg ha^{-1}), DBW 316 (4146 kg ha^{-1}), 40ESWYT07 (4118 kg ha^{-1}), 40ESWYT33 (4610 kg ha^{-1}) and 40ESWYT37 (4562 kg ha^{-1}) produced desirable yield with water productivity ranging from 2.50 to 2.85 kg m^{-3}. The identified water use efficient genotypes can be useful for developing water use efficient varieties with high yield. Adoption of water use efficient genotypes will reduce water consumption by 20%, as well as help in reducing the cost of cultivation.

Keywords: Climate-smart technologies, Water use efficiency, Wheat, Yield

Effect of *in-situ* rice residue management practices on wheat productivity, profitability and soil health at graded N levels in North-west India

Tripathi, S. C.[*], Nitesh Kumar[1], Karnam Venkatesh[2], Meena, R. P. [1] and Gyanendra Singh[1]

[1]ICAR-Indian Institute of Wheat and Barley Research, P.B. No. 158, Agarsain Marg, Karnal-132 001, Haryana, India
[2]ICAR-Indian Institute of Millets Research, Rajendranagar -500 030, Hyderabad, Telangana, India

*sc.tripathi@icar.gov.in

Rice residue burning is one of the major problems in the rice-wheat cropping system of India, which contributes to environmental pollution leading to health problems and loss of nutrients to a great extent. To address this menace, rice residue retention (RRR) and incorporation (RRI) at graded N levels (0, 50, 100, 150 and 200 kg ha^{-1}) along with farmers' practice was studied for three years (2020-21 to 2022-23) with the objective to enhance the wheat productivity, profitability and soil fertility of this system. Pooled analysis results revealed that RRR produced higher grain yield than RRI at lower doses of nitrogen, whereas RRI recorded 7.5, 7.4 and 10.0% more biological yield over RRR at higher doses of nitrogen (100, 150 and 200 kg ha^{-1}), respectively. This was possible owing to 10.5 and 5.0% higher effective tiller m^{-2} under RRR and RRI, respectively, than farmers practice at 150 kg N ha^{-1}. NDVI values at the flag leaf stage (DC37) were higher with RRR (0.76), followed by both RRI and farmers' practice (0.73) at 150 kg N ha^{-1}, suggesting the advantages of RRR practices over others. At the recommended N dose (150 kg N ha^{-1}), the cost of cultivation under RRR was 9.6% lower than the RRI as well as farmers' practice. Additionally, net return was 19.6% higher at lower N levels (50 kg ha^{-1}) under RRR as compared to RRI, suggesting more benefits under low input conditions. At 150 kg N ha^{-1} application, the B:C value was highest under RRR (2.75), followed by RRI (2.59) and farmers' practice (2.55). The organic carbon content significantly increased under RRR (0.49-0.54%) over the initial value (0.38%) after a period of three years. Therefore, it could be said that long-term adoption of RRR by farmers is a better option than RRI or present practice for improving wheat productivity in an eco-friendly manner under a rice-wheat system.

Keywords: B:C value, Grain yield, Incorporation, Rice residue retention

Bloom occurrence of a rare and harmful dinoflagellate, *Scripsiella trochoidea* in the coastal waters off Kochi during the late summer monsoon of 2021 and its impact on the phytoplankton community structure

Reena V. Joseph*, Lavanya Ratheesh, Vineetha Gopinath, Shelton Padua, Prema, D., Ratheesh Kumar, R., Akhil Babu, Parvathy, R., Sruthy, V. L. and Grinson George

ICAR-Central Marine Fisheries Research Institute, Ernakulam North P.O., Kochi-682 018, Kerala, India

*reenavjoseph@gmail.com

A light brownish to blood red coloured bloom of *Scrypsiella trochoidea,* a harmful dinoflagellate was observed in the coastal waters off Kochi during the late summer monsoon of 2021 extending from 10 m to 40 m depth stations. *S. trochoidea* is a cyst producing photosynthetic, marine dinoflagellate occurring in both temperate and tropical waters and are known to produce "red tide" events. For the present study, surface and bottom waters and phytoplankton samples were collected and analysed to understand the hydrologic characteristics using standard protocols. The highest cell count ($7x10^6$ cells l^{-1}) was noticed at 40 m surface waters (10° 3'53.64"N, 75°55'56.40"E) with thick red colouration, showing a declining trend towards the coast with 8×10^5cells l^{-1} and 8.5×10^4cells l^{-1} at 30 m and 20 m depth stations respectively. *S. trochoidea* dominated the phytoplankton community (97.6%) with very few dinoflagellates like *Gonyaulax* sp. and *Prorocentrum micans* (2.4%) with no diatoms. During the bloom, the sea surface temperature was low (28±1.32˚C) and turbid (7.18 NTU) compared to previous monsoon months. The dissolved oxygen ranged from 1.21–6.52 mg l^{-1}, at 40 m depth station with maximum at the surface and minimum at the bottom indicating stratified waters. Chlorophyll *a* concentration was observed to be maximum at this station (5.82± 1.49 mg m^{-3}) where the highest cell count was observed. However, higher total ammoniacal nitrogen (TAN) concentration (0.25±0.05 mg l^{-1}) observed here (40 m) indicated the bloom to be in its late phase while the TAN levels observed in the nearshore stations were within the limits (0.03±0.05 mg l^{-1}) indicating the bloom to be in its log phase. The nitrite (0.007±0.001 mg l^{-1}) and nitrate (0.02±0.002 mg l^{-1}) concentrations were slightly lower which may be due to the oligotrophic conditions that existed due to a diatom bloom of *Coscinodiscus granii* observed during the initial stages of late summer monsoon in the coastal waters. The oligotrophic conditions that might have developed due to the nutrient utilization by diatom bloom and the absence of vertical mixing might have triggered the cysts of *S. trochoidea* to bloom. In the present study, no fish mortality was reported during the bloom period, but the fish catch composition was dominated by the jellyfish *Netrostoma coerulescens* (87.6%) during the experimental trawling conducted at 20 m and 30 m depths. Continuous monitoring of the phytoplankton dynamics in the area is required as it is influenced by the climatic settings and has profound impacts on the marine fish resources.

Keywords: Dinoflagellate, Oligotrophic condition, Red tide, *Scrypsiella trochoidea*

Identification of stable short duration genotypes for introducing finger millet in summer season in Bihar

Sweta Mishra*, Adithay Rajendran, S., Shivaraj, G., Shailesh Kumar, Kaushal Kishor and Gouri Shankar Giri

Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur848 125, Bihar, India

*sweta.mishra@rpcau.ac.in

Finger millet is a preferred small millet crop that is being consumed with gusto in Bihar State. Bihar receives an average annual rainfall of 1000-1500 mm and many districts in north Bihar are flood prone during kharif season. Finger millet is normally taken as a Kharif crop in the state, either directly sown or transplanted. However, there is loss in yield whenever heavy rainfall is encountered as finger millet is a dryland crop and the root system is shallow to withstand the high moisture stress under flooded condition. Besides, the farmers are mostly interested to take up rice as the main crop during the kharif season. Therefore, an alternate season has been evaluated to introduce short duration varieties of finger millet, in order to address the above mentioned issue. The advantage of introducing short duration finger millet in summer season are: it can easily fit into the cropping pattern in the state; can fill in the gap period between the rabi and the kharif as a catch crop and the state will achieve increase in area as well as production of finger millet. As such 200 germplasm and 15 high yielding released varieties were screened for earliness in summer season. Out of these, 50 germplasm lines and 10 high yielding varieties were selected for determining the effect of genotype, environment and their interaction for grain yield and earliness to identify more stable finger millet genotypes for the summer season at two locations and for two consecutive years. Highly significant variations were observed for all yield attributing traits among the genotypes sown under RCBD. The mean grain yield ranged from 1986.52 kg ha^{-1} to 3012.35 kg ha^{-1}. Finger length, ear length, fingers per ear, plant height, number of productive tillers per plant and 1000 grain weight showed significant positive correlation with grain yield. Genotypes with higher seed vigour index II, chlorophyll content and speed of germination, also had high grain yield and were of short duration. Using GGE-Biplot, the stable genotypes (RPCAU-FM-14, RAU3, RAU 8, RPCAU-FM-86, RPCAU-FM-26, RPCAU-FM-140, Rajendra Madua 1 and RPCAU-FM-19) and stable donor traits (ear length, fingers per year, productive tillers and 1000 grain weight) were identified to be evaluated across Bihar State for summer season and the genotypes with specific yield attributing donor trait can be used in pre-breeding programmes.

Keywords: Finger millet, GGE-biplot, Pre-breeding, Short duration, Stability

Projecting the spatial distribution of major marine fishery resources along the west coast of India under varying climate change scenarios

Rose P. Bright*, Muhammad Shafeeque, Eldho Varghese, Alphonsa Joseph, Radhika Balachandran, Nanda Kishore, Rahul, R., Jayasankar, J., Ratheesh Kumar, R. and Grinson George

ICAR- Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*rosemol.bright@gmail.com

Species distribution models (SDMs) are mathematical tools used to predict the geographic distribution of species based on known occurrences and environmental variables. These models can help researchers and policymakers to understand and manage species distributions, especially in the face of ongoing climate change and habitat loss. In this study, we developed SDMs for 10 commercially important resources by incorporating the environmental factors to project the probable species niches along the west coast of India so that its spatial distributions can be studied under varying climatic scenarios. The entire Indian EEZ was gridded into 951 grids; each of size 0.5 X 0.5 degree and each grid assigned with unique grid ID. The passive geo-referenced species distribution data along with the various environmental data such as ocean temperature, salinity, dissolved oxygen and chlorophyll were assigned to each grid cell and spatially linked with the Indian EEZ gridded data. All environmental parameters were assigned to each grid cell with the information of species presence or absence and number of occurrence of species. Further, a generalized linear model was used to build a relation between the dichotomous dependent variable (presence/absence) of the species with the environmental drivers. After validating and assessing the model performance, we attempted future projection using climate change scenarios to understand how the species distribution might change over time. The results indicated a good fit as well the influence of climatic factor were evident. Therefore, the fitted models were used to project the probable distribution of the species in the west coast of India.

Keywords: Climate change, Environmental drivers, Fishery resources, Species distribution models (SDMs)

Influence of major environmental drivers on selected marine fishery resources of the south-eastern region of India

Alphonsa Joseph*, Sathianandan, T. V., Jayasankar, J., Eldho Varghese, Ratheesh Kumar, R., Grinson George, Najmudeen, T. M., Sreepriya, V., Radhika Balachandran, Nanda Kishore, Muhammad Shafeeque, Rahul, R. and Rose P. Bright

ICAR- Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*jalphonsamattathil@gmail.com

The study aims to understand the impact of major environmental factors on the selected marine fishery resources in the south-eastern region of India. To understand the dynamics of fish population biomass, the future biomass is modelled as a function of current biomass, change in biomass due to growth, recruitment and mortality. However, modelling fish biomass dynamics requires time series data on fish catch and fishing effort. The marine fishery is complex in tropical regions due to its multi-gear and multi-species nature. Therefore, estimating the fishing effort for every fish species becomes challenging. Moreover, climatic factors such as sea surface temperature (SST), sea surface salinity (SSS), and chlorophyll a (Chla) can also affect the fish population biomass. To address these issues, a modified biomass dynamics model was proposed, incorporating the effort expended by multiple fishing gears and the influence of environmental factors. The modified model was used to examine changes in biomass for the selected commercially important marine resources with changes in climatic factors.

Keywords: Biomass dynamics model, Climate change, Environmental drivers, Fishing effort

Impact of cyclones on marine fisheries in the Arabian Sea: A comparative study between Ockhi and Tauktae

Nanda Kishore*, Muhammad Shafeeque, Radhika Balachandran, Ratheesh Kumar, R. and Grinson George

ICAR- Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India.

*nandakishoree1995@gmail.com

Cyclones pose a significant threat to marine ecosystems in the Arabian Sea. In this study, we assessed the impact of cyclones on marine fish catch, with a special focus on comparing the effects of cyclones Ockhi and Tauktae on fish landings along the south-west coast of India. These cyclonic disturbances possess the potential to cause extensive damage to marine habitats, disrupt the food web, modify fish distribution patterns, and create unfavorable living conditions for marine resources. To investigate these impacts, various environmental parameters such as Sea Surface Temperature (SST), Chlorophyll-*a* (Chl-*a*), Sea Level Anomaly (SLA), winds and current patterns were gathered from satellite sources. 8-day and 6-day composites of these parameters were considered for the analyses of the Ockhi and Tauktae cyclones, respectively. The fish landing data were obtained from the National Marine Fisheries Data Center database of the ICAR-Central Marine Fisheries Research Institute. Spatial maps of the climate variables were examined during the 'pre-cyclonic days', 'cyclonic days', and 'post-cyclonic days' to identify changes associated with the hydrography of the Arabian Sea. We used the Generalized Additive Model to determine the environmental parameter with the most significant influence on fish landing during the cyclone period. The analysis revealed extensive alterations in the marine environment. The SST, Chl-*a*, SLA, wind, and current exhibited distinct variations during active cyclone days compared to the pre-cyclonic and post-cyclonic periods. These changes indicate the potential impacts on fish distribution, habitats, and overall fish catch in the study area. The stressful living conditions caused by these cyclones may adversely affect the overall health and productivity of the marine resources in the Arabian Sea. This study highlights the significance of considering environmental factors when assessing the impact of cyclones on marine ecosystems.

Keywords: Climate variables, Conservation strategies, Environmental parameters, Fisheries management, Generalized Additive Model (GAM)

Unveiling the natures' alchemy: Estimation of blue carbon sequestration potential of mangroves in Kerala

Rahul, R.*[1,2], Vinod, K., Ratheesh Kumar, R., Shinoj Parappurathu, Pranav, P., Muhammad Shafeeque, Alphonsa Joseph, Radhika Balachandran, Nanda Kishore, Rose P. Bright and Grinson George

[1]ICAR- Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

[2]Kerala University of Fisheries and Ocean Studies, Panangad, Kochi-682 506, Kerala, India

*rahulsambunivas@gmail.com

Mangroves are prominent blue carbon ecosystems mitigating climate change due to their ability to harvest and store carbon. This study focuses on estimating the blue carbon sequestration potential of mangroves in Kerala. To assess the above and below-ground biomass of mangroves, measurements of tree girth of mangrove species were taken from 51 mangrove sites across 10 districts in Kerala. Within each mangrove forest area, three transects with dimensions of 100*100 m were randomly selected, and within each transect, three quadrats with dimensions of 10*10 m were randomly selected. In all selected quadrats, mangrove trees with a girth of ≥ 10 cm were measured at breast height. Standard allometric equations for mangrove plants were applied to estimate the plant biomass, which was subsequently converted into carbon stocks using a multiplication factor of 0.5. Eventually, these carbon stocks were extrapolated to the entire mangrove area in Kerala to determine the total carbon storage capacity of mangroves in the state. The values were further converted into CO_2 equivalence to quantify the reduction in CO_2 emissions resulting from the carbon sequestration performed by mangroves. In Kerala's mangrove ecosystems, the biomass comprises top biomass (286.479±200.3 T ha^{-1}) and root biomass (121.761±79.49 T ha^{-1}), contributing to a total biomass of 408.24±279.72 T ha^{-1}. The carbon stock includes top carbon (143.24±100.18 T ha^{-1}) and root carbon (60.88±39.74 T ha^{-1}), along with sediment carbon stock (64.76±24.5 T ha^{-1}), resulting in a total carbon stock of 268.885±164.48 T ha^{-1}. For the entire area of Kerala's mangrove ecosystems (*i.e.*, 9 km^2), the total carbon stock is approximately 241,996.5±148,032 t, with a corresponding total CO_2 equivalence of about 88,570±541,791 t. This study results offer a valuable understanding of the significance of mangroves as a potential blue carbon ecosystem in the area, emphasizing their essential contribution to the sequestration and storage of carbon. Understanding the carbon sequestration potential of mangroves is crucial for formulating effective conservation and restoration strategies, as well as for encompassing blue carbon ecosystems into climate change mitigation efforts.

Keywords: Carbon sequestration, Carbon sink, Climate change, Coastal Ecosystem, CO_2 equivalence

Integrated assessment of fishing and environmental drivers on the sustainability of threadfin breams (*Nemipterus* spp.) in the South-eastern Arabian Sea

Radhika Balachandran*, Zacharia, P. U., Purushottama, G. B., Sudarsan, K. S., Ratheesh Kumar, R., Muhammad Shafeeque, Alphonsa Joseph, Rahul, R., Nanda Kishore, Rose P. Bright and Grinson George

ICAR- Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*radhika_balachandran@yahoo.com

The study aimed to assess the cumulative impact of climate change and sustainable fishing levels on the long-term sustainability of threadfin breams, a demersal species inhabiting the South-eastern Arabian Sea (SEAS). We utilized the dataset derived from the commercial fisheries in the South-west coast of India and employed an integrated approach that accounted for both fishing and the influence of environmental factors. The threadfin breams stock status was estimated by employing two methods *viz*. the Monte Carlo catch - MSY (CMSY) and Bayesian Schaefer Model (BSM). The investigation found that the catch rate of threadfin breams declined as fishing intensity increased in terms of effectiveness of advanced fishing methods. This empirical inquiry leveraged the Generalized Additive Model (GAM) to assess the impact of environmental parameters on the fish stock. The analysis indicated that precipitation had a profound positive impact on this fish group, whereas Sea Surface Temperature (SST) and Sea Surface Salinity (SSS) had a negative impact beyond the optimum level. The study unveiled that the targeted stock of threadfin breams had medium resilience, indicating that optimizing fishing practices could help replenish the stock for future sustainability, even if there is a negative influence by environmental parameters to a certain extent. Overall, the investigation provides important insights into the impact of climate change and sustainable fishing practices on the sustainability of demersal species in the SEAS and emphasizes the innovative ways to manage fishery resources in a manner that is ecologically sustainable and yet economically viable and socially acceptable.

Keywords: Climate change, GAM, Overfishing, Stock assessment, Threadfin breams

Species distribution modelling for evaluating the habitat suitability of patagonian toothfish in the Southern ocean

Vishnu, C. B. *, Mohamed Nisin, K. M. N., Sreenath, K. R., Ratheesh Kumar, R. and Grinson George

ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*vishnucb666@gmail.com

The Southern Ocean, renowned for its unique biodiversity, is an essential habitat for many species, especially the Patagonian toothfish (*Dissostichus eleginoides*). This species ranges from the Sub-Antarctic islands to the southernmost waters of South America. Analyzing the spatial distribution of the Patagonian toothfish is vital for sustainable harvesting and economic production. In our research, we employed ensemble species distribution modelling to study their distribution in waters north of 40° latitude in the Southern Ocean. Species occurrence data was sourced from open-source databases. We integrated eleven environmental and geographic covariates, derived from databases like Bio-ORACLE and GMED. Our results indicate the habitat suitability of the Patagonian toothfish in specific areas such as the coasts of Argentina and Chile, and the Sub-Antarctic islands of Patagonia, South Georgia, Macquarie Island, and the Falkland Islands. To implement effective proactive management strategies, understanding the likelihood of occurrence is crucial. Despite the challenges faced, species distribution models play a pivotal role in guiding decisions related to fisheries management and conservation. The projections from this study provide a solid foundation for identifying suitable habitats for the Patagonian toothfish in the Southern Ocean.

Keywords: Environmental determinants, Fishery management, Habitat preference, Polar waters, Sub-Antarctic islands

Unveiling climate-resilient coral conservation zones in India:Fostering fisheries sustainability

Niya Joseph, K.*[1,2], Gopalakrishnan, A., Nandini Menon, N. and Grinson George

[1] ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

[2]School of Marine Sciences, Cochin University of Science and Technology, Kochi-682 016, Kerala, India

* niyajosephk@gmail.com

Coral reefs are vital marine ecosystems, serving as crucial nursery grounds for various marine species and sustaining the livelihoods of coastal communities through fisheries. However, the devastating impacts of climate change have led to the widespread degradation and loss of coral reef ecosystems worldwide. In the face of this crisis, it is imperative to conserve the remnants of coral reefs and identify climate-resilient areas suitable for restoration and other coral-related activities. This research focuses on four major coral reef ecosystems in India, namely Lakshadweep, Gulf of Mannar, Gulf of Kutch, and the Andaman and Nicobar Islands. Long-term benthic cover percentage secondary data spanning from 1998 to 2019 were collected to assess the state of these ecosystems and also utilised the time series satellite data on SST, Chl-a, Salinity, and PAR from NOAA Coral Reef Watch, Ocean color, and APDRC. A Generalized Additive Model (GAM) analysis was conducted to identify the Optimum Environmental Window (OEW) for each environmental variable conducive to coral survival and growth. The study then compared recent environmental data for the selected study sites to determine whether these locations fall within the OEW, making them suitable areas for initiating coral reef-related activities. The results of this study provide crucial insights into the current state of these Indian coral reef ecosystems and their potential for resilience in the face of climate change. By identifying areas that meet the OEW criteria, this research contributes to the strategic planning of preserving and rehabilitating these vital ecosystems, to safeguard marine biodiversity and to support the livelihoods of coastal communities dependent on fisheries. This research underscores the urgency of proactive conservation measures and offers a practical framework for the sustainable management of coral reef ecosystems in India and beyond.

Keywords: Climate change, Coral reef conservation, Ecosystem resilience, Remote sensing, Sustainable fisheries

Invasion of Corallimorpharians: Assessing competitive success over corals in Lakshadweep's shallow reefs

Alvin, A*., Aju K. R., Sreenath K. R., Pradeep M. A., Nisha E. A. and Joshi K. K.

ICAR-Central Marine Fisheries Research Institute, Abraham Madamakkal Road, Kochi-682 018, Kerala, India

*alvinantoz@gmail.com

Coral reefs, among the most diverse ecosystems on Earth, face unprecedented challenges due to anthropogenic impacts and climate change. The survival and growth of corals depend on their symbiotic relationship with photosynthesizing dinoflagellate Zooxanthellae, which provide them essential energy for reef building. Light availability and space are critical limiting resources for sessile marine organisms like corals. So, competition for space in light is a never-ending process in coral reefs. This study investigates the competitive success of corallimorpharians over hard corals in Kavaratti Island, Lakshadweep. The presence of *Rhodactis bryoides* and its advantage over corals is documented for the first time. *R. bryoides* thrives in nutrient-rich, low-visibility areas, outcompeting hard corals requiring more transparent and low-nutrient waters. The protected and shallow reef environment enhances corallimorpharians' success, protecting them from air exposure and wave damage. Unlike corals, corallimorpharians exhibit unique traits, including elongated marginal tentacles and clonal replication abilities, enabling rapid colonization and overgrowth of the reef substrate. As observed elsewhere, the corallimorpharian invasion poses a significant threat to the coral reef ecosystem, potentially leading to phase shifts in Kavaratti Lagoon's shallow reefs. Urgent conservation efforts are imperative to mitigate CM impacts and preserve the region's health and diversity of coral reefs.

Keywords: Bioinvasion, Coral reefs, Corallimorpharia, Phase shift, *Rhodactis bryoides*

Analyzing vegetation changes in Kerala forests: Effects of temperature and rainfall using Google Earth Engine

Adithya Chandra, P. B.*[1,2], Sreenath, K. R.[1], Shelton, P.[1], Grinson George[1], Ratheesh Kumar, R.[1] and Nameer, P. O.[2]

[1]ICAR–Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India
[2]College of Climate Change and Environmental Science, Kerala Agricultural University, Thrissur–680 656, Kerala, India

*adichandra2255@gmail.com

Plant-centric ecosystems are pivotal in maintaining Earth's ecological balance. Their significance necessitates detailed scientific analysis and robust conservation strategies of forests, including mangroves. Tracking the spatiotemporal shifts in their health is crucial to understanding and implementing proper management measures. The NDVI (Normalized Difference Vegetation Index) provides a quantifiable metric to assess vegetation health and density from satellite imagery, offering crucial insights into ecosystem vitality and environmental changes over time. Producing such time series data over a long period of time is difficult and time-consuming. However, the Google Earth Engine facilitates the generation of time-series data, enabling users to analyze and visualize temporal changes in environmental and geographical datasets over extended periods. In this study, we have generated seasonal time series NDVI data using Landsat 8 images in Google Earth Engine and studied its association with the temperature and rainfall data using linear regression. Our results indicate that the forest range exhibits pronounced seasonality, with NDVI values showing strong correlations to rainfall patterns and, to a lesser extent, temperature variations. The NDVI has shown a significant relation with the rainfall with an R^2 value of 0.69 and <0.01 p value. This research underscores the importance of multi-temporal analyses in understanding forest health and provides valuable insights for forest management and conservation strategies in the face of changing climatic conditions.

Keywords: Ecosystem health, Forest coverage, Time series data, Vegetation

Opportunities in big data analytics and ICTs to accelerate climate adaptation

Sudhanshu Singh*

International Rice Research Institute (IRRI)-South Asia Regional Centre, Varanasi-221 106, Uttar Pradesh, India

*sud.singh@irri.org

Climate change will continue to pose a significant negative impact on the global agricultural sector due to rising temperatures, rainfall variability, and intensifying extreme weather events, which will lead to reduced crop yields and higher food prices. The priority regions for climate action are South Asia and South-east Asia, especially due to the predicted negative impact on the livelihoods of farmers and other value chain actors, especially in rice sector. Frontier technologies like artificial intelligence (AI), Internet of Things (IoT), big data analytics (BDA), machine learning (ML) and remote sensing hold huge promise for engineering smart innovations and solutions to combat climate change. Advances in the field of agriculture lead to the generation of huge data in the form of geospatial maps, soil health, crop production, market information, survey data and weather information. In BDA, these are processed in cluster mode to extrapolate the real-time situations for providing customized services to different stakeholders. Real-time programming is possible with AI concepts and IoT devices for making appropriate farm decisions. With the lens of BDA and ICTs, we can analyze climate data, generate helpful insights such as trends and patterns, and implement climate forecasting models. The climate-informed crop calendars including early warning and predictive advisory services based on climate forecasts, crop monitoring and risk area identification can be delivered for better farming decisions and risk reductions. Data-driven agronomic intelligence system is one of the recent developments for precision farming, which provides soil and crop management recommendations for each location, using ML methods. This location intelligence helps fertilizer manufacturers to produce custom blended fertilizers to address specific regional soil fertility problems. Seed, pesticides, and the market sector can all benefit from similar knowledge and intelligence to reduce costs while increasing resource use efficiency. Developed and maintained by IRRI, there are a number of ICT tools, IoT solutions and digital databases (*e.g.*, AutoMon^{PH}, CF-Rice, COMPARE, Crop Manager, Rice Doctor, RIICE, RKB, MapAWD, SECTOR, Seedcast, EasyHarvest, PriSM and WeRise), aiming to support the scientific research and practical farm management needs in rice sector. Thus, application of BDA and ICTs in climate-smart agriculture can play a potential role in helping smallholder farmers to maximize their productivity and profitability through effective monitoring of climate change, thereby mitigating and adapting to its impacts. However, taking these technologies and ICT tools to the farmers' fields becomes a challenge, especially where socio-technical and institutional constraints are prevalent.

Keywords: Big data analytics, Climate-smart agriculture, ICTs, Smallholder farmers

Index-based insurance–A step to strengthen resilience of fishing sector in the Bay of Bengal, amidst climate shifts

Krishnan Pandian[1], Rajdeep Mukherjee[1], Murugesan Sri Hari[1]* and Kishore Davala[2]

[1]Bay of Bengal Programme Inter-Governmental Organisation, Chennai – 600 018, Tamil Nadu, India
[2]School of Ecology and Environment Studies, Nalanda University, Rajgir-803 116, Bihar, India

*sriharimuruegesan94@gmail.com

Insurance is a pivotal financial tool to mitigate climate change risks. However, identifying a suitable insurance product for the marine fisheries sector is challenging, leading to low insurance penetration. This study focuses on the Bay of Bengal, known for its extensive marine fisheries activities and climate change vulnerability. In response, the study examines the existing mechanisms for risk transfer and mitigation concerning climate change in the fisheries sector, with insurance emerging as a viable option. The study aimed to assess current insurance coverage, common loss and damage experienced by fishers, and their perception of insurance. We adopted an exploratory research methodology to bridge the knowledge gap concerning the financial aspects of the marine fisheries sector. This involved organizing workshops and Focus Group Discussions with 200 stakeholders from India, Bangladesh, and Sri Lanka. The research identified various risks faced by fishers due to climate change, including reduced fishing days, damage to boats during frequent weather events, and limited insurance coverage. A significant number of fishers indicated that current insurance policies do not adequately cover their operational risks, and there is a misalignment between insurance products and the needs of the marine fisheries sector. It was also observed that considerable production disruptions in major fisheries adversely affect fishers' income. On the other hand, the low penetration and high risk have discouraged many insurance companies from offering coverage to fishermen. Based on the insights gathered from stakeholder consultations, it is recommended to develop a Strategic Plan for the Bay of Bengal region and establish a Model Parametric Insurance Scheme based on the weather parameter, that would guide the insurance sector. Furthermore, the implementation of parametric or index-based insurance programs (IBIP) can help fishers overcome the adverse effects of climate change. However, this study has certain limitations with respect to gaps in the data collected, and the stakeholder representation may not fully capture the diverse experiences of all fishers in the region. Nevertheless, we posit that the introduction of IBIP can motivate fishers to embrace voluntary compliance measures.

Keywords: Bay of Bengal, Climate change, Index-based insurance, Marine fisheries, Risk management

Temperature and moisture dependent virulence of the entomopathogenic nematodes against larval and pupal stages of *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

Jagadeesh Patil*, Linga, V., Kesavan Subaharan and Sushil, S. N.

ICAR-National Bureau of Agricultural Insect Resources, Bengaluru-560 024, Karnataka, India

*patiljaggi@gmail.com

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), predominantly attacks maize, sorghum, millets and sugarcane in Asia. However, in India it causes considerable economic losses only in maize crops. Virulence of *Heterorhabditis indica* NBAIIH38 and *Steinernema carpocapsae* NBAIRS59, was evaluated at different temperatures and soil moisture against the larval and pupal stages of fall armyworm. The tested EPNs species showed a temperature dependent virulence against the larval stages of fall armyworm. Both the EPNs species showed a poor infectivity, penetration and reproduction at the lowest temperature (15°C) and a high infectivity, penetration and reproduction at the highest temperature (37°C). At 30°C, both EPNs species caused the highest mortality in fall armyworm larvae, but *H. indica* performed significantly ($p<0.05$) better than *S. carpocapsae*. In lower soil moisture levels (1% and 3%), both the EPNs species showed less virulence against pupal stages of fall armyworm. In this study, these two EPNs species not only caused the mortality in pupae but also found responsible for the emergence of malformed adult moths from nematode infected pupae. The EPNs infectivity increased with increasing temperature and soil moisture. Overall, *H. indica* performed the best against the fall armyworm larvae and pupae at all temperature and soil moisture levels tested.

Keywords: Entomopathogenic nematodes, Fall armyworm, Moisture, Temperature, Virulence

Waterlogging tolerance in cassava: Morphological traits, yield, proline content and catalase activity

Arunachalam, V.*, Ashwini Toraskar, D. and Krutika R. Mardolkar

Horticulture Section, ICAR Central Coastal Agricultural Research Institute, Ela-403 402, Old Goa, Goa, India

*v.arunachalam@icar.gov.in

Cassava/tapioca or kappa (*Manihot esculenta* Crantz), is a major tropical tuber crop of coastal India. It is a hardy plant whose starch-rich root is used as food, feed, biofuel and Sabudhana. In recent years, due to shifts in the rainfall patterns that caused heavy rainfall over a few consecutive days leading to severe flooding in major cassava growing areas in 2018, 2019 and 2021 years in Ernakulam District of Kerala and in three Districts of Tamil Nadu *viz*., Villupuram in 2015, Perambur in 2011, and Kanyakumari in 2021. Due to excessive rainfall and waterlogging, cassava crop is harvested prematurely with low tuberization due to hypoxia and also suffer from root rot disease. The study aims to identify a cassava genetic stock with waterlogging-tolerance, evaluate the performance in waterlogging condition for growth, yield and biochemical parameters. During the survey in the severe flood (Aug 2018) hit regions of Ernakulam District of Kerala, surviving plants of cassava to soil flooding were identified and multiplied and evaluated for water logging at Goa, India. The water logging tolerant cassava germplasm (GC1) and a waterlogging susceptible variety (Goa Local) were planted both at normal soil and water logging prone soil. Morphological traits, tuber yield, proline content and catalase activity in leaves were recorded. Tolerant cassava germplasm had a shorter plant stature, fewer leaves with longer petiole, longer internodes and lower percent of yellowing of leaves than susceptible germplasm. Number of leaves per plant differed between the tolerant and susceptible cassava in waterlogged soils. Tolerant germplasm produced 146+29 leaves per plant than susceptible check with 249+72 leaves per plant in waterlogged soils. Tolerant germplasm produced almost similar number of leaves (166+30) as susceptible check (198+19) per plant in normal soils. Tuber yield per plant differed between the tolerant and susceptible cassava in waterlogged soils. The waterlogging tolerant cassava germplasm recorded twice the tuber yield (0.98+0.27 kg per plant) than susceptible check variety (0.52+0.17 kg per plant) in waterlogged condition. Proline content (micro mole g^{-1} fresh weight) of cassava leaves was higher (4.13+0.95) in tolerant germplasm than (2.92+0.88) in susceptible check. Catalase activity (Units mg^{-1}) of cassava leaves was lower (0.49+0.10) in susceptible type than tolerant type (1.03+0.17). The tolerant cassava germplasm (GC1) is shortlisted as Goa cassava 1 variety for water logging/ flood prone areas.

Keywords: Catalase, Hypoxia, Proline, Tapioca, Tuber

Variety x Landrace derived recombinant inbred line population reveal high genetic variability and transgressive segregants for grain yield and attributing traits in rice

Manohara, K. K.*, Yogini Shanbhag, Paramesha, V. and Parveen Kumar

ICAR-Central Coastal Agricultural Research Institute, Ella-403 402, Old Goa, Goa, India

*manohar.gpb@gmail.com

Rice is an important food crop in India, serving as a staple food source for majority of the population. It holds significant agricultural importance in the coastal regions of India, where its cultivation faces unique challenges like salinity, submergence, and stagnant flooding. There is a growing demand for development of salt-tolerant rice varieties for ensuring sustainability of rice farming in coastal areas. The current study aims at identification of transgressive segregants for grain yield and its attributing traits in the recombinant inbred line (RIL) population developed from the cross Jaya x Goa Dhan 2. The RIL populations with three check varieties were evaluated for grain yield and its attributing traits in the wet season of 2022. Analysis of variance revealed significant genetic variability among RILs. Phenotypic coefficient of variation values ranged from 9.35 (panicle length) to 47.83 (grain yield), and genotypic coefficient of variation ranged from 7.62 (% fertility) to 44.85 (grain yield). Grain yield, grains per panicle, and productive tillers per hill exhibited the highest variability, while panicle length, days to maturity, and per cent fertility showed lower variability. Most traits displayed high heritability, especially days to 50% flowering and days to maturity (99.09% and 95.82%), and plant height, panicle length, grains per panicle, and grain yield (91.1%, 92.55%, 84.17%, and 87.92%). Genetic advance ranged from 17.84 to 86.77 with grain yield, grains per panicle, and plant height having the highest values, while percent fertility and panicle length had the lowest genetic advance. Correlation analysis revealed a strong positive correlation between grain yield and days to 50% flowering, days to maturity, productive tillers per hill, grains per panicle, and per cent fertility, while plant height exhibited a negative correlation. The RIL population displayed positive skewness for most traits, except percent fertility, which showed negative skewness. Plant height and panicle length had nearly symmetrical distributions. Transgressive segregants varied from 39 to 246 individuals across traits, with productive tillers per hill having the highest percentage (90.44%), followed by days to 50% flowering, days to maturity, and grains per panicle (86.02%, 77.57%, and 75.73%, respectively). Plant height had the lowest percentage of lines deviating from both parents (14.33%). The current study unveiled significant genetic variability among RILs, with a high number of transgressive segregants observed for the studied traits. Therefore, the RIL population under study holds value in mapping QTLs associated with salinity tolerance and in developing high-performing lines for coastal salinity conditions.

Keywords: Coastal ecology, Heritability, Landrace, Recombinant inbred lines, Transgressive segregants

A novel coupled approach (AquaCrop-Economic Model) to explore future climate response to food security

Manivasagam, V. S.* and Arivelarasan, T.

Amrita School of Agricultural Sciences, Amrita Vishwa Vidyapeetham, Myleripalayam, Coimbatore – 642 109, Tamil Nadu, India

* vs_manivasagam@cb.amrita.edu

Climate change significantly imperils food security, especially in developing countries that rely heavily on essential food crops such as rice and wheat. This research proposed a novel integrated methodology to examine food security, combining the AquaCrop model to forecast future rice production with an economic model to estimate rice demand. The proposed assessment is tested on the Cauvery Delta region, a crucial rice farming region in Southern-peninsular India for the period 2021-2050. The research findings indicate a substantial decline in rice productivity in the Cauvery Delta region over the next few decades. The projected productivity decreased to 35% between 2021 and 2040, followed by a 16% decrease between 2041 and 2050. These results highlight the detrimental effects of climate change on agricultural yields and the potential consequences for food security. Despite the predicted decline in rice productivity, the study reveals a positive supply-demand gap within the Cauvery Delta region, indicating a rice surplus. The surplus is estimated to be 0.39 million t for 2021-2030, 0.23 million t for 2031-2040, and 0.35 million t for 2041-2050. However, it is important to note that these surplus quantities may not be adequate to meet Tamil Nadu State's overall demand, considering neighbouring regions' reliance on rice production from the Cauvery Delta. As climate change progresses, it is expected to boost rice yields in the new delta region, while a decline in yields is projected in the old delta region. This variation in response to climate change can be attributed to the distinct soil characteristics of these two regions. These findings underscore the urgent need for the development of location-specific policies to mitigate the adverse effects of climate change for a larger region.

Keywords: AquaCrop model, Cauvery delta zone, Economic model, Irrigated rice, Predictive assessment

Biochemical analysis and antioxidant activity of shrubs under hot arid condition

Mahesh Kumar*, Saurabh Swami and Anil Patidar

ICAR-Central Arid Zone Research Institute, Jodhpur-342 003, Rajasthan, India

*Mahesh.kumar14@icar.gov.in

Arid shrubs comprised 17% of the total floristic composition and constitute 26.7% of the total 131 medicinally important plants in western Rajasthan. Arid shrubs have a wide range of adaptability to the desert ecosystem, which allows them to survive under imitated water, extremes of temperatures and nutrient poor environment of arid regions. The tolerance capacity of plants depends on various genetic, physiological and biochemical parameters which are involved in modulating the defence mechanism under abiotic stress. Four arid shrubs *Leptadenia pyrotechnica* (Kheep), *Calligonum Poligonoids* (Phog), *Haloxylon recurvum* (Lana) and *Aerva javanica* (Bui), were selected for the study. Shoot and root samples were collected from natural vegetation in sandy plains and sand dune areas of Bikaner, Jaisalmer and Tanot, under dry hot weather, ambient weather and cold weather conditions. All four species showed significant variation in the content of total phenolic compounds, flavonoids, tannins, and antioxidant activity under different weather conditions. Maximum antioxidant activity was found in Phog leaves (53.14±0.69 mg ascorbic acid equivalent g^{-1}) and Kheep root (65.76±0.52 mg ascorbic acid equivalent g^{-1} of fresh sample) under extremely dry hot conditions. These results can be further investigated for the development of functional foods rich in antioxidants in hot arid regions.

Keywords: Antioxidant activity, Arid shrubs, Seasonal variation, Total phenolic content

Climate smart technologies in the rice based farming system of Kumarakom

Jayalekshmi, G.*, Bhindhu, P. S. and Minnu John

Krishi Vigyan Kendra, Kumarakom, Kottayam-686 563, Kerala, India

*jayalekshmi.g@kau.in

Kumarakom is a well-placed location on the world map owing to its distinct lowland rice cultivation and backwaters. The inhabitants here predominantly depend on below sea-level rice cultivation. Recurring floods, water logging, salt water intrusion, soil acidity, un- scientific farming practices and aquatic weeds posed major challenges in rice cultivation, limiting the cultivation to a single crop in a year. *Thekkeppallippadam Paadashekharam* – a paddy cluster with an area of seventy acres in Kumarakom village was selected under ICAR sponsored NICRA Project for demonstrating climate resilient technologies for enhancing crop yield. Crop calendar was prepared for the cultivation of two crops in a year with a medium duration and a short duration variety. Soil health cards were issued with recommendation for lime application and fertilizers. Technologies like seed treatment with pseudomonas, sowing using drum seeder, weed management with conoweeder and KAU weed wiper, spraying of micronutrient mixture with drone were demonstrated. The seed rate for broadcasting is around 50-60 kg acre^{-1}. By using the drum seeder technology, the seed rate could be reduced by 50%, thus reducing the cost of seed, which is one of the major inputs. Regular monitoring and agro-advisories kept the pests and diseases under control. Yield contributing characters like number of tillers, grains per panicle and 1000 grain weight were recorded in the demo plot. The number of tillers per hill in the demo plot was 16 as against 12 in the control field. The number of grains per panicle and test weight recorded was 87 and 28 g, respectively as against 82 and 26.5 g in the control field. With the technology interventions, farmers could produce 5.8 t ha^{-1}, with a yield increase of 24.76% over control. The B:C ratio could be enhanced to 2.59 over 2.18 in the control plot. A short-duration second crop was raised with an additional 5 t ha^{-1} yield. The scope for increasing the productivity in the garden land especially in the bunds, was also exploited using the climate smart technologies developed by KAU and other ICAR institutes. The project, through its interventions hopes to level up the farming as well as living situations in Kumarakom.

Keywords: Below sea level, Interventions, Kuttanad, NICRA, Rice Cultivation

Development of drought tolerant mulberry genotypes for rainfed sericulture

Suresh, K.*, Yallappa Harijan, Deepika, K. U., Mijingthi Goyari, Subhojit Pal and Satadal Chakrabarty

Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India

*suresh4211@gmail.com

Drought is the most widespread limiting factor for sustainable mulberry sericulture in India. Modern mulberry varieties are highly sensitive to drought stress which results in decreased leaf yield and economic loss to sericulture farmers. In the present investigation, a physio-morphological trait-based breeding was undertaken to develop drought-tolerant mulberry genotypes for rainfed sericulture. Fifteen trait-specific promising accessions identified at CSGRC Hosur were hybridized in the strategic trait-based crossing to potentially complement the physiological traits. The resulting hybrid seedlings of ten crosses were screened for low moisture stress under nursery and field plots. Thirty superior genotypes for leaf yield and physiological traits associated with drought tolerance were selected for evaluation in well-watered and water-stressed conditions. The relative water, leaf moisture content, specific leaf area, primary shoots and total shoots length were observed to be associated with leaf yield under both conditions. Based on correlation, Principle components, and Biplot analysis. MP, GMP, HAM, STI, YI, K_1STI and K_2STI were identified as most suitable indices to select for drought tolerant mulberry genotypes. Ten genotypes were identified as drought tolerant based on indices and percent yield reduction. The tolerant genotypes were further evaluated for leaf yield and quality under rainfed conditions for two years. AMMI analysis of variance for leaf yield showed 94% of the total sum of squares was attributable to environmental, only 4.50% to genotypic and 0.55% to G x E effects. The mulberry genotype PD-1, PD-4, PD-7, PD-8, PD-9, and PD-21 were identified as drought tolerant and high stable yielding under rainfed condition over checks C-1730 (>15%) and C-2038 (>11%). These newly developed drought tolerant genotypes may further be evaluated in target areas before commercial exploitation for increasing silk production in rainfed areas.

Keywords: AMMI, Drought, Indices, Leaf productivity, Rainfed

Effect of zinc nanoparticle on physiology of finger millet [*Eleusine coracana* (*L.*)] under saline condition

Bute Paresh Shailendra, Shailesh Kumar*, Sweta Mishra and Ratnesh Kumar Jha

Department of Botany, Plant Physiology and Biochemistry, College of Basic Sciences and Humanities, Dr. Rajendra Prasad Central Agricultural University, Pusa—848125, Bihar, India

*shaileshk@rpcau.ac.in

The experiment was performed to determine the optimum concentration of ZnO nanoparticles and to recognize the ZnO nanoparticle's ameliorative effects on morpho-physiological characteristics of finger millet seedlings. Experiment was performed in a small plastic pot under a completely randomized design. It was observed that the ZnO nanoparticles at low concentrations, *i.e.* 100 ppm and 250 ppm, enhanced the emergence percent of both genotypes (RAU 8 and BR-407) in comparison to control. Seed priming with 250 ppm of ZnO nanoparticles increased plant height, root and shoot length, root volume, root fresh weight, root and shoot dry weight in both genotypes. The leaf relative water content increased by 6 to 10% and the membrane stability index increased by 4 to 6% under salinity stress conditions. Salinity stress decreased the total chlorophyll content by 25%, SPAD value by 17% and 24% and chlorophyll stability index by 5% in BR-407 and 7% for RAU 8. The ZnO nanoparticle treated plant maintained the higher value of photosynthetic pigments under salinity stress condition. Salinity stress induced the activity of antioxidant enzymes like superoxide dismutase (27% to 44%), catalase (64% to 66%), and ascorbate peroxidase (38% to 39%). The enzyme activities were further enhanced in both genotypes under ZnO nanoparticles treated plants in saline conditions. In the present experiment, it was concluded that seed priming with optimum concentration (250 ppm) of ZnO nanoparticles had a positive influence on the plant's morpho-physiological and biochemical parameters of finger millet seedlings under saline stress conditions.

Keywords: Antioxident enzymes, Millet, Nanoparticles, Salinity, Zinc

Transcriptome dynamics under waterlogging stress in tropical maize (*Zea mays L.*)

Bhupender Kumar*, Krishan Kumar, Abhishek Kumar Jha, Neha Gulati, Chayanika Lahkar and Shankar Lal Jat

ICAR-Indian Institute of Maize Research, Delhi Unit, Pusa Campus, New Delhi-110 012, India

*bhupender.icar@gmail.com

Maize (*Zea mays*) is one of the most important crops for billions of people worldwide. Its production in rain-fed ecologies is affected by water logging stress caused by sudden high rainfall. Keeping in mind the erratic weather patterns and the importance of the maize crop, a better understanding of molecular mechanisms that result in maize's tolerance for waterlogging stress is essential for mitigating the impact of this stress. In this context, comparative transcriptomics is a powerful approach for pinpointing important genes, regulatory processes, and intricate gene networks involved in high moisture stress adaptation. Therefore, a set of 100 inbred lines were evaluated for water logging stress under glasshouse conditions. Water logging stress was imposed by maintaining 3.5±0.5 cm water level in pots after germination continuously for 15 days. Observations were recorded on all important shoot and root parameters. The root and shoot samples from highly tolerant and susceptible genotypes under waterlogging stress were used for high-throughput RNA sequencing by the Illumina HiSeq to generate a transcriptome profile. A total of 16 sequencing libraries were prepared and 71-97% of the sequenced raw reads were mapped to reference B73 maize genome which indicates the good quality of sequencing data. Genes with p-value ≤ 0.05 and fold change of ≥ 2.0 were considered as differentially expressed genes (DEGs) in six different combinations performed between susceptible and tolerant genotype tissues. Thousands of DEGs were identified in our study which were classified into different functional categories and pathways according to their putative functions. Gene Ontology based annotation of these DEGs identified three different functional categories: biological processes, molecular function, and cellular components. The KEGG and mapman-based analysis revealed that most of the DEGs fall into various metabolic pathways, biosynthesis of secondary metabolites, signal transduction, phenylpropanoid biosynthesis, plant hormone signal transduction, MAPK signalling pathway, and starch and sucrose metabolism. Furthermore, top-20 differentially expressed transcription factors in these six combinations were also identified. Additionally, we validated a few waterlogging-response DEGs using qRT-PCR. The findings of the current study might provide new insights for understanding the regulatory network associated with waterlogging stress in maize. Further, the expression of key genes belonging to signal transduction, transcription factors and metabolic pathways, which are highly differentially expressed in this study could be modulated to develop stress-resilient genotypes.

Keywords: Differentially expressed genes, Maize, RNA-seq, Waterlogging stress

Climate resilience: Plant breeding perspective

Ajaz A Lone*, Asmat Ara, Dar, Z. A., Gul, A., Sofi, P. A., Rashid, M., Hassan, S., Ali, G., Dar, S. A. and Hamid, A.

Dryland Agriculture Research Station, Sher-e-Kashmir University of Agriculture Sciences and Technology of Kashmir, Srinagar-190 025, Jammu and Kashmir

*ajaz999@gmail.com

Increasing average temperatures, increased rainfall, alterations in pests and illnesses, increase in atmospheric carbon dioxide, increase in ground-level ozone concentrations, and changes in the nutritional value of some foods are just a few of the ways that climate change affects agriculture. Consequently, ensuring global food security in the face of a growing world population and a limited amount of arable land is a significant problem in the twenty-first century. To combat or adapt to climate change, farmers are urged to adopt climate-resilient crops and crop kinds. Pulses are often cultivated on marginal land with little inputs in a number of resource-poor countries across the world and are the main source of protein and minerals for vegetarians. As a result of their growth in resource-constrained conditions, they are exposed to a variety of abiotic and biotic problems, which causes significant output losses. Additionally, they are more vulnerable to new biotic and abiotic stressors as a result of climate change brought in by global warming, which could get significantly worse in the years to come. The current study's objective was to test the drought resistance of a panel of elite lines in common beans and a germplasm collection in cereals (corn, rice) using column platforms in controlled environments. By depriving the test entry of irrigation after seedling establishment, drought was imposed on them. Climate-resilient smart pulse and cereal crop breeding and development have become more difficult as a result of the changing climate situation. Although pulses are climate smart, adapting to the consequences of climate change while also reducing them, their limited genetic variety has always been a key barrier to their ability to become more adaptable. For the development of cultivars that are climate-resilient, however, the genetic variety that currently exists still offers chances to take advantage of unique traits. Additionally, maize, a C4 plant, has a high yield potential, as evidenced by the highest compound annual growth rate. However, due to the full exploitation of hybrid and manufacturing technology, maize production has plateaued in many nations. Therefore, it is necessary to generate maize ideotypes with favourable trait architecture for greater stress resistance and higher yield under changing climatic conditions. Abiotic stress in maize, such as drought, causes a delay in silking, which increases the anthesis-silking gap and is a key contributor to yield losses. Every crop improvement programme must inevitably put a strong emphasis on making significant use of wild germplasm and unlocking the genetic diversity store. However, current developments in genomics, high-throughput phenomics, sequencing, and breeding methods, as well as state-of-the-art genome-editing tools coupled with artificial intelligence, open up new directions for the enhancement of climate-resilient crops. Adaptive characteristics that confer tolerance or resistance to climate-smart pulses and maize can be mined and exploited more quickly by applying cutting-edge biotechnological techniques including transgenics, genome editing, and epigenetics. In order to combat climate change and create new crop types that are better suited to the changing climate, holistic smart breeding approaches may be a feasible solution.

Keywords: Abiotic stress, Biotic stress, Climate resilient crops

Multiple indices-based selection of functional traits and elite mustard genotypes for cultivating salt affected soils

Ravikiran, K. T.[1]*, Jogendra Singh[2] and Vijayata Singh[2]

[1]ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh, India
[2]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana, India

*rkravikirankt@gmail.com

Soil salinity is one of the land degradation phenomena that is posing a serious threat to agricultural production worldwide. Indian mustard is an important oil seed crop of India, particularly in the northern and eastern states of the country. However, it is sensitive to salinity. Breeding of salt-tolerant mustard varieties is one of the economically and environmentally viable approaches for sustaining crop production under salt-affected soils. An important pre-requisite for breeding tolerant varieties is the information on genetic variability, which is seriously missing for Indian mustard. Hence, in this maiden study, a set of 210 diverse Indian mustard genotypes were screened under control and salt stress (ECiw ~12 dS m^{-1}). The genotypes were characterized for 14 morpho-physiological attributes estimated at late seedling to vegetative stage. A significant reduction was observed for all the traits under salinity stress compared to control, except water use efficiency (WUE) and Na^+ content in root and shoot. Interestingly, genotypes tried to restrict Na^+ in the root, with substantial accumulation observed in the shoot, indicating that root exclusion may not be the sole mechanism of salt tolerance in Indian mustard. The significance of treatment, genotype, and genotype × treatment components with the highest contribution of treatment to total variance. Close correspondence was observed between PCV and GCV values under both control and salt stress reflecting the high repeatability of the experiment. A significant negative association between shoot and root; Na^+ contents and rate of photosynthesis resulting in the ultimate growth reduction under salt stress. With the multi-trait (both control and salt stress) membership function value of salinity tolerance (MFVS) a total of 10 best genotypes were selected. Further, the classical Smith-Hazel index, factor analysis ideotype-best linear unbiased prediction (FAI-BLUP) index and multi-trait genotype-ideotype distance index (MGIDI) were calculated for genotypes under salt stress. Four genotypes, CS 2009-159, CS 2009-420, CS 2009-124, and Swarn Jyoti (RH-9801), were found common across three indices. Finally, 12 genotypes were selected, collating findings from these indices. The identified functional traits can serve as phenotypic markers to screen mustard germplasm for assessing the magnitude of the genetic variation and early responses towards salt stress. Further, a combination of forward genetics with the identified functional traits will be useful to researchers in identifying the genomic region/genes/QTLs underlying early response to salt stress.

Keywords: GWAS panel, Mustard, Photosynthetic traits

Mapping land availability and potential bioenergy feedstocks for India

Amit Kushwaha*, Anjali Gawade and Deepak Jaiswal

Environmental Sciences and Sustainable Engineering Centre (ESSENCE), IIT Palakkad, Kanjikode, Palakkad-678623, Kerala, India

*162204001@smail.iitpkd.ac.in

The paramount need for viable fossil fuel substitutes is pressing, especially for countries like India. India heavily depends on importing over 75% of its crude oil, which poses a dual risk. Firstly, fossil fuels contribute to global warming, worsening the environmental crisis. Secondly, the fluctuating oil prices jeopardize real living standards, affecting the economy and the well-being of the people. This study centers around two primary objectives: mapping land availability by highlighting the unutilized and interim-fallow lands and identifying promising bioenergy feedstock crops and suitable regions that are not in any conflict with food crops. Interim-fallow land refers to agricultural land that is left uncultivated for a specific period, following the primary crop's harvest. These lands provide the opportunity to grow energy crops with relatively short growing periods without impacting primary crops. In doing so, it underscores the significance of biofuels as an environmentally sound and sustainable energy alternative. We have selected these crops based on characteristics such as high oil content in seeds, suitability for ethanol production, low input requirements, and fast-growing biomass for heat and electricity generation. By utilizing ArcGIS Desktop, we did a thorough analysis of land use/land cover provided by the National Remote Sensing Centre (NRSC) and climate data, including precipitation and temperature extremes, to pinpoint promising regions in India for bioenergy production.

Keywords: Bioenergy feedstock crop, Climate data, Interim-fallow lands, Land use, Land cover, Unutilized land

Theme: Climate Action for Sustainable Agri-food Systems

How does incorporating atmospheric CO_2 concentration into FAO penman-monteith equation change reference evapotranspiration for future climate conditions projected over India?

Surendran, S. *, Pahari, T., Jaiswal, D. and Nandhana Sunil

Environmental Sciences and Sustainable Engineering Centre, IIT Palakkad, Kanjikode, Palakkad-678623, Kerala, India.

*162114001@smail.iitpkd.ac.in

The combined Penman-Monteith equation is widely used to estimate evapotranspiration rates, which play a crucial role in determining water requirements. However, with the current changes in climatic conditions, such as increasing CO_2 concentration in the atmosphere, emphasis on modification of standard equations, in order to incorporate the effect of erratic climate change patterns has been done in many research works and studies. As a step towards it, this work makes use of a modified version of the FAO Penman Monteith equation, and future climate projection over India, to examine the relationship between atmospheric CO_2 and Reference evapotranspiration. In this study, we have used a python package PyETo (https://github.com/woodcrafty/PyETo) and a modified hyperbolic g_s-CO_2 model and built upon function (fao56_penman_monteith) to create a new function that incorporates the effect of CO_2 concentration on stomatal conductance and hence on reference evapotranspiration rates. This modification made use of the existing literature on the effect of atmospheric CO_2 on stomatal conductance. We use future climate projection data from global circulation models (GCM) outputs to plot reference evapotranspiration using the original FAO Penman-Monteith equation and modified equation to show the impact of CO_2 concentrations on the reference evapotranspiration under different future scenarios.

Keywords: Climate Change, FAO Penman-Monteith, Increasing CO_2, Reference evapotranspiration

Yield and yield attributes of various foxtail millet (*Setaria italica L.*) cultivars under western Zone of Tamil Nadu

Gobikashri, N.*, Udhaya Kumar, K., Kousalya, A. and Jennifer Flora, G.

Division of Agronomy, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore-641 114, Tamil Nadu, India

*gobikashri08@gmail.com

Agricultural sector is greatly vulnerable to environmental fluctuations, as it relies directly on climatic conditions for farming operations. In response to these changing conditions, cultivating varieties and landraces would be an effective adaptation strategy for changing climatic conditions. Foxtail millet, a highly nutritious grain is often used as a food source for both humans and animals and is similar to other millets. Being a resilient crop, it is regarded as a promising crop for ensuring future food security in the face of climate change. Thus experimental study was carried out in the *rabi* season of 2022-23 at an experimental farm in Karunya Institute of Technology and Sciences, Coimbatore, under the Western Zone of Tamil Nadu. The field experiment laid out in Randomized Block Design with three replications and eight treatments consisted of foxtail millet varieties and landraces *viz*., T1–ATL-1 (Control), T2–SiA-3222 *(Garuda)*, T3–SiA-3088 *(Suryanandhi)*, T4–SiA-3085, T5–SiA-3156, T6–SiA-3233 *(Reynaudu)*, T7–*Mookanthathinai* and T8–*Koranthinai*. According to the findings, yield attributing characters like days to 50% flowering and days of maturity were noticed low in SiA-3222 *(Garuda)* and high in landrace *Mookanthathinai;* number of productive tillers per plant (7) was recorded higher in Variety SiA-3085 and test weight (3.60 g) registered higher in ATL-1 control variety. SiA-3233 *(Reynaudu)* outperformed the other examined varieties and landraces in terms of grain yield (2933 kg ha^{-1}), straw yield (5500 kg ha-1) and dry matter production (5686 kg ha^{-1}). It could be concluded from the study, that the variety SiA-3233 *(Reynaudu)* is the best alternative to the control variety ATL-1 for cultivation in the Western Zone of Tamil Nadu.

Keywords: Foxtail millet, Landraces, Varieties, Western zone, Yield

Development of a common multi-parental population as genetic resource for mitigating heat and drought stress in wheat

Satish Kumar*, Rajitha Nair, Disha Kamboj, Kiran Pal, Anshul Chhahhiya, Rajesh Aggarawal, Vikesh Tanwar, Mishra, C. N., Tyagi, B. S., Ahlawat, O. P. and Gyanendra Singh

ICAR–Indian Institute of Wheat and Barley Research, Karnal-132 001, Haryana, India

*satish.kumar8@icar.gov.in

Wheat production in India, ever since has increased by many folds from 6.4 mt in 1950 to 112.7 mt during 2022-23. The most serious constraints to wheat production are various biotic and abiotic stresses. The expected onslaught of climate change is also a worrisome aspect and breeding strategies have to be reoriented to care for the abiotic stresses such as heat and drought. It is estimated that, on average, up to 20% of the crop is lost due to various abiotic stresses, annually. Climate change can have significant effects on wheat production due to its sensitivity to temperature, precipitation, and other environmental factors. Extreme heat events during critical growth stages can also lead to heat stress and spikelet sterility, resulting in lower grain quality and yield losses. Besides, changes in precipitation patterns due to climate change can impact water availability for wheat cultivation. Shifts in the timing and intensity of rainfall can lead to water stress during crucial growth periods, affecting grain development and overall yields. The current trends in India indicate that the 'cool period' for the wheat crop is shrinking, while the threat of terminal heat stress is increasing. Heat stress is reported to reduce the grain filling duration and change the starch composition and activity profiles of starch biosynthesis enzymes. However, very few sources are floating in the wheat breeding programs in India. The known sources for tolerance to heat and drought stress of wheat were used to develop a multi-parent population using a complex crossing scheme using eight donors and eight recipients. Eight tolerant varieties (GW322, WH730, WH1024, Raj3765, C306, Dharwad dry, NI5439 and Halna) were used along with eight high-yielding commercial wheat varieties (HD2967, Lok1, DBW187, DBW222, DBW17, PBW771, K1006 and PBW703). The complex F1 was produced during 2022-23 crop season and was planted at an off-season location (Dalang Maidan) during 2023. Selfed seed from this F1 will be used to plant approximately 6000 F2 plants during 2023-24. The purpose is to map QTLs/gene(s) for heat and drought tolerance and to, directly and indirectly, use the highly recombined lines in breeding programs. This MAGIC population will act as a useful genetic resource with diverse allelic combinations to be exploited by the wheat community.

Keywords: Abiotic stresses, Climate change, Food Security, Multi-parent population, Wheat

Evaluation of *Yr*-gene introgressed wheat lines for morpho-physiological and yield traits

Rajitha Nair, Satish Kumar*, Rajesh Aggarwal, Disha Kamboj, Kiran Pal, Anshul Chhachhiya, Vikesh Tanwar, Mishra, C. N., Tyagi, B. S., Ahlawat, O. P. and Gyanendra Singh

ICAR–Indian Institute of Wheat and Barley Research, Karnal-132 001, Haryana, India

*satish.kumar8@icar.gov.in

India the second largest producer of wheat, has witnessed a record wheat production of 112.74 million t during 2022-23. Challenges posed by various biotic and abiotic stresses, further compounded by climate change, have made it increasingly difficult to sustain wheat production across the globe. Wheat rust, particularly yellow rust, is a major factor impacting wheat productivity. Yellow rust remains crucial to sustain wheat productivity under biotic stress by countervailing potential yield losses through breeding programs utilizing advanced technologies. One of the efficient ways to sustain global wheat production against yellow rust is to use durable rust-resistant genes. In this context, a study was conducted using 37 introgressed wheat lines having yellow rust-resistant genes, such as *Yr18*, *Yr29*, *Yr36*, and Yr46, along with 10 check varieties. The check varieties included DBW187, DBW222, HD2967, NIAW3170, HI1628, HI1605, PBW771, WH1270, WH1105, and PBW725. These resistant genes are present individually and in different combinations in these genotypes, which makes it easy to evaluate and validate. The study aimed to analyse yield and its contributing traits during *Rabi* 2022-23. The experiment was conducted in a randomized block design (RBD) with two replications. Morpho-physiological and yield data were recorded for various characteristics, including yield, test weight, days to heading, days to booting, tillers, plant height, flag leaf length, flag leaf width, peduncle length, spike length, spikelets per spike, spike yield, biomass, 1000 grain weight and NDVI. The introgressed lines yielded at par with the checks, which are commercially grown wheat varieties. For most of the other traits studied, these introgressed lines were identified having unique traits. For each parameter, superior lines were identified. These identified lines will be further evaluated and tested in multi-location yield trails. These gene combinations can be a novel source of resistance to yellow rust and provide diversity to the wheat gene pool.

Keywords: Biotic stresses, Resistance genes, Wheat, Yellow rust, Yield stability

Trends in surface weather parameters of coastal India and implications for brackishwater aquaculture

Kumar, C., Ashok Kumar, J.*, Jayanthi, M. and Muralidhar, M.

ICAR-Central Institute of Brackishwater Aquaculture, RA Puram, Chennai-600 028, Tamil Nadu, India

*Ashok.Jangam@icar.gov.in

Prediction of trends in climatic variables is crucial to understand the dynamic nature of the environment and helps in evaluating the potential impacts of climate change on agriculture and allied sectors. Brackishwater aquaculture (BWA), predominant in coastal regions of India, is synonymous with shrimp aquaculture. The cropping calendar in a particular area is prepared based on the understanding of the changes in weather parameters over the years and the physiology and growth of the cultured species. In this study, forty-one years (1969 to 2009) of daily climatic data of 52 grid points located in the eight coastal states of India were collected and analysed the trends for three key climatic variables *viz.*, maximum temperature, minimum temperature, and rainfall. To identify and quantify the trends in the climatic variables, we employ two widely recognized statistical methods namely Mann-Kendall trend test and Sen's slope estimator. The Mann-Kendall test examines the presence and significance of monotonic trends, while Sen's slope estimator calculates the magnitude and direction of the trend. Results revealed significant trends in rainfall for 20 locations, with 11 being positive and 9 negative trends. Significant positive trends in rainfall were limited to Gujarat, Andhra Pradesh and West Bengal states. Heavy rainfall affects shrimp farming by lowering water pH, decreasing dissolved oxygen values due to cloudy weather, and animals become stressed and susceptible to diseases. Regarding maximum temperature, significant trends were observed for 39 locations, with 38 trends being positive and one trend being negative in West Bengal. The increase in maximum temperature at a few locations for a shorter duration could be the reason for heat waves, negatively affecting BWA. The increase in maximum temperature in areas with a significant negative trend in rainfall results in a decrease in the freshwater flow from the upstream which reduces the quantity and quality of source waters for BWA. Similarly, for minimum temperature, significant positive trends were observed for a total of 47 locations. A future scenario of an increase in minimum temperature enables prolonging the culture or starting the culture at an early date during the winter months. A heat map was generated to depict the spatial distribution of state-wise coastal grid mean values along with future scenarios of 2020, 2050 and 2080 generated for RCP 4.5. The trends in weather parameters are useful in planning the crop calendar activities, such as pond preparation and stocking of the brackishwater cultured species.

Keywords: Brackishwater aquaculture, Coastal India, Mann Kendall, Sen's slope, Trend analysis

Vermicomposting with poultry litter and its effect on crop yield – Wealth out of waste

Mahapatra, R. K.*, Pankaj, P. K., Bhanja, S. K., Prakash, B., Shanmugam, M., Anand Laxmi, N. and Yadav, S. P.

ICAR-Directorate of Poultry Research, Rajendranagar, Hyderabad-500 030, Telangana, India

*rkmpatra@gmail.com

One of the major issues the poultry industry is currently facing is the accumulation of large amounts of waste, especially manure and litter, generated by intensive production, which is causing major environmental problems. To overcome environmental issues, environmentally sustainable management technologies have been evolved to mitigate the adverse effect of poultry waste to utilize these for producing by products like compost. Application of compost on the field influences yields and well-being of farmers. Converting poultry litter into compost is one of the best solutions which can take care of productivity and also minimise environmental pollution. The compost was prepared having C/N ratio of 35:1 by mixing 13 kg of litter was mixed with 46 kg of dry leaves and 25:1 by mixing 40 kg of litter with 40 kg of dry leaves. The relative humidity of 48%, pH 5.2 and temperature of 36.2^{0}C was maintained. The final product, compost, was ready on 57th day. These bio-fertilizers were applied to the field to see the effect on crop production, using the green gram variety WGG-45. The total duration of the crop was 65 days and spacing between the plants was 45x10 cm. The plant population was 22 m^{-2}. Along with the control, recycled derived fertilizer, met from 18 kg urea and 125 kg SSP, was also applied to the field for crop production. The maximum number of branches per plant in the group having a carbon to nitrogen ratio 35:1 (C/N ratio) was found to be 2.67±0.14, 4.33±0.23 and 6.67± 0.84 on days 30, 45 and 60, respectively after sowing. However, the number of branches per plant in the group having C/N ratio 25:1 was found to be 2.33±0.09, 3.33±0.12 and 5.67± 0.13 on days 30, 45 and 60, respectively after sowing. The average age to 50% maturity was 42.33±0.47 and 3.33±0.12 in C/N ratio 35:1 and 25:1, respectively. The average stover yield was also recorded to be 43.33 ±3.47 and the average number of pods per plant, pod length (cm) and number of seeds per pod were 14.33±0.88, 8.33±0.09 and 12.00 ±0.58 in C/N ratio 35:1 group, respectively which were higher than C/N 25:1. Seed index and average seed yield were 5.00 ±0.25 and 12.83 ±0.86, respectively in C/N 35:1. It can be concluded that the compost having C/N ratio 35:1 is better than the compost having C/N ratio 25:1 in terms of overall crop production.

Keywords: Compost, Crop yield, Poultry litter, Waste

A comparative analysis of energy use, carbon footprint and related environmental burdens of different fishing systems through Life Cycle Assessment approach

Paras Nath Jha* and Leela Edwin

Fishing Technology Division, ICAR-Central Institute of Fisheries Technology, Kochi-682 029, Kerala, India

*paras.jha@icar.gov.in

Fish harvesting is one of the energy intensive food production systems, responsible for greenhouse gas emissions. Fossil fuel continues to be the main source of energy for the major fishing methods *viz.* trawling, gillnetting, purse seining and long lining, releasing high amount of CO_2 and other greenhouse gases (GHGs). The world fishing fleet has burnt about 40 billion liters of fuel in 2011 and emitted 179 million t of CO_2 equivalent (CO_2 eq.) and other GHGs to the atmosphere. During the present study, 15 fishing harbours and 30 fish landing centers of 7 maritime states were selected for data collection for the period of two years. Structured questionnaires and templates were used to collect primary data on the constructional aspects of fishing vessel with fishing gear and recurring data on operational aspects from fishermen, net makers, boat building yards and vessel operators. Secondary data were collected from state departments, fishermen cooperative societies and log books maintained onboard fishing vessels. Details of operational inputs *viz.* consumption of fossil fuel, lubricants, fresh water and ice blocks were collected from 90 fishing vessels for LCA and DEA analysis. Longliner-cum-gillnetters in the size range of 14-20 m, purse seiners in the size range of 15-22 m and trawlers in the size range of 14-18 m were selected for the study. It was found that per kg of live fish landed, trawlers contributed maximum towards carbon footprint among other fishing systems, followed by longliner-cum-gillnetters and purse seiners. Hotspot analysis revealed that diesel contributes maximum to global warming potential and associated environmental burdens, among other operational inputs. For more in-depth information, further analysis is being carried out.

Keywords: Energy use, Carbon footprint, Fishing systems, Life cycle assessment

Effect of improved staking method with plastic mulching for tomato cultivation in kharif season

Suchismita Dwivedy* and Anil Kumar Swain

Krishi Vigyan Kendra, Orissa University of Agriculture and Technology, Nayagarh, Odisha-752 070, India,

*suchi.44@gmail.com

Tomato is a widely cultivated and consumed horticultural produce of Nayagarh District in Odisha. The distress sale of tomato during the winter season compelled us to focus on off season tomato production. Hence, the study was carried out in Kharif season to evaluate the response of the staking method with plastic mulching on tomato fruit yield, quality, and net income. Treatments were with no staking + no mulching (Control), Fish net staking (FNS) + With plastic mulching (WPM), Wooden staking (WS) and Wire trellis (WT). Treatments were applied in a randomized complete block design (RCBD) with three replications. Fish net staking with 100 micron Black and Gray coloured plastic film resulted 45.5 t acre^{-1} yield, 50 g average fruit weight, 15.4 kg yield per plant and 88.5% weed control efficiency. The optimum plant height was found to be 3 ft, and highest total number of fruits per plant was 32.5. The annual net income obtained was ₹2.7 lakh from the selling price of ₹60 per kg of tomato during the season. Thus, the combination of FNS + WPM resulted in better yield with higher income.

Keywords: BC ratio, Fish net staking, Fruit quality, Income, Yield

Present status of sesame diseases and their integrated management using indigenous practices

Gupta, K. N.* and Vishwakarma, A. K.

Project Coordinating Unit (Sesame &Niger), ICAR-Jawaharlal Nehru Krishi Viswa Vidyalaya Campus, Jabalpur-482 004, Madhya Pradexh, India

*kngupta1@rediffmail.com

Chemical fungicides are the first choice for the farmers to combat diseases because of their easy adaptability and immediate therapy. Since sesame seed and oil are in high demand for export due to their high unsaturated fat and methionine content, focus has been shifted to safer alternatives to chemical fungicides in recent years. Biological control has attained importance in modern agriculture for disease control. Since the efficacy of bio-control agents in disease abatement has been inconsistent due to their inability to maintain a critical threshold population necessary for sustained bio-control activity, bio-control with antagonistic microorganisms alone could not be a complete replacement for management strategies currently employed. To enhance and extend the desired response, specific substrates are added which are utilized selectively by the introduced microbes employed as a biocontrol agent. Therefore, Integrated Disease Management (IDM) that incorporates biocontrol agents, botanicals and organic amendments would reduce the number of fungicides used per season in addition to combat diseases in an economically viable and ecologically safe proportion. Among the many production constraints, the most important includes a lack of improved cultivars and a poor seed supply system. The production and productivity of sesame is constrained by various abiotic and biotic stresses, such as root rot and stem rot, Bacterial blight, Phyllody, Powdery mildew, Alternaria and *Cercospora* leaf spot. Sesame diseases cause damage to seed, seedling, root, stem as well as foliage resulting in significant loss. Seed treatment with Thiram (0.2%) + Carbendazim 50WP (0.1%) and two foliar sprays done with wettable sulphur (0.25%) were most effective to minimize the incidence of powdery mildew. Two foliar sprays of Mancozeb 2%+ Carbindazim1% was effective for management of *Alternaria* and *Cercospora leaf spot* disease. Seed treatment with Imidacloprid (17.8 SL @ 5 ml kg^{-1}) followed by foliar spray of acetamiprid 20% SP @ 0.3 g l^{-1} was found effective in reducing the vector population and phyllody incidence. Seed treatment with *T. viride* @ 10 g kg^{-1}, furrow application of enriched *T. viride* (2.5 kg in 100 kg of FYM) @ 250 kg ha^{-1} followed by two foliar sprays of combo-product (Tebuconazole 50% + Trifloxystrobin 25%) @ 0.5 g l^{-1} was found economical for the management of *Macrophomina* root and stem rot as well as *Alternaria* and *Cercospora* leaf spot disease of sesame.

Keywords: Biocontrol agents, Fungicides, Integrated disease management (IDM), Sesame

Quantifying dry spell dynamics for sustainable rainfed agricultural production systems

Santanu Kumar Bal*, Subba Rao, A. V. M., Manikandan, N., Sarath Chandran, M. A., Timmanna and Singh, V. K.

ICAR-Central Research Institute for Dryland Agriculture, Hyderabad-500 059, Telangana, India

*Santanu.bal@icar.gov.in

Dry spells can have a profound impact on rainfed agriculture, which relies heavily on precipitation for crop production. Prolonged dry spells can result in soil moisture deficits, making it difficult for crops to thrive and causing reduced yields. Additionally, they can disrupt planting schedules, stunting crop growth and development. To quantify the cumulative effect of dry spells on India's main rainfed crops during the kharif season (Jun-Sep), a new indicator called the Dry Spell Index (DSI) was developed. Using observed rainfall data from 1636 stations across six Indian states, the spatial variability and trends of DSI at the district level were examined across the major arid and semi-arid regions of the nation. Comparison of DSI with Standardized Precipitation Index (SPI), hitherto, a widely used drought index was also carried out to assess the comparative performance of DSI over SPI. The results revealed that, regions especially central and eastern Karnataka, northern Rajasthan and western Gujarat are becoming wetter in terms of total seasonal rainfall as indicated by SPI, and simultaneously becoming drier in terms of total dry spell duration within the season as per DSI. The impact of DSI on the yield of major rainfed crops *viz*., cotton, groundnut, maize, pearl millet, pigeon pea and sorghum were estimated by employing appropriate statistical methods. From the correlation analysis of DSI and SPI, it was observed that the impact of number and duration of dry spells integrated in the form of DSI was higher in comparison to the influence of total rainfall indicated by SPI on the yield of six major rainfed crops in India. It was also noticed that, districts with higher DSI showed lower productivity in all the crops compared to the districts with lower values of DSI having better productivity levels. Yield loss of 75-99% was observed in 24% of sorghum, 23% of groundnut and 13% of pearl millet growing regions. The yield loss was also observed to the tune of 50-74% in 44% of cotton, 24% of groundnut, 17% of maize, 16% each of pearl millet and sorghum and 12% of pigeon pea growing regions. It was inferred that by mitigating the cumulative impact of dry spells, yield could be significantly increased twice in more than 55%, 49% and 42% area of pearl millet, pigeon pea and groundnut growing regions, respectively. This study is aimed to provide detailed information on dry spell characteristics and its influence on crop productivity; identification of vulnerable regions and management of available water resources for sustainable crop production in rainfed regions of India. Farmers can adopt practices like rainwater harvesting, drought-resistant crop varieties, and improved irrigation systems to mitigate the impacts of dry spells. Diversifying crops and implementing better soil conservation methods can also help build resilience in rainfed agriculture systems, ensuring food security in regions vulnerable to erratic rainfall patterns.

Keywords: Dry spell, DSI, Rainfed, SPI, Yield

Assessment of *in-situ* residue management on carbon mineralisation and soil physico-chemical properties in rice-wheat system

Amrit Lal Meena*, Megha Chaudhary, Raghavendra Singh, Sunil Kumar, Phool Chand Jat, Ghasal, P. C., Jairam Choudhary, Meena, L. R., Kamlesh Kumar, Adarsh Kumar Meena, Ashutosh Kumar Rai and Sunil Kumar

ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh, India

*amrit.iari@gmail.com

The food grain production in India has attained self-sufficiency in recent years. The major portion of food grain in India is covered by rice-wheat cropping system. With 24 million ha (M ha) in Asia, the RWCS: rice-wheat cropping system (*Oryza sativa-Triticum aestivum*) is the most common production system worldwide. Approximately 682.6 Mt (dry weight basis) of residual biomass are produced in India each year; of this amount, 58.6% is produced during the kharif (June to October), 38.9% is during the rabi season (November to April/May), and 2.5% during the summer season. Managing leftover residue in the field within a limited timeframe of 10-20 days to prepare for the winter season wheat is a challenging undertaking, either for reusing or safely disposing it. As a result, over 70% of fresh rice straw produced in Asian countries is burned. India's Pusa decomposer developed by the Indian Agriculture Research Institute (IARI), New Delhi is a bio-decomposer that turns rice waste into manure and is affordable and farmer-friendly for putting an end to paddy residue burning. This study was planned to quantify the impact of *in-situ* residue management on carbon mineralisation and soil extracellular enzymes in rice wheat system. For this, soil either alone or in combination with Pusa decomposer spray was tested, in soil samples collected at various soil depths *i.e.* 0-5; 5-15 and 15-30 cm. Soil bulk density (BD) was lowered by 6.11%, 5.28%, 4.21% and 3.79% in the RI+PD, RR+PD, RI, and RR treatments over the RB treatment, respectively. Application of crop residue along with a spray of Pusa decomposer microbial consortia in treatments RR+PD and RI+PD improved the WHC by 18.99% and 12.88% over the sole application of RR and RI treatments, respectively. Interestingly, in the 5-15 cm soil depth, the range of N content varied from 29.33% to 92.97% higher among the residue incorporation treatments as compared to RB treatment. The P content ranged from 20.20 mg kg^{-1} to 25.21 mg kg^{-1}; 38.89 mg kg^{-1} to 67.71 mg kg^{-1}, and 9.44 mg kg^{-1} to 12.47 mg kg^{-1} in 0-5, 5-15 and 15-30 cm soil depths, respectively. Treatments comprised of RR+PD and RI+PD recorded 56.2% and 26.6% higher DHA content as compared to RR and RI treatments in surface soil, respectively. Cumulatively, MBC ranged from 284.0 µg g^{-1} to 534.1 µg g^{-1} in RB and RI+PD treatments across the soil depths. Our results showed that RS incorporation resulted in increased enzyme activities like FDA, which was linked to the increased C input, and root exudates containing C-rich substrates such as organic acids and carbohydrates.

Keywords: Crop residues, Cropping system, Pusa decomposer, Residue management, Soil enzymes

XII AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 3

Frontier Science and Emerging Genetic Technologies: Genome Breeding, Gene Editing

Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Application of CRISPR-Cas Systems for Crop Improvement and Sustainable Development

Genome Editing: IPR Policy for Product Development and Socio-economic Considerations

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

OsPSTOL gene-driven adaptive alterations: Comparative transcriptomic study of Pusa44 and its *Pup1* introgressed NIL

Thomas, A.*, Gopala Krishnan, S., Bhowmick, P. K., Bollinedi, H., Kumar, S., Anantha, M. S., Singh, A. K. and Vinod, K. K.
ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110 012, India
*amritathomas75@gmail.com

Phosphorous (P) is an indispensable macronutrient for the vital physiological functioning of rice. P is limited in soil, hence plants often suffer P deficiency stress when continuous repletion with phosphatic fertilizer is stopped. Under P deficit conditions, plants use various adaptive mechanisms associated with morphology, physiology, and biochemistry to cope with the prevailing stress. In rice, low P tolerance is known to be conferred by a QTL, *Phosphorous uptake 1* (*Pup1*). To confer low P tolerance to Pusa44, a popular rice variety, 22 *Pup1* near-isogenic lines (NILs) were developed through a marker-assisted backcross breeding program having 98.5% recurrent parent genome recovery. Among these, one of the NILs, NIL15 was used for deciphering the mechanism of low P tolerance through transcriptome analysis. The NIL along with the recurrent parent Pusa44 were subjected to hydroponic studies for 30 days at National Phytotron Facility, New Delhi in PusaRICH standard solution. The nutrient regime for the study was maintained at low (2 ppm) and high (15 ppm) respectively. Thirty day-old tissues were sampled and processed for RNA extraction using standard procedures. The tissue used for the analysis was root of the seedling in 2 replications each giving a total of 8 samples subjected to the analysis. The transcriptome data showed significant variation between the genotypes with 3797 differentially expressed genes (DEGs) found under low P conditions. Surprisingly higher number of genes were found downregulated than upregulated. Under low P stress, several genes vital for the functioning of physiological process was downregulated in Pusa 44 such as *WRKY24*, *WRKY42*, *CMPG1*, *ERF20*, Phytosulfokine receptor precursor, and heat shock protein, while the same was found upregulated in NIL15 indicating a better adaptation towards the stress in the *Pup1* introgressed line. The major gene upregulated in Pusa44 was related to cytochrome P450, CHIT5, helicase activity gene, and disease resistance protein (RPM1) indicating a higher stress susceptibility in the genotype. Serine threonine kinase activity was found specifically upregulated in NIL15 which is the prominent protein involved in the response of root for stress reception. The study has generated adequate data *vis-à-vis* molecular, cellular, and biological processes deciphering the downstream mechanism of *Pup1* regulation in the introgressed and control lines. Our research paves the path for further studies and examination in the same to decode the action of QTL in parallel studies *i.e.*, metabolomics and proteomics.

Keywords: Differentially expressed genes, Marker-assisted backcross breeding, Phosphorous uuptake1, PusaRICH, Serine threonine kinase

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Identification of novel putative alleles conferring resistance to wheat rusts using genome-wide association study

Hanif Khan*, Gopalareddy, K., Sudheer Kumar, Satish Kumar, Mishra, C. N., Om Parkash, Harikrishna, Devate, N. B., Singh, G. P. and Gyanendra Singh

ICAR-Indian Institute of Wheat and Barley Research, Karnal – 132 001, Haryana, India

*hanif.khan@icar.gov.in

Although several race-specific seedling genes were identified for wheat rusts, genetic dissection of rust resistance through QTL/Association mapping is equally important in the management of wheat rust as the durability of most of the race-specific seedling genes is very low, particularly, under high disease pressure in regions with wide distribution of single or similar varieties. Breeding for rust resistance is as important as that of grain yield improvement *per se* in wheat. Genomic regions governing stem rust, leaf rust, and yellow rust were studied in a set of 280 bread wheat genotypes. The genome-wide association (GWAS) panel was genotyped using a 35K Axiom array and phenotyped at 8 environments for stem rust, 10 environments for leaf rust, and 11 environments for yellow rust during the year 2019-20. Pair-wise LD values (r^2) were estimated through TASSEL version 5.0 and significant MTAs were identified using the BLINK model implemented in GAPIT version 3.0. The LD decay for the whole genome was 4.9 cM, LD was rapid in the A subgenome (3.6 cM) followed by the D subgenome (5.2 cM) and B subgenome (5.7 cM). A total of 41 Bonferroni-corrected marker-trait associations (MTAs) were detected covering all three subgenomes of bread wheat. Trait-wise distribution of genomic regions includes 24 MTAs for yellow rust and 17 MTAs for stem rust. A maximum of 17 MTAs was located on the D subgenome, followed by 14 MTAs on B, and 10 MTAs on A subgenome. A set of 10 stable MTAs including five for stem rust (*AX-94580041, AX-94883961, AX-94716205, AX-94843704, AX-94878781*) and five for yellow rust (*AX-94990952, AX-94723806, AX-95203560, AX-94875635, AX-95172478*) were identified. Several MTAs explained more than 10% of phenotypic variation explained (PVE). Understanding the genetic basis of complex traits through GWAS with a diverse panel of genotypes can significantly improve QTL mapping resolution compared to bi-parental populations-based QTL mapping. The effects of newly identified MTAs particularly stable MTAs and MTAs with higher PVE will be validated in different genetic backgrounds for further utilization in marker-aided breeding. Also, Insilco analysis with wheat genome sequence will be carried out to identify putative candidate genes associated with the identified significant SNPs.

Keywords: Genome-wide association study, Marker-trait association, QTL mapping, Wheat rust

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Identification of inbreds possessing favourable alleles for genetic improvement of grain yield and yield components in maize (*Zea mays* l.)

Sabitha, N.*

Acharya N.G. Ranga Agricultural University, Agricultural College, Mahanandi-518 502, Andhra Pradesh, India

*nsabitha84@gmail.com

Identification of inbred sources possessing favourable alleles to improve existing hybrids is one of the most important problems faced by maize breeders. Improvement of constituents of a single cross-hybrid can be achieved by improving or recycling one or both the parental lines. The present investigation on the identification of favourable alleles for improvement of single cross hybrids in maize was carried out at ARS, Perumallapalle from over three seasons *viz.*, R*abi* 2016-17, S*ummer* 2017 and K*harif* 2017) to identify inbred lines possessing high frequency of favourable alleles for grain yield and yield components. Out of 45 hybrids made from a 10×10 diallel, only four superior hybrids *viz*., Heypool × PDM 1474; BML 7 × DFTY; DFTY × Heypool and BML 15 × PDM 1474 were considered based on pooled mean grain yield in addition to the target hybrid DHM117 (BML 6 × BML 7). Dudley's (1987b) model was followed in the identification of favourable alleles (μG') present in donor inbreds. The estimates of μG' for the eight possible donor lines out of 10 inbreds were studied for grain yield plant^{-1}, ear length, no. of kernels row^{-1}, and 100 seed weight (g). Inbreds with significant and positive μG' estimates were considered a good source of favourable alleles. The study indicated significant effect of environment (seasons) on the estimates of μG' though variable estimates of μG' for the same character and hybrid across seasons which can be attributable to the differential effect of environmental factors on the same set of genes governing expression of the same character under different environments. The common donor inbreds identified with a higher frequency of positive and significant favourable alleles include Heypool, DFTY, PDM 1474 and PDM 1452. The inbred lines DFTY and PDM 1474 for BML 6 × BML7; DFTY and BML 2 for Heypool × PDM 1474; Heypool and PDM 1452 for BML 7 × DFTY; PDM 1474and PDM 1452 for DFTY × Heypool and Heypool and PDM 1452 for BML 15 ×PDM 1474 were the potential donors. Breeding strategies for genetic improvement of grain yield were formulated for the target and selected superior hybrids in addition to the target hybrid DHM117 (BML 6 × BML 7) based on the parameters of Dudley's model (μB' to μG') and genetic affinity of donor inbred lines with parental constituents of the target/selected hybrids.

Keywords: Dudley's method, Grain yield, Favourable alleles, Maize

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Comparison of genomic prediction models in genomic selection for leaf, stem and yellow rust resistance at seedling and adult plant stage in bread wheat (*Triticum aestivum* L.)

Vikas, V. K.*[1], Pradhan, A. K.[2], Budhlakoti, N[3], Mishra, D. C[3]., Prasad, P[4]., Bhardwaj, S. C[4]., Kumar, S[4]., Sivasamy, M[1]., Jayaprakash, P[1]., Geetha, M[1]., Nisha, R[1]., Shajitha, P[1]., John Peter[1], Amandeep Kaur[5], Satinder Kaur[5], Mir, R. R[6]., Kuldeep Singh[7] and Sundeep Kumar[2]

[1]ICAR-Indian Agricultural Research Institute, Regional Station, Wellington-643 231, The Nilgiris, TamilNadu, India
[2]ICAR-National Bureau of Plant Genetic Resources, New Delhi-110 012, India
[3]ICAR-Indian Agricultural Statistics Research Institute, New Delhi, Delhi-110 012, India
[4]ICAR-Indian Institute of Wheat and Barley Research, Flowerdale, Shimla–171 002, Himachal Pradesh, India
[5]School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana -141 004, India
[6]Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar-190 025, Jammu & Kashmir, India
[7]International Crops Research Institute for the Semi-Arid Tropics, Patancheru-502 324, Telangana, India

*vkvikaswtn@gmail.com

In the last two decades, genomic predictions (GP) have been widely adopted in various plant and animal breeding programs globally, because of their potential to improve selection accuracy by increasing genetic gains. GP is a promising method that employs genomic markers to calculate genomic-estimated breeding values (GEBVs) to choose the best individuals. The same technique can also be used to select plant genotypes that are resistant to certain plant diseases. To evaluate the performance of different genomic selection (GS) models, we examined six different parametric and non-parametric statistical models including Ridge Regression (RR), Least Absolute Shrinkage and Selection Operator (LASSO), Genomic Unbiased Linear Prediction (GBLUP), Elastic Net (EN), Reproducing Kernel Hilbert Spacing model (RKHS), and Random Forest (RF) in relation to seedling and adult plant resistance to leaf, stem and yellow rust of wheat in the panel of 347 Indian wheat germplasm lines. GBLUP and RF performed noticeably better than other GS models, with mean predictive abilities of 0.4 and 0.55 for the seedling stage and 0.4 and 0.3 for APR for LR and SR, respectively. Additionally, it was noted that, except for a few environments, the performance of all GP models in the current study is quite low for YR for both seedling and APR. The outcomes of this study show the capability of GP to be applied for breeding initiatives aimed at developing wheat varieties resistant to wheat rust diseases.

Keywords: GEBVs, Genomic prediction, Genomic selection, Leaf rust, Stem rust, Yellow rust

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

sRNAseq identifies known and novel miRNAs in drought tolerance in Black pepper (*Piper nigrum* L.)

Sona Charles*, Priyanka Behera, Fayad, M. A., Krishnamurthy, K. S., Sheeja, T. E. and Johnson George, K.

ICAR- Indian Institute of Spices Research, Kozhikode, Kerala, India-673 012

*sonayuv@gmail.com

Black pepper (Piper nigrum), also known as the "King of Spices" is widely known for its panoply of metabolites with potential medicinal and biological properties. Transcriptome-wide studies on non-coding RNAs will aid in shedding light on the regulatory roles of small RNAs in stress tolerance in black pepper. miRNAs are single-stranded non-coding RNAs with 21-25 nucleotides that regulate port transcriptional gene expression. In this study, the black pepper genotype (IC 317179) was used. Rooted cuttings of the genotype were grown under normal as well as water-stressed (15 days stress by withholding water) conditions. sRNA was isolated from the leaves of both normal and water-stressed plants and the Illumina HiSeq 2000 platform was used for the paired-end sequencing. Raw reads were pre-processed using FASTQC. The reads were aligned with small RNAs from the GenBank database and Rfam database to remove all small RNAs except miRNAs. For the identification of known miRNAs, clean reads were searched against miRBase by alignment with other species. The 31 significantly differentially expressed miRNAs (log fold change |>1| and $p<0.05$) were filtered. Putative targets of miRNAs were also predicted which will be experimentally validated. The target genes were involved in stress and were found to be involved in carbohydrate metabolism, translation, and ribosome biogenesis. The study provides a foundation for understanding miRNA regulation in Black pepper.

Keywords: Black pepper, Novel miRNAs, sRNAseq, Transcriptome

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Genome-assisted breeding for the integration of triple rust-resistant genes to fast-track improvement for disease resistance in Bread wheat (*Triticum aestivum* L.)

Prashanth Babu, H*, Manjeet Kumar, Kiran Gaikwad, B., Naresh Kumar and Rajbir Yadav

ICAR-Indian Agricultural Research Institute, New Delhi -110012

*Prashanth.h@icar.gov.in

It is a very well-known fact that most of the recently released Indian wheat varieties covering large wheat-producing areas have fallen prey to new pathotypes of wheat rusts and hence, alternate resistance sources are very much required in the country, which presses an immediate need to pyramid novel genes into the current cultivars. Genetic resistance is the most cost-effective and durable protection against major diseases in crop plants. The durability of the protection can be achieved by combining more than one gene for resistance against a specific pathogen. The application of fast-track technologies in achieving multiple resistance in a reduced number of reproductive generations will save time and labor. We have used the integrated approaches of genomics, including, tGBS, KASP, and MAS technologies in association with speed breeding to achieve the target in a fast-track manner. The advance backcross lines generated in PBI, Uni Sidney, Australia by crossing of Indian cultivars (PBW550 and DBW17) with donors of *Sr22*, *Sr26*, *Yr57* and Yr47/*Lr52* (Australian origin). The integration lines with two-stem rust (*Sr22* and *Sr26*) and two-stripe rust (*Yr47/Lr52* and *Yr57*) in two Indian common wheat varietal backgrounds were used to develop Nils in the background of two important wheat varieties of India (HD2967, HD 3086). In parallel, a wheat-maize-based DH production technique was used to produce diverse haploid plant profiles having, gene combinations for *Sr26/*PBW550 and *GpcB1*, *Yr57/*DBW17 and *GpcB1*, *Sr22/*PBW550 and *Sr26/*PBW550, *Sr22/*PBW550 and *Yr57/*PBW550and; *Yr47/* DBW17 and *GpcB1 and these are also being used in the integration of triple rust genes in wheat.* The integration of new genes into wheat varieties will increase the income of farmers through improvement in yields due to the resistance to these diseases. In the Indian context, any good quality variety must also have adequate resistance to prevailing diseases and very high yields. Several newly released Indian wheat varieties have become susceptible to new pathotypes of yellow rust and alternate resistance sources are lacking in the country. Therefore, through the present work, we have attempted to develop superior materials through the transfer of diverse sources of rust resistance to Indian bread wheat.

Keywords: Diseases, Genome-assisted, Resistance, Triple Rust, Wheat

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

A comparative study on sugar-related transcripts in sugarcane hybrid, Co 11015, and progenitor species *S. officinarum* and *S. spontaneum*

Afseena Abdul Ameer*, Namrata, P. M., Prathima, P. T.

ICAR- Sugarcane Breeding Institute, Veerakeralam, Coimbatore-641 007, Tamil Nadu, India

*fiyaazwa@gmail.com

Interspecific breeding is an essential strategy in sugarcane breeding programs through which modern hybrids were derived. The 'noble cane', *S. officinarum* is the primary progenitor species that contributes to the high sugar content whereas the 'wild cane' *S. spontaneum* provides stress tolerance and disease resistance to sugarcane. A deeper look into the genetic composition of these progenitor species is highly demanding for a better understanding of their contribution to the modern sugarcane cultivar and also to reflect their importance in future breeding programs. The polyploidy and high complexity of the sugarcane genome necessitate transcriptome analysis as a better option as the complete genome sequence is still unavailable. The transcriptome sequences were generated from the leaf and stem of *S. officinarum* (BC), *S. spontaneum* (SP), and a high sugar variety sugarcane Co 11015, through the advanced Iso seq sequencing technique. The advantage of using long reads is that it avoids assembling which leads to chimeric transcripts in a polyploid species with several homologues. The transcriptomes were analyzed and compared for transcripts that contribute to the synthesis, transportation, and accumulation of different sugars. Most of the sugar-related genes were present in Co 11015 and BC than SP. Different sugars included sucrose, glucose, trehalose, xylulose, galactose, lactose, and mannose altogether contributed to 1033, 839, and 494 transcripts in Co11015, BC, and SP respectively. The major transcript fraction was the sugar transporters with a total of 499, 609, and 267 transcripts present in Co 11015, BC, and SP respectively. The key regulatory enzymes of sucrose metabolism, sucrose synthase (SuSy), sucrose phosphate synthase (SPS), sucrose phosphatase (SPP), and invertase were also profiled. Transcripts of SuSy in BC were the highest (204), followed by Co 11015 (144) and SP (107). There were 113 SPS transcripts, followed by SP (69) and Co 11015 (67). A similar expression pattern was observed for SPP, with BC (23), SP (11) and Co 11015 (6). However, invertase was the highest in Co 11015 (95) among the three genotypes studied. Tracing back into the sub-genomic origin of sugarcane will help decipher valuable information for targeted breeding and gene editing approaches in sugarcane.

Keywords: Iso seq sequencing, Sugarcane, Transcriptome

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Validation of KASP markers associated with foliar blast resistance in Pearl millet delineated through GWAS and biparental mapping approaches

Mukesh Sankar, S.[1,6*], Singh, S. P.[1], Srivastava, R. K.[2], Prakash, G.[1], Soumya, S. L.[1], Arun Kumar, M. B.[1], Kapoor, C.[1], Hossain, F. A.[1], Rao, R.[3], Mithra, A.[4], Singhal, T.[1], Mallik, M.[1], Tara Satyavathi, C.[5], and Aravind, J.[7]

[1]ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi, India
[2]International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Telangana, India
[3]ICAR-Indian Agricultural Statistical Research Institute, Pusa Campus, New Delhi, India
[4]ICAR-National Research Centre on Plant Biotechnology, Pusa Campus, New Delhi, India
[5]ICAR- All India Coordinated Research project on Pearl Millet, Jodhpur, India
[6]ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India
[7]ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi, India

*mukesh.genetics@gmail.com

Foliar blast (FB), aka leaf spot caused by the fungus *Magnaporthe grisea*, has emerged as a formidable menace to the cultivation of pearl millet (*Pennisetum glaucum* L. Br.) hybrids and parental lines, severely impacting both forage and grain production. Despite the presence of a vast reservoir of genetic variability against FB, concerted endeavors to systematically discern and map novel resistance genes have been conspicuously poor. In our investigation, a GWAS panel of 250 accessions was evaluated across seven distinct environments under natural epiphytotic conditions. The disease scores were recorded on per 0-9 scale, across all seven environments. Single nucleotide polymorphism (SNP) genotyping based on the genotype-by-sequencing (GBS) approach resulted in 71,783 good-quality SNPs employed in a genome-wide association study (GWAS), aimed at discerning genes/alleles associated with FB resistance. The magnitude of each association was gauged by the proportion of variation explained (r^2) by the marker, employing a threshold of $-\log_{10}$ p-value > 5.00. A strikingly consistent association with FB resistance was observed for an SNP situated on Chromosome 3. Meticulous examination of upstream and downstream regions encompassing a +2 kb window around the SNP loci facilitated the unearthing of putative candidate genes encoding Fbox-LRR proteins. The validity of genes toward FB resistance reaction is further confirmed by the qRT-PCR method. Substantiating expression studies effectively validated the SNP among the resistant genotypes, culminating in the development of KASP markers validated in mapping populations involving contrasting parents. This ground-breaking report marks the pioneering endeavor to delineate the genes intricately involved in the Pearl millet-Magnaporthe interaction.

Keywords: Foliar blast disease, GBS, GWAS, KASP marker, MAS, Millet

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Genome-wide SNP discovery and annotation in the Gir breed of cattle

Raja, T. V.[1*], Alex, R.[2], Singh, U.[1], Kumar, S.[1], Singh, A. K.[1], Rani, C. and Das, A. K.[1]

[1]Molecular Genetics Laboratory, Cattle Genetics and Breeding Division, ICAR-Central Institute for Research on Cattle, Meerut Cantt, Uttar Pradesh, India
[2]ICAR-National Dairy Research Institute, Karnal, Haryana, India

*venkatesanraja09@gmail.com

Gir is a potential milch breed of cattle in India found mainly in the Saurashtra region of Gujarat. The Gir breed has the genetic potential for higher milk production along with other qualities like low nutritional requirement, and resistance to tropical climatic conditions and diseases. The genetic improvement of Gir cattle is essentially required to increase its milk production potential. The marker-assisted breeding through the use of genomic markers is promising in improving the productivity of cattle. The Single nucleotide polymorphism (SNP) is one of such potential markers used nowadays in the selection program as they explain the genetic variations at the nucleotide level of the genome. The SNPs can be identified through sequencing of the genome. The double digestion restriction site associated DNA (ddRAD) sequencing method is one of the cost-effective reduced representation methods used to infer the genetic diversity and population structure through the identification of SNPs. The study aimed to identify and annotate the SNPs in Gir cattle using the ddRAD sequencing technique. A total of 1939949 SNPs were identified at RD10 and Q30 concerning the *Bos taurus* reference genome. The SNPs were annotated for their location, impact, and functional class. A total of 3047179 effects were identified and the majority of them (48.71%) were in the intron region of the genome followed by intergenic (41.95%). The majority (99.27%) of the variants had the modifier effect. The results revealed a higher magnitude of transitions (70.79%) as compared to the transversions (29.21%) with a transition transversion (Ts/Tv) ratio of 2.42. The classification of SNP by functional class revealed a majority of silent (58.07) and missense (41.01%) effects. Out of 24995 genes identified, 627 SNPs were annotated in 212 candidate genes responsible for various milk production and reproduction traits. The results revealed that identified SNP variations can be used as markers for efficient identification of the QTLs in Gir cattle which may aid in bringing genetic improvement in Gir cattle.

Keywords: Genome-wide SNP discovery, Gir cattle, QTL identification, Selection

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Artificial Intelligence for CRISPR/Cas9 off-target prediction in crop plants

Abhishek Anand, Chandini, B. C., Jutan Das, Sudhir Srivastava, Mishra, D. C. and Sanjeev Kumar*
ICAR-Indian Agricultural Statistics Research Institute, PUSA, New Delhi
*sanjeev.kumar@icar.gov.in

Gene editing allows us to modify organisms at the genome level enabling us to control their phenotypic traits. CRISPR-Cas9 is one such technology that has surpassed all the existing technology for gene editing. It is an RNA-mediated nuclease genome editing system. Its mechanism replicates the naturally occurring immune defense system of bacteria but the same technology can be adapted to modify eukaryotic genes as well. However, off-target cleavage is one of its major challenges preventing its application in the real world because of its detrimental effect on the target organism. Several techniques have been developed to predict off-target in CRISPR-Cas9 like *in vivo*, *in vitro* and *in silico* techniques but these techniques are costly, labor-intensive, and time-consuming. However, *in silico* off-target predictions are possible through the use of data from previously conducted *in vivo* and *in vitro* experiments by modeling the relationship. Though different *in silico* off-target prediction techniques have been developed in the recent past, tools based on Machine/Deep Learning/ Artificial Intelligence have gained popularity. They have overshadowed the tools based on the traditional alignment approach in terms of accuracy in predicting CRISPR-Cas9 off-targets. However, most of these developed tools have used data either from human or animal genomes for model development. The present work explored the possibility of modeling off-target prediction using crop plant data exclusively. The study also examined the applicability of such ML/DL/AI-based off-target prediction models in the case of plants and exhibited improved performance. To facilitate the end use, a web-based online tool, named IASRI-CRISPR (i-CRISPR), has been developed to predict off-targets in plants using these ML/DL/AI-based models. The current study showed how machine learning and deep learning approaches might be better used for off-target prediction in the CRISPR-Cas9 system of gene editing and genome editing, exclusively for plant genomes.

Keywords: Artificial intelligence, CRISPR-Cas9 gene editing, Machine learning, Off-target prediction

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

CRISPR/Cas9-RNP-Mediated MSTN gene editing in buffalo fibroblasts: Unlocking growth potential for enhanced meat production

Dharmendra Kumar*, Meeti Punetha, Sheetal Saini, Surabhi Sharma, Renu Bala, Swati Thakur, Pradeep Kumar, Sharma, R. K., Yadav, P. S. and Datta, T. K.

ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana-125001, India

*dharmendra.kumar@icar.gov.in

The myostatin (MSTN) gene plays a crucial role in regulating skeletal muscle growth, with mutations in this gene often leading to a double-muscular phenotype in farmed animals, thereby holding significant potential for enhancing meat production. However, limited research has been conducted on water buffaloes (*Bubalus bubalis*) in this context. In this study, we employed the CRISPR/Cas9 ribonucleoproteins (RNPs) gene-editing system to target the MSTN gene in buffalo fibroblast cells. To achieve this goal, we employed lipofection and nucleofection delivery methods to target the MSTN gene in buffalo fibroblasts. For this, we compared the cell viability and transfection efficiency of both delivery methods using flow cytometry and Sanger sequencing. The cell viability and transfection efficiency were found to be significantly ($p<0.05$) higher in nucleofection compared to lipofection. We also analyzed the mutation rated using tracking of indels by decomposition (TIDE) software and found that the editing efficiency was significantly ($p<0.05$) higher in nucleofection (52.4%) as compared to lipofection (8.1%). Using nucleofection, we generated MSTN edited fibroblast colonies which were further analysed for the functional characteristics *in silico* which revealed that the edited cell lines were non-deleterious. These results indicate that nucleofection is a more efficient method to deliver RNP in buffalo fibroblasts for MSTN-RNPs delivery. The methods described here should broaden the accessibility of RNP-mediated nucleofection for laboratory genome-editing experiments. This study not only advances our understanding of CRISPR/Cas9 RNP delivery techniques but also contributes valuable insights into the potential for MSTN gene knockout in buffalo, offering promising prospects for the enhancement of meat production in this economically important livestock species.

Keywords: Buffalo fibroblasts, CRISPR/Cas9-RNP-Mediated gene editing, Gene knockout, Myostatin gene

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Genetic analysis of pre-weaning growth rate and efficiency-related traits in inter-cross sheep

Abdul Rahim, Rajni Chaudhary* and Pourouchottamane, R.

ICAR-CSWRI, North Temperate Regional Station, Garsa, Kullu (H.P.)175141, India
*choudhary633@gmail.com

Growth performance traits are primarily expressed and described by body weight and growth rate. Evaluation of the population under selection for economic traits in every generation is essential as it is a pre-requisite for deciding and formulating effective breeding strategies. Since individual sheep differ in their efficiency in utilizing feed, selecting the most efficient animals, those with lower maintenance requirements, results in a significantly lower production cost. Inter-cross sheep is a dual-purpose synthetic sheep (fine wool and mutton production) with 75% exotic inheritance and is well adapted to the sub-temperate Himalayan region of Himachal Pradesh. The present investigation was carried out to analyze the growth rate and efficiency-related traits of intercross sheep developed and maintained at North Temperate Regional Station, ICAR-Central Sheep and Wool Research Institute, Garsa, Kullu (Himachal Pradesh), India. Early growth traits *viz.,* birth weight (BW) and weaning weight (WW) of 1891 lambs born between 2012-2023 were recorded. Efficiency-related traits *viz.,* pre-weaning average daily gain (PADG), pre-weaning Kleiber ratio (PKR), pre-weaning growth efficiency (PGE), and pre-weaning relative growth rate (PRGR) from birth to weaning were calculated. Data were analyzed by least-squares analysis of variance (Harvey, 1990) taking sire as a random effect, whereas lambing year, parity of dam, genotype, sex, and birth status of lambs were considered as fixed effects. Dam weight at lambing was used as a covariate effect in the statistical model. Least square ANOVA revealed a significant influence of sire, lambing year, and birth status (single/twin) on all the studied traits. However, the genotype of sheep had a non-significant effect on all traits. The sex of the lamb had a significant effect on BW, WW, PADG, and KR where males recorded significantly higher values as compared to females. The overall least squares mean of BW, WW, PADG, PKR, PGE, and PRGR were 3.29±0.04 kg, 15.08±0.25 kg, 130.55±2.67 g, 16.96±0.15, 353.23±7.41 and 1.65±0.02, respectively. The corresponding heritability estimates were 0.19±0.06, 0.20±0.06, 0.21±0.06, 0.16±0.06, 0.22±0.07 and 0.19±0.06, respectively. Genetic and phenotypic correlations among body weights were low to moderate and positive. BW was negatively correlated with all the efficiency-related traits. The genetic and phenotypic correlation among efficiency-related traits was high and positive. The moderate heritability estimates for weaning weight and its positive association with other growth efficiency-related traits indicated that selection based on weaning weight could be used as selection criteria for the improvement of efficiency-related traits in inter-cross sheep.

Keywords: Average daily gain, Body weight, Efficiency-related traits, Growth rate, Kleiber ratio

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Advances in Genomics and CRISPR-Cas Systems for Crop Improvement

Molecular cytogenetic analysis to unravel the genome architecture of modern sugarcane cultivars

Sobhakumari, V. P.*
ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India
*vpsobhakumari@rediffmail.com

Modern sugarcane cultivars are derived from the hybridization between *Saccharum officinarum* (2n=80) x *Saccharum spontaneum* (2n=40-128), leading to a variety of complex genomes with highly polyploid and varied chromosome structures. Although classical cytological studies in sugarcane allowed a better understanding of the sugarcane genome, molecular cytogenetic methods led to important breakthroughs, not only revealing the level of the complexity of modern sugarcane cultivars but also unraveling the taxonomy of the *Saccharum* genus. Modern sugarcane cultivar is one of the most difficult species to work with on a genetic and molecular level. High homology between the species needs special attention in the optimization of conditions for molecular cytogenetic technique. Using comparative genomic *in situ* hybridization (GISH) we demonstrated that it is possible to distinguish the chromosomes contributed by different species in F1 interspecific hybrids and cultivars of sugarcane. We analysed two interspecific F1 hybrids between the basic species *S. officinarum* x *S. spontaneum* and observed n+n and 2n+n segregation respectively. Two tropical varieties (CoJ 64 and Co 0238) and four subtropical varieties (Co 86032, Co 7201, CoC 671, and Co 11015) were subjected to classical as well as molecular cytogenetic analysis. The somatic chromosome is determined for all the varieties. GISH analysis with *S. spontaneum*-specific probe revealed that the genome of studied modern sugarcane cultivars consists of 10-23% of entire chromosomes from *S. spontaneum* (wild species) and 9-13% chromosomes derived from interspecific recombination. The diverse type of chromosome combinations in sugarcane cultivar infers that the hybrid gametes of *S. officinarum* and *S. spontaneum* may form unusual chromosome pairs including homoeologous or non-homoeologous chromosomes either between or within *S. officinarum* and *S. spontaneum*. Although classical cytological studies in sugarcane provide a better understanding of the polyploidy genome, molecular cytogenetic methods lead to important breakthroughs in revealing the genome complexity of modern cultivars.

Keywords: Genomic *in situ* hybridization (GISH), Interspecific hybridization, *Saccharum officinarum*, *Saccharum spontaneum*, Sugarcane varieties

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Application of CRISPR-Cas Systems for Crop Improvement and Sustainable Development

CRISPR Cas9-based starch modifications in cassava paving way to futuristic-based industries

Krishna Radhika, N.*, Sheela, M. N., Asha, K. I., Shirly Raichal Anil, Sreekumar, J. Senthilkumar, K. M., Prakashkrishnan, B. S. and Maria Joji

ICAR–Central Tuber Crops Research Institute, Sreekariyam, Trivandrum–695 017, Kerala, India

*Krishna.RN@icar.gov.in, krishna.rn@gmail.com

CRISPR Cas9 technology is a fast and cost-effective technology for bringing out precise genetic modifications within in short period. A CRISPR Cas9-based approach has been adopted to bring out genetic modifications in cassava to alter the ratio of amylose and amylopectin to make it a suitable raw material for starch-based industries. Native starch is composed of mostly amylopectin and nearly 20% amylose. The current status of the starch industry in India is that we are importing starch from Thailand, Vietnam, and Cambodia. India is also exporting starch to various countries including South Africa. This indicates that there is a specialized need for various starch-based industries, which work by altering the starch composition to get novel starch that suits various industrial requirements. The development of modified starches will reduce the excessive use of chemicals and thereby environmental pollution. Cassava, *Manihot esculenta* Crantz, is a perennial crop, grown specifically for its starch content. High amylose starch from cassava can be developed through gene editing and will be an industrial raw material and an alternate source for starch from maize, potatoes and cereals. Starch modified with no amylose in starch is waxy starch suited for adhesive making, corrugated paper making, photographic film making, and many other industries. High amylose starch is preferred to make biodegradable plastic and biofilm making. In addition, high amylose starch is a resistant starch that has a significant role in improving human gut health. It acts as a prebiotic and also it is the type of starch that can be consumed by diabetic patients. The availability of complete genome sequences and standardized transformation protocols in cassava makes it feasible to develop gene editing constructs that can effectively transform cassava and generate modified starch *in planta*. The paper describes the designing of a GBSS silencing construct targeting the silencing of amylose synthesis in cassava.

Keywords: Bio-based industries, Cassava, CRISPR Cas9, GBSS, Starch, Resistant starch, Waxy starch

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Application of CRISPR-Cas Systems for Crop Improvement and Sustainable Development

CRISPR/Cas9-mediated lignin modification in sugarcane towards improved lignocellulosic biofuel production

Lakshmi, K.[1*], Prathima, P. T.[1], and Appunu, C.[2]
ICAR-Sugarcane Breeding Institute, Coimbatore
*K.Lakshmi@icar.gov.in

Lignocellulosic biomass consists of cellulose and hemicellulose, the main source of sugar for biofuels production. However, utilization of sugar is restricted due to the protective coverage of lignin. The saccharification process is affected by high syringyl to guaiacyl (S/G) ratio in the bagasse. We have identified Ferulate 5 Hydroaxlase (F5H) and cinnamyl alcohol dehydrogenase (CAD) as the potential targets in synthesis of syringly monomeric units. The sequence of F5H was submitted in CRIPOR. It showed 366 possible guide sequences. One 20-bp sequence followed by a trinucleotide (50 -NGG-30) protospacer adjacent motif (PAM) located in the second exon region of F5H was selected as the sgRNA complementary site. Two guide RNA sequences were chosen for F5H gene and oligonucleotides were synthesized. This sgRNA is cloned in pGREB31 vector using *Bsa*I restriction digestion. The sgRNA cloned vector was transformed into DH5α and the cloning was confirmed through sequencing. The confirmed CRISPR vector was mobilized into agrobacterium (LBA4404) through freeze thaw method. Later plasmid DNA (pGREB31::F5H) was isolated from agrobacterium and confirmed through PCR. These cultures are being used for sugarcane transformation. Sugarcane leaf whorls are being excised and placed in callus induction media in dark. After a period of 4 to 5 weeks the embryogenic call was co cultivated with agrobacterium harbouring CRIPR CAS Constructs for lignin modification. After co-cultivation the calli is placed in regeneration medium with Hygromycin for selection of transformants. As a proof of concept, F5H gene was sub-cloned into the pCAMBIA 1305.1 binary vector. And used for the genetic transformation of tobacco plants. The transgenic tobacco plants were analysed for the expression and the copy number was calculated. The F5H gene copy number was quantified using the absolute quantification method. The reference curve with the plasmid DNA of F5H has been generated to calculate the copy number of the genes in varying tissues. A 10-fold diluted F5H plasmid ranging from 1×10^5 to 1×10^9copies l^{-1}, and the Ct values of the corresponding plasmid DNA was used to calculate the slope-intercept form. The slope value was -3.22 which falls under the range of–3.1 ≤ slope ≤–3.6. The copy number of the transgene F5H was 5985.31 in transgenic, while in wild type it was 1307.47. Our results showed that the transgenic tobacco plant showed a 4.5-fold increased expression in comparisons to the wild type. The tobacco transgenic plant was used for the functional characterization of F5H gene.

Keywords: Bioenergy, Genome editing, Lignin, Plant cell wall, Sugarcane

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Application of CRISPR-Cas Systems for Crop Improvement and Sustainable Development

Delineating the molecular pathway of pretermination of sex in buffalo using CRISPR/Cas9

Meeti Punetha*, Dharmendra Kumar, Sheetal Saini, Surabhi Sharma and Yadav, P. S.
ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana-125 001, India
*meetipunetha283@gmail.com

Sex determination is the process through which a bipotential gonad develops into a testis or ovary depending on the genetic background of the individual. The early developmental events that determine male-specific gonad formation are initiated by the expression of SRY. Nuclear translocation of the SRY protein and, subsequently, of SOX9 (an SRY downstream effector) diverts the fate of somatic cells in primordial gonads from the ovarian pathway towards testicular differentiation. To investigate the molecular regulation of the sex determination process in buffalo, we used the loss of function approach using the CRISPR-Cas9 strategy. In the present study, SRY-knockout (SRY-KO) embryos were generated by electroporating RNP targeting the HMG domain of SRY at a single stage using an optimized protocol. The presumed KO male embryos were confirmed by using Sanger sequencing. The control male, female, and SRY-KO embryos were subjected to analysis of the downstream pathway of sex determination by using real-time analysis. *In silico* analysis revealed that mutations in the SRY gene altered the functional properties of the SRY gene and its interaction network with other genes (Sox9, Foxl2, β-catenin, Amh, FGF9, PGD2, WNT4, and DMRT1). To determine the impact on protein structure and function of these mutations in SRY protein, HOPE server was used and the analysis showed that selected mutations were located in functionally important regions and were shown to change protein–protein interacting interfaces. Thus, the prediction of these protein-protein interactions demonstrated how SRY interacts with other related genes and its importance in various pathways. Thus, the present study will help in delineating the molecular pathway for sexual determination in buffaloes.

Keywords: Buffalo, CRISPR/Cas9, Embryos, SRY

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Application of CRISPR-Cas Systems for Crop Improvement and Sustainable Development

TALEs are virulence factors of pomegranate bacterial blight

Ginny Antony* and Sruthi Sivaraman
Central University of Kerala, Periye, Kasaragod-671 320, Kerala, India
*ginnyantony@gmail.com

Bacterial blight of pomegranate is a major constraint for pomegranate production in India. This disease is caused by *Xanthomonas citri* pv. *punicae* (*Xcp*) and affect all ariel parts of the plant with 60-80% losses. Transcription activator-like effectors (TALEs) encoded by *tal*genes play critical roles in the pathogenesis of most Xanthomonads. This study employed transcriptomics to identify TALE targeted host genes. Further, we have generated TALE mutants which fail to induce any symptoms on the plants or are weakly virulent. These mutants also failed to induce the expression of the predicted targets, indicating the possibility that these genes may be susceptibility factors. Promoter analysis using GUS reporter indicate that one of the TALE directly bind to the promoter of 2 oxoglutarate dioxygenase. The data from our study suggest the role of TAL effectors in modulating host susceptibility in pomegranate, which can be used to develop better control strategies for pomegranate bacterial blight.

Keywords: Bacterial blight, Pomegranate, TALEs, Virulence factors

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Application of CRISPR-Cas Systems for Crop Improvement and Sustainable Development

Unraveling the genetic gain trends in Basmati rice over 37 Years: Insights from historical data for grain yield and quality

Pallavi Mohanapure, Ranjith Kumar Ellur*, Pramod Pimpale, Meghraj Chavhan, Manoj Gowda, M., Shiwkumar Prajapati, Dheeraj Rana, Fiyaz R. A., Vinod, K. K., Gopala Krishnan, S., Prolay Kumar Bhowmick, Haritha, B. and Singh, A. K.

ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India

*ranjithellur@gmail.com

Basmati rice is considered the 'Queen of Fragrance' due to its appealing aroma and exquisite quality parameters. The systematic genetic improvement program has significantly improved the yielding ability as well as quality parameters such as cooked kernel length. Several high-yielding varieties including Pusa Basmati 1, Pusa Basmati 1121, Pusa Basmati 6, Pusa Basmati 1509, and Pusa Basmati 1692 were released for commercial cultivation. The cooked kernel length of 20 to 22 mm in the new varieties has attracted global consumers creating tremendous demand in the international market. Indian Basmati rice exports surged up to the tune of 4.8 mt worth US$ 4.78 billion during the year 2022-23 with equal volume traded in the domestic market. These varieties have improved the livelihood of millions of farmers, millers, exporters, and all the stakeholders in the Indo-Gangetic plains of India. However, evaluating the breeding programs is of utmost importance to understand the current rate of genetic improvement. This helps us in setting the baseline while preparing to re-orient the breeding program based on the targets. The current study investigated the genetic improvement of Basmati rice that has been achieved from 1985 to 2022. We evaluated 37 years of historical data generated in the multi-location traits conducted under the All India Coordinated Rice Improvement Project. Overall, 540 trials conducted across 12 locations generated 18,718 data points. A total of 1193 breeding lines and 6 checks (PB1, PB1121, TB, PRH10, PB6, and PS5) were evaluated in 2 to 3 replications under irrigated conditions. A two-step mixed model analysis was carried out, wherein, in the first step BLUEs were generated and in the second step the genotypes were considered random and a pedigree-relationship matrix was used to generate estimated breeding values (EBVs). The regression of EBVs over a year of testing deduced the annual genetic gain to be 0.19%, while that for cooked kernel length was 0.56%. The results indicated that there has been a significant focus on improving the cooked kernel length in the breeding programs as it is the unique selling proposition of Basmati. However, re-orienting the breeding program to achieve better genetic gains for yield without compromising the cooked kernel length is essential. In this direction, a core set of Basmati breeding lines has been identified and improved lines are being developed through a modified breeding pipeline implemented with genomic selection. This approach ensures making informed decisions while realizing the improved annual genetic gains.

Keywords: Basmati rice, Cooked kernel length, Estimated breeding values, Genetic gain, Genomic selection, Yield, Quality

Theme: Frontier Science and emerging genetic technologies: Genome Breeding, Gene Editing
Sub theme: Genome Editing: IPR Policy for Product Development and Socio-economic Considerations

Patents, technology licensing and inclusive innovation for access and commercialization of technology: The case of CRISPR Cas9

Poonam Jayant Singh*
ICAR- National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh, India
*Poonam.jayant@icar.gov.in, poonamjayant@gmail.com

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is a powerful foundational genome editing technology in the hands of researchers for unforeseen possibilities of cure in health, industrial biotechnology, and agriculture. The social, legal, and ethical concerns regarding the patents associated with CRISPR Cas and their licensing to avoid patent thickets are looming. The legal patent war surrounding CRISPR Cas could be transformed by inclusive innovation and creating a patent pool or Joint Licence Framework for furthering innovation and breakthroughs in the gene editing domain. The major application of CRISPR is projected to increase the productivity of agriculture, animal husbandry, and fisheries sectors. However, ethical and social concerns will loom looking into regulation in the gene editing sector. Patents associated with CRISPR were mined to get insights into the technological domain and understand companies and competition in the field. A total of 11,675 patents were mined with technology dominated by the Massachusetts Institute of Technology, CRISPR Therapeutics, The Broad Institute, President and Fellows of Harvard College, Editas Medicine, and The Regents of the University of California. The dominant IPC class were C12N, A61K, C07K A61P, A01H and A01K. Feng Zang the inventor has 678 patents filed. The invention was developed by publicly funded Universities and licensed by some as exclusive to companies. Broad Institute through Addgene uses UBMTA (Uniform Biological Material Transfer Agreement) for academic and non-profit research without written approval for further transfer among academia. Patents create monopoly and technology blockage and hindrance to the commercialization of technology. Technology commercialization for foundation technologies needs regulation by the government to foster innovation and for the growth of the technology. Open licensing for research by academia, and creating patent pools and consortia for technology can be some ways for inclusive innovation. The landscape of patents of CRISPR is complex and needs simplification of policy and government regulation to foster innovation.

Keywords: CRISPR Cas, Genome editing, Intellectual Property Rights, Patent

XII AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 4

Livestock-based Transformation of Food Systems

Towards livestock production sector transformation

Livestock Products, Health and Support Sciences

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Genetic analysis of variability and associations of fertility and production traits in crossbred cattle of Kerala using multi-trait models

Jamuna, V.*, Tina Sadan, Anilkumar, K., Venkatachalapathy, T. and Aravindakshan, T. V.

Centre for Advanced Studies in Animal Genetics and Breeding, Kerala Veterinary and Animal Sciences University, Thrissur-680 651, Kerala, India

*jamuna@kvasu.ac.in

The major objectives of the present study were to estimate genetic parameters and to identify the candidate genes associated with fertility and production traits using multi-trait animal models. Data of about 1180 crossbred cattle sired by 208 Frieswal bulls, spread over a period from 2003 to 2022, maintained at different farms of Kerala Veterinary and Animal Sciences University and field centres of ICAR-Filed Progeny Testing Scheme, were analysed in the study. Major fertility traits considered were daughter pregnancy rate (DPR), service period (SP), and age at first calving (AFC). The lactation milk yield (MY) was considered as the production trait. Covariance components and genetic parameters of traits were estimated using multi-variate models of restricted maximum likelihood (REML) approach. It was observed that DPR had low heritability (0.092 ± 0.03), compared to MY (0.170 ± 0.094). Phenotypic (rp), genetic (rg) and residual (re) correlation indicated unfavourable association of fertility with production traits. The results indicated that DPR was having lower direct additive (σ^2 a) 0.046 and environmental variance (σ^2e) 0.063 compared to other traits. The highest additive genetic variance (σ^2 a) of 27035.8 was obtained for MY. Genetic variants were identified using PCR Single stranded Conformation Polymorphism (SSCP). Important genes considered in the study were *CAST, CD14, FSHR, POU1F1, STAT5A, TLR4, MFGE8, B4GALT1, PRL* and *PPP1R11*. All the genes except *PRL, MFGE8* and *PPP1R111* were polymorphic and a total of ten SNPs were detected, of which two each were found in *CAST, B4GALT1* and *CD14*, one each in *FSHR, STAT5A, TLR4* and *POU1F1*. Association analysis revealed that *B4GALT, STAT5A, TLR4,* and *POU1F1* genes could be used as genetic markers for production traits, and *CD14, FSHR,* and *CAST* genes could be used as genetic markers for reproduction traits. The study suggested the importance of fertility as an indirect measure along with production traits in multi-trait animal models, including genetic variants for the evaluation and selection of cattle for better performances.

Keywords: Associations, Crossbred cattle, Fertility, Production, Muti-trait models, Polymorphisms

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Genetic evaluation of Frieswal cattle under marginal production system

Das, A. K.[1*], Ravinder Kumar[1], Umesh Singh[1], Sushil Kumar[1], Raja, T. V[1]. and Anil Kumar K[2]

[1]ICAR-Central Institute for Research on Cattle, Meerut.-250 001, Uttar Pradesh, India
[2]Kerala Veterinary and Animal Science University (KAVASU), Thrissur-680 651, Kerala, India

*achintya137@yahoo.com, achintyadasak@gmail.com

The investigation was undertaken to determine the genetic worth of Frieswal crossbred cattle young bulls through a field progeny testing (FPT) project under AICRP on cattle in field conditions in Kerala State, India. The FPT project was initiated at Kerala Veterinary and Animal Science University (KVASU) in 1992. The first set of 12 test bulls was inducted in January 1992. A total of 339 Frieswal bulls have been inducted in 17 different sets since inception. A total of 145752 artificial insemination (AI) has been done, out of which 100551 AI was followed and 41083 pregnancies were confirmed, leading to an overall 41% conception rate. A total of 65 Frieswal bulls were evaluated based on 1037 first lactation records of their daughters calved over 15 years from 1995 to 2010. The average breeding value for the first lactation 305-day milk yield was estimated at 2229.19 ± 50.91 kg with a range of 2193.74 ± 66.59 to 2280.62 ± 66.59 kg. Out of 65 bulls inducted in 7 different sets, 33 bulls (50.7%) had breeding values higher than the herd average (2229.19 kg). The number of daughters per bull varied from 7 to 51, whereas the average number of daughters per bull was 16. The genetic superiority and percentage genetic superiority of the top 25 bulls (38.46%) over the population ranged from 6.26 to 51.43 and 0.28 to 2.30, respectively. The least squares analysis of variance revealed that the year of calving significantly affected the first lactation milk yield of daughters. The increasing trend of first lactation milk yield over the year/bull set observed in the present study indicates the successful implementation of a large-scale field progeny testing programme under field conditions.

Keywords: Field progeny testing, First lactation milk yield, Frieswal, Genetic evaluation

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Field progeny testing of Frieswal bulls–An important tool for genetic improvement of cattle in the existing scenario

Ravinder Kumar*, Das, A. K., Umesh Singh, Sushil Kumar and Raja, T. V.

ICAR-Central Institute for Research on Cattle, Grass Farm Road, Post Box No.17, Meerut Cantt.- 250 001, U.P., India

*ravinder774@gmail.com

The Field Progeny Testing (FPT) program is the only reliable available option in the Indian situation for the genetic improvement of crossbred animals in rural areas. A mega project on FPT was initiated during the mid-eighties by the ICAR-Central Institute for Research on Cattle (ICAR-CIRC), Meerut, in collaboration with SAUs and NGOs. The technical program envisaged testing 30 Holstein-Friesian (HF) crossbred bulls in each batch having 50-75% exotic inheritance and the dam's mature equivalent milk yield of a minimum of 4500 kg. The bull–dams should be of good conformation. A bull set of thirty young Frieswal crossbred bulls were introduced at 15-18 months. The target was to record at least 40 daughters per bull spread over 04 units. So far, 334 young Frieswal bulls (cross of HF X Sahiwal) have been put under test mating in 16 different sets. Daughters born up to the 13th set of bulls have completed their first lactation 305 days milk yield and have been evaluated. A total of 513134 artificial inseminations (AIs) were done under the project, of which 453204 AIs were meticulously tracked, and 206215 pregnancies were confirmed, amounting to an overall conception rate of 48.15%. About 65361 female calves were born, of which 19365 reached age at first calving, till 2022. Since the inception, 247 bulls have been evaluated based on 11191 daughters' first lactation 305-day milk yield records showing an increasing trend in breeding values from the first set (1958.0 ±26.90) to the last evaluated set (3360.95±44.56). Through the intervention of the FTP, the average first lactation 305 days milk yield of the Frieswal progenies in the adopted villages of the FPT project has been increased by 76.29% in KVASU, 43.80% in GADVASU, 21.40% in BAIF and 44.30% in GBPUA&T unit. The average age at first calving (AFC) of the Frieswal progenies has been reduced by 13.80% in KVASU, 19.80% in GADVASU, 1.60% in BAIF and 12.80% in GBPUA&T unit. The project objective is successfully achieved through the genetic improvement of crossbred cattle maintained by the farmers in terms of increase in milk production and decrease in age at first calving, resulting in improved economic status of small, marginal and landless farmers in the villages.

Keywords: Age at first calving, Breeding value, Field progeny testing, Frieswal, Genetic improvement

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Whole genome sequencing and analysis of Vechur cattle

Poorvisha, V. M., Shivani Kumari.*, Rajesh Vakayil Mani, Manpreet Kaur, Balu Bhaskar, Rajeev Raghavan Pillai, Thankappan Sajeev Kumar, AnilKumar, T. V. and Sadananda Singh, N.**

[1]Indian Institute of Science Education and Research, Thiruvananthapuram, Maruthamala P.O., Vithura, Thiruvananthapuram-695 551, Kerala, India

*shivanikiphd21@iisertvm.ac.in, **nssingh@iisertvm.ac.in

The dairy and meat industry contribute significantly to the nutritional needs and economy. There are well-established high milch breeds of cattle *viz*., Holstein Friesian (HF), Jersey and Brown Swiss. However, the performance and fitness, including disease resistance of the breed, depend on the response and adaptation to the geographical, management and local climatic conditions. Understanding genetic factors and variants would help to select or develop improved and adapted high-yield synthetic crossbreeds. It is well established that native tropical breeds show high resistance to infections like *M. bovis*, parasitic diseases and tolerance to heat and adverse climatic effects. Therefore, genomic studies of the native breeds become crucial to understand the genetic basis of disease resistance and heat tolerance. In this study, we have conducted genome sequencing of Vechur cattle, a native breed of Kerala, south India. We carried out genome sequencing of the Vechur genome on both short-read Illumina and long-read nanopore platforms. Using these data, we carried out hybrid *de novo* genome assembly. We also carried out short-read whole genome sequencing of the dam and sire. Using the trio-binning method, we could build a haplotype-resolved genome of the Vechur cattle. PCA plot analysis, phylogenetic analysis, and admixture analysis of these genomes established that Vechur is an indicine bovine breed.

Keywords: *De novo* genome assembly, Genome sequencing, PCA plot, Trio binning, Vechur

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Rumen fermentation profile and faecal microbiota altered in response to electrohydrodynamically encapsulated probiotics in indigenous cattle calves

Vinay, V. V. and Sachin Kumar*

Rumen Biotechnology Lab, Animal Nutrition Division, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India

*arensachin@gmail.com

Early microbial colonization is a determinant factor in animal health, and probiotic administration has been demonstrated to modulate intestinal microbiota and promote health in young calves. This study aimed to evaluate the influence of encapsulated, lyophilized, and fermented milk using *Lactobacillus* strains on rumen fermentation profile, faecal microbiota, and the overall health status of indigenous calves. Forty indigenous calves, 5-10 days old were randomly assigned into five treatment groups based on body weight (5–10 days old; 24.86 ± 0.22 kg). The calves were fed the basal diet with respective supplementation as follows: Group I (CT)–no supplementation; Group II (AT)–supplemented with antibiotic chlortetracycline (55 mg kg^{-1} of calf starter); Group III (FM)–supplemented with milk fermented with probiotics (*L. plantarum* CRD7 and *L. rhamnosus* CRD11) @ 100 ml d^{-1} $calf^{-1}$; Group IV (LP)–supplemented with lyophilized probiotics (1 g d^{-1} $calf^{-1}$); Group V (EP)–supplemented with encapsulated probiotics (1 g d^{-1} $calf^{-1}$) having 1x109 CFU g^{-1} of both *L. plantarum* CRD7 and *L. rhamnosus* CRD11, respectively. At the end of the trial, faecal samples were randomly collected from 4 calves per group for analyzing the bacterial community by high-throughput sequencing. Rumen fluid was also collected from calves. The results revealed that the ruminal concentration of SCFA and population of *Lactobacillus* and *Bifidobacterium* were significantly higher ($p<0.05$) in the probiotic-fed group with a concomitant reduction ($p<0.05$) in pH and *E. coli* population. Moreover, metagenomics insights of faecal samples revealed that the relative abundance of *Lactobacillaceae* was significantly higher in probiotic-supplemented calves than in the control calves. It is concluded that the administration of probiotics significantly improved gut health by modulating the intestinal microbiota of indigenous calves.

Keywords: Calves, Gut health, Metagenomics, Probiotics, Rumen fermentation

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Genetic evaluation of Gir bulls for first lactation milk yield through associated herd progeny testing programme

Umesh Singh*, Raja, T. V., Savaliya, B. D. and Solanki, G. B.

ICAR-Central Institute for Research on Cattle, Meerut-250 001, Uttar Pradesh, India

*usinghas@gmail.com

Gir cattle is one of the important indigenous dairy breeds of the country known for higher milk production. The native tract of the breed is the Saurashtra region of Gujarat and nearby states like Rajasthan and Maharashtra. This breed originated mainly from the Gir forest, and the main breeding tract is Junagadh, Amreli, Bhavnagar, Rajkot and Porbandar districts of Gujarat State. Under the All India Coordinated Research Programme (AICRP) on Cattle, the genetic improvement of this breed is undertaken by ICAR-Central Institute for Research on Cattle, Meerut, Inida. The breed improvement requires an early and accurate selection of the breeding bulls as they contribute nearly 61% of the genetic gain. In this view, the present study was undertaken to evaluate the genetic worth of nine Gir bulls inducted in the second set under the programme. The first lactation 305-day milk yields of 347 daughters calved from 2016 to 2021 in the data recording units were used for the evaluation. The year and season of calving were considered as fixed effects, and the bull effect was considered as random. The BLUP method was used to estimate the Estimated breeding values (EBVs) of bulls using the LSMLMW models. The overall average EBV of Gir bulls is 2494.24 kg. The breeding values of Gir bulls ranged between 23.76 and -22.49 kg. Four of the nine bulls had EBVs higher than the average EBV, while the other five had lower EBVs. Based on the results, the top two bulls were recommended for nominated mating with the elite cows to produce male calves, which can be selected as the future young bulls for evaluation.

Keywords: BLUP method, Breed improvement, Estimated breeding values

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Fostering a livestock production sector transformation in India: An analysis of credit empowerment and innovations in value chain dynamics

Ajay S. Mahajan* and Anupama Kar
State Bank Institute of Rural Banking, Lingampally, Hyderabad – 500 019, Telangana, India
*ajay.mahajan@sbi.co.in

The dairy business holds significant importance in the Indian economy. This study examines the feasibility of employing value chains to mitigate financing risks and improve the creditworthiness of small and marginal farmers (SMF), with a specific emphasis on the Indian setting. This study thoroughly examines the obstacles encountered by smallholder and medium-scale farmers (SMFs) in obtaining financing. It explores alternate strategies for enhancing financial inclusivity for small-scale dairy producers. This paper suggests adopting and utilising novel financial instruments, such as the Farmers' Choice Card Loan, Contract as Collateral, and a platform based on Blockchain technology. The aforementioned innovative approaches offer distinct avenues for tackling the financial requirements of dairy farmers in India, making a significant contribution to the advancement of sustainable agricultural practices and the promotion of economic self-sufficiency. This paper highlights the significance of fostering collaboration among financial institutions, dairy cooperatives, government bodies, and agricultural firms to deploy these innovative financial instruments effectively. Implementing these strategies can stimulate the expansion and advancement of the dairy sector, augmenting the socioeconomic circumstances of dairy farmers in India.

Keywords: Indian dairy, Financial inclusion, Innovative instruments, Small and marginal farmers, Value chains

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Bovine population dynamics and milk production in India: A household and district level analysis

Sivaram, M.* and Shivaswamy, G. P.

ICAR-National Dairy Research Institute, Southern Regional Station, Adugodi, Bengaluru-560 030, Karnataka, India

*sivaram.ndri@gmail.com; m.sivaram@icar.gov.in

Over the years, India witnessed a shift in bovine functions from agricultural use with milk as a byproduct to dairying. Several studies analyzed the changes in the demographic structure of the bovine population and milk production using national and state-level data. However, state-level studies do not capture district-level variations in bovine demography and milk production within a state. This paper explores the patterns and determinants of district-level bovine demographic structure and milk production in India. The study used bovine demographic data for 526 districts of 20 major states from two quinquennial rounds of livestock census for the years 2012 and 2018. The bovine ownership data for 13797 dairy households was extracted from the Livestock Holdings Survey conducted by NSSO in 2018-19. Between 2012 and 2018, the population share of indigenous cattle declined across the districts, giving way to crossbred cattle. Notably, buffaloes-dominated districts of Haryana, Punjab and Andhra Pradesh registered a decline in the share of buffaloes. At the district level, the ratio of in-milk bovines to total bovine stock (herd efficiency ratio, HER) increased from 28 to 31%. The HER of indigenous and crossbred cattle and buffaloes continued to grow during the study period. The HER was higher for crossbreds (37.12%), followed by buffaloes (32.28%), and lower for indigenous cows (26%). The eastern and tribal districts of India were found to have a higher share of indigenous cattle, lower HER and low milk productivity. Districts located in Haryana, Punjab, Kerala, Tamil Nadu, Haryana and Karnataka are marked by a higher share of crossbred cattle, HER and milk productivity. The regression analysis revealed a positive and significant association between HER and milk productivity in the districts. It implied that HER could be used as a potential indicator of dairy development. Household-level regression analysis showed that HER was significantly higher among landless and smaller landholding and female-headed households. The landless households had the highest average milk productivity. The study reveals that dairying contributes to a greater share of farm income for marginal and small farmers.

Keywords: Farm income, Herd efficiency ratio, Marginal farmers, Milk productivity, Small farmers

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Changing breed preference among dairy farmers in Andhra Pradesh: Patterns and determinants

Shivaswamy, G. P.*, Vijay Vardhan, R. and Sivaram, M.

ICAR-National Dairy Research Institute, Southern Regional Station, Adugodi, Bengaluru-560 030, Karnataka, India

*Shivaswamy.gp@icar.gov.in

Andhra Pradesh, known for its thriving dairy sector, witnessed a structural transformation in adopting bovine breeds. The share of crossbred cattle in the total bovine population has increased while the share of indigenous cattle and buffaloes has decreased. The adoption of bovine breeds by farmers is influenced by several socioeconomic factors that interplay at various levels. This study aimed to provide an in-depth analysis of socioeconomic factors influencing changing breed preferences among dairy farmers. The field survey was conducted in the Anantapur, Chittoor, and Nellore districts, which had a higher share of indigenous cattle (35%), crossbred cattle (80%), and buffaloes (87%) in the total bovine population, respectively. A total of 270 dairy farmers were interviewed using a well-structured and pretested schedule. The results showed that, in the last ten years, over 35% of sample dairy households from Anantapur replaced the indigenous cattle with crossbred cattle, over 34% of households started dairying with crossbred cattle, and 31% continued to prefer the same breed, mostly indigenous Hallikar cattle. In the Chittoor District, most dairy households (54%) started dairying with crossbred cattle, whereas 29% of sample dairy households shifted from indigenous to crossbred cattle. In contrast, most of the sample dairy households (80%) in the Nellore District preferred to rear the same breeds, mostly non-descript buffaloes and indigenous cattle, due to their adaptive and productive traits under local hot and humid conditions. The majority of sample dairy farmers who shifted to crossbred cattle were landless, marginal, and small landholders. The herd size, share of female animals, and herd efficiency ratio were found to be significantly higher for newly adopted dairy households, followed by replaced breed dairy households. The milk production and productivity were also higher in the case of newly adopted dairy households, followed by replaced dairy households. Probit analysis showed that breed adoption was significantly high among landless, marginal and small landholders. Association with FPO and private processing companies, access to artificial insemination, formal training in dairy farming, farm mechanisation and adequate water availability also had a significant positive influence. Therefore, the study suggests a policy to improve these aspects in districts with poor dairy development.

Keywords: Breed preference, Crossbred cattle, Organised value chain, Probit model, Small landholders

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Institutional credit to dairy farming in Kerala for sustainable income: An economic analysis

Nithin Raj, K.*, Ajay Verma, Dixit, A. K., Ajmer Singh, Bhandari, G., Ponnusamy, K. and Sen, B.

Division of Dairy Economics, Statistics and Management, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India

*nithinplus96@gmail.com

Kerala state has higher capital requirements for modernizing dairy farming, and the banking infrastructure available for credit disbursal is much better than other states. This study attempts to assess the impact of institutional credit in dairying. The study is based on primary data collected from 200 dairy farmers in Kerala, selected using multistage stratified random sampling. Palakkad and Wayanad were chosen randomly from the stratum of high and low institutional credit disbursed districts, respectively. Endogenous Switching Regression (ESR) was used to assess the impact of institutional credit on various outcome variables. The results of the outcome equation that evaluates the impact of credit on *per capita* consumption expenditure found that the Age of Household Head, Annual Income, Net Returns per Animal, Farming Experience, Total land (ha), Household size and overall annual income of the farmers had a significant impact on the *per capita* monthly consumption expenditure of the dairy farmers. The positive value of transition heterogeneity (TH) suggests that borrowers and non-borrowers differ significantly. It also confirms the presence of some unobserved heterogeneities that make borrowers better-off than non-borrowers. The results of the outcome equation that assesses the impact of access to institutional credit on farmers' income from dairying found that the age of household head, household size and net returns from agriculture had a significant effect on the dairy farmers' farm income. The expected average farm income of farmers who had accessed institutional credit is ₹118.45 per day per animal, and that of non-borrowers is ₹89.63. In the counterfactual scenario, the expected average farm income from dairy of borrower farmers, assuming they had not accessed the credit is ₹91.42, and that of non-borrowers assuming they accessed is ₹111.93. The value of transitional heterogeneity was 4.73, indicating that the effect of credit would be greater for the treatment group than for the control group. The result of the outcome equation that assesses the impact of access to institutional credit on the employment generation in dairy farms found that the household size, number of machinery used, net returns per animal per day, area under fodder cultivation, and area under dairy farm, significantly affected the outcome variable. The transitional heterogeneity effect for employment generation of dairy farmers was found to be positive, indicating that the impact of credit would be greater for the treatment group than for the control group.

Keywords: Endogenous Switching Regression, Dairy farming, Impact, Institutional credit

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

On-farm assessment of different total mixed rations (TMRs) for dairy cows towards enhanced milk production in Ernakulam District

Smita Sivadasan, K.* and Shinoj Subramannian

ICAR-Krishi Vigyan Kendra of Central Marine Fisheries Research Institute, Narakkal, Ernakulam-682 505, Kerala, India

*drsmitavet@gmail.com

The Total Mixed Ration (TMR) feeding system in dairy cows is the system of feeding a mixture of forage, concentrates, vitamins and minerals to provide required energy, protein, fibre, vitamins and minerals in each bite for enhanced production. It is a better alternative during lean periods, including calamities like floods and draught. The TMR can be made available to a farmer either as readymade TMR blocks or, on-farm prepared dry fodder-based TMR, or on-farm prepared green fodder-based TMR. An on-farm study was conducted in the Ernakulam District of Kerala to assess which of the above TMRs is most beneficial in terms of milk production and milk quality. Farmer's preference was also noted. Dewormed crossbred (Holstein Friesian × Local) cows in their second and third lactation having average daily milk production of 13.5 l and a fat percentage of 3.5 were selected for the study and grouped into 4, each containing 5 animals. The first group (T1) was kept in control (Farmer's feeding practice of separately feeding Green fodder, Paddy straw, Concentrate feed, Rice bran and Coconut cake). The second group (T2) was fed readymade TMR blocks, the third group (T3) was fed on-farm prepared dry fodder-based TMR, and the fourth group (T4) was fed on-farm prepared green fodder-based TMR. All the feeds were isonitrogenous and isocaloric. Data on milk yield and milk fat percentage were noted for 45 days. The results were statistically analyzed using one-way ANOVA and *post hoc* Tukey HSD test. Milk yield and milk fat percentage were significantly higher than control in all the trials. The average milk yield of cows in T2 (16.0 ± 0.27 l), T3 (16.1 ± 0.58 l), and T4 (15.8 ± 0.41 l) were significantly higher ($p<0.05$) than that in the control group T1 (14.0 ± 0.35 l), but there was no significant difference between the milk yields of various treatment groups (T2, T3 and T4). Similarly, the milk fat percentage of cows in T2 (4.92 ± 0.17%), T3 (4.58 ± 0.21%), and T4 (4.44 ± 0.16%) was significantly higher ($p<0.05$) than that in the control group T1 (3.72 ± 0.09%). It can be concluded from the study that TMR, either in block or mash form based on dry fodder or green fodder, gives better results in terms of milk yield and milk fat percentage. The on-farm prepared green fodder-based TMR was found to be easier for farmers to adopt in their farms.

Keywords: Milk fat, Milk yield, Total mixed ration

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

CRISPR and SCNT technology for production of β-lactoglobulin (BLG) gene knockout blastocyst stage buffalo embryos

Aseem Tara*, Priyanka Singh, Devika Gautam, Gaurav Tripathi, Shreya Malhotra, Sacchinandan De, Manoj K. Singh and Naresh L. Selokar

Animal Biotechnology Division, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India

*aseem.tara@gmail.com

Milk stands as a universally consumed dietary element. In certain regions around the globe, buffalo milk has replaced cow milk due to its increased nutritional and economic significance. In India, buffaloes serve as the primary source of dairy, accounting for 45% of the nation's overall milk output. In addition to milk's nutritional worth, several allergenic proteins, including casein, α-lactalbumin, β-lactoglobulin (BLG), and immunoglobulins, have been documented. While breeding techniques, dietary control, and quantitative genetics have enhanced milk production, they have not yielded substantial modifications in milk composition. Advancements in biotechnology, particularly genome editing tools like CRISPR, offer the potential to create novel value-enhanced items such as specialized hypoallergenic milk, yielding human health advantages. In comparison, gene editing technology has been previously applied to produce BLG-free cows and goats; no such attempts have been made in buffaloes. Bearing this in mind, we devised a strategy to employ the CRISPR/Cas9 system to disrupt the buffalo β-lactoglobulin (BLG) gene. To accomplish our objectives, we formulated three single guide RNAs (sgRNAs) targeting buffalo's BLG gene locus. We then evaluated the effectiveness of these sgRNAs in inducing edits by employing Sanger sequencing, followed by subsequent analysis using tools such as TIDE and ICE. Out of the three sgRNAs, the most efficient sgRNA was selected to create a clonal population of modified cells. Numerous single-cell clones were established and subjected to assessment through TA cloning followed by Sanger sequencing. Out of the 14 single-cell clones analyzed, it was determined that 7 of them exhibited disruptions in the BLG gene. These edited single-cell clones showed various mutations, including bi-allelic heterozygous, bi-allelic homozygous and mono-allelic gene disruptions, each involving distinct nucleotide deletions and insertions. By employing somatic cell nuclear transfer (SCNT), we successfully generated cloned embryos at the blastocyst stage using four BLG-disrupted clonal cell clones. The cloned blastocyst production rates and quality of produced blastocysts were similar to non-edited control cells. Our current aim is to establish pregnancies from BLG-KO cloned embryos. This study will contribute to establishing the foundation for the production of a buffalo model of hypoallergenic milk.

Keywords: β-lactoglobulin, Buffalo, CRISPR, Hypoallergenic milk, SCNT

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Convergence policy strategies to conserve and propagate Nili-Ravi buffalo for higher returns in its breeding tract

Krishan Ahuja.[1], Gururaj, M.[2*], Navneet Saxena[2] and Tuteja, F. C.[2]

[1]ICAR-Natioanl Dairy Research Institute, Karnal -132 001, Haryana, India
[2]ICAR-Central Institute for Research on Buffaloes, Hisar- 125 001, Haryana, India

*gururaj.makarabbi@icar.gov.in

India is enriched with superior buffalo breeds, playing an important role in the dairy sector by contributing 45% of the milk. Despite significant contribution, the buffalo population declined to 22% in the dairy progressive state of Punjab from 2012 to 2019. The present study was conducted in Firozpur, Tarn Taran and Hoshiarpur districts of Punjab based on the highest decline in buffalo population. The compound annual growth rate, binary logistic regression model and budgetary analysis were applied. Livestock census data from 1997-2019 was used to check the growth rate of buffalo population, milk production and productivity among Indian states and Punjab. Overall, the buffalo population, milk production and productivity witnessed a positive growth rate due to better acceptance of buffalo throughout the country. However, the buffalo population in Punjab has registered a negative growth rate of -9.60%, but milk production has increased due to an incremental growth rate in milk productivity. Buffalo breed-wise analysis revealed that, In Punjab, the Murrah breed experienced a positive growth rate, whereas the Nili-Ravi buffalo breed population declined to 74.47% from 2012 to 2019. It may be attributed to the lack or non-availability of superior germplasm, no breed improvement programs for the Nili-Ravi breed and grading of breeds with unknown breeds. However, 180 dairy farmers from selected districts were interviewed personally through a structured questionnaire during the study period. Binary logistic regression results revealed that productive, reproductive parameters, the tradition of rearing breed and the docile nature of the Nili-Ravi breed significantly influenced dairy farmers' preference compared to the Murrah breed. The economics of Murrah and Nili-Ravi buffalo milk production revealed that net returns were better for the Nili-Ravi breed than the Murrah breed; it may be attributed to the productive and reproductive parameters of the breed. The farm combination with only the Nili-Ravi breed had shown the highest net returns per farm in the study area. The study concludes that economic returns from Nili-Ravi buffalo milk production are better than the Murrah breed in the study area. Thus, it is suggested to incentivize the Nili-Ravi buffalo owners by introducing milk recording programs, improving the supply of superior germplasm of this important breed, and organizing awareness campaigns and training programs in convergence with research institutes and state animal husbandry departments to propagate and conserve the Nili-Ravi buffalo breed in the state.

Keywords: Binary Logistic Regression, Breed preference, Budgetary analysis, Buffalo population, CAGR, Murrah

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Extent of adoption of scientific dairy farming practices by tribal dairy farmers of Wayanad District in Kerala, south India

Alimudeen, S*. and Senthilkumar, R.

College of Veterinary and Animal Sciences, Kerala Veterinary and Animal Sciences University, Lakkidi, Wayanad- 673 576, Kerala, India

*alimudeens@gmail.com

Tribal communities, often called Adivasis, are significant in India's cultural and historical tapestry. Kerala, a southern state in India, is home to 37 distinct tribal groups comprising 1.45% of the state's total population. Notably, every district in Kerala hosts a tribal people, with Wayanad district as a focal point, housing a third of the tribal population. This district's unique position has earned it the title of the "tribal hamlet of Kerala" and inclusion in the NITI Aayog's Aspirational District Program. Historically, forests played a crucial role in the survival and livelihoods of tribal communities. However, their dependence on forests has diminished due to changing economic needs. Today, these tribes engage in various activities, including livestock farming. However, their livestock farming practices differ significantly from those of non-tribal farmers, characterized by a low-input, low-output system. Livestock farming provides them with cash income and fulfils their non-cash income needs through self-consumption of livestock products. An *ex-post facto* research study was conducted among tribal dairy farmers in Wayanad istrict, Kerala, to evaluate their adoption of scientific farming practices. Official approvals were obtained from the Directorate of Scheduled Tribe Development Department and the Integrated Tribal Development Project, Government of Kerala. Random sampling was used to select 20 tribal dairy farmers from the Vythiri, Sulthan Bathery, and Manathavadi taluks. The study employed an adoption index, modified to suit the context. A structured interview schedule was used to collect data through interviews and observations. The study's findings revealed that more than half of the tribal dairy farmers fell into the medium adoption category, with the remainder distributed between the high and low adoption categories. The highest levels of adoption were observed in breeding practices, followed by animal selection, housing, feeding, and animal health care. Conversely, the lowest adoption rates were observed in management practices. Importantly, Mananthavady exhibited statistically significantly lower overall adoption rates than Vythiri and Sulthan Bathery, signalling a need for more awareness about modern scientific dairy farming practices. To address these findings, it is recommended that concerted efforts focus on raising awareness about the benefits of adopting these practices among tribal dairy farmers. Workshops, training sessions, and awareness campaigns could play a pivotal role in promoting wider adoption and enhancing the livelihoods of these marginalized communities.

Keywords: Adoption, Adoption Index, Scientific farming practices, Tribal farmers, Wayanad

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Transcriptional profiling of GDF9 and it's signaling receptors in caprine granulosa and theca cells

Anjali, Amit Kumar, Lipika Sarma, Poonam Yadav, Shweta Sharma, Shivani Khanna, Gyanendra Singh and V. S. Chouhan*
Division of Physiology and Climatology, ICAR-Indian Veterinary Research Institute, Izatnagar – 243 122, Uttar Pradesh, India
*vikrant.chouhan@gmail.com

Fecundity genes such as GDF9 (growth differentiation factor 9) are expressed by both granulosa and theca cells and are associated with enhanced ovulation rate, fertilization and rate of embryonic development. Genetic regulation of the GDF9 gene is a crucial field that needs to be investigated in caprine species. Therefore, this study intends to summarize the transcriptional profiling of the GDF9 gene and its receptors in granulosa and theca cells. Our present study characterized the transcriptional profiling of GDF9 and BMP receptors (BMPRs) in the theca and granulosa cells from caprine antral follicles. We observed that all the GDF9 gene and BMP receptors, such as BMPR-II, BMPR-IA and BMPR-IB, were expressed in both theca cells and granulosa cells extracted from antral follicles of various diameters. Significantly ($p<0.05$) lower transcripts of GDF9 mRNA in granulosa and theca cells were obtained from the large antral follicles, whereas the BMPR expression increases with an increase in follicular size. Hence, our findings suggested that GDF9 enhances the proliferation of granulosa and theca cells with the help of BMPRs and also synthesized DNA content in granulosa and theca cells.

Keywords: BMP receptors, Caprine, GDF9, Granulosa cells, Theca cells,

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Performance evaluation of crossbred pigs reared in coastal ecosystem

Amiya Ranjan Sahu*, Gokuldas, P. P. and Sajan Naik
ICAR-Central Coastal Agricultural Research Institute, Ela-403 402, Goa, India
*dramiyavet@gmail.com

Pig husbandry is one of the most profitable livestock enterprises for uplifting farmers and entrepreneurs in India. The crossbred pigs are well adapted to the local environment with better re(productive) efficiency due to exotic and indigenous inheritance. Hence, the research was carried out to analyze the effect of genetic and non-genetic factors on the growth and reproductive performances of crossbred pigs with 75% Large White Yorkshire and 25% Agonda Goan inheritance. The pigs were reared in an intensive system following scientific management practices with concentrated feeding. Growth traits were recorded by measuring the body weights at birth, weaning and in monthly intervals till ten months of age. Reproductive efficiency, such as litter size, litter weight, and age at first farrowing, were also recorded. Body weights were analyzed by least-square means (SAS) considering different effects of generation, sex, litter size at birth, parity, season and period of birth. The heritability and correlations of varying growth traits were estimated by REML (WOMBAT software). There was a significant difference ($p<0.05$) in body weights among the generations, with the maximum in the fifth generation indicating ideal selective breeding in the herd. In the fifth generation, the mean body weights were 1.05±0.01 kg at birth, 7.72±0.07 kg at weaning and 74.79±0.58 kg at marketing (eight months of age). The average litter size at birth and weaning were 8.50±0.90 and 8.10±0.52 nos. and litter weights at birth and weaning were 9.11±0.70 kg and 70.27±1.61, respectively. The heritability estimates showed higher and positive values for all the body weights. The genetic and phenotypic correlations were moderate to high among growth traits. It is concluded that the crossbred pigs with 75% exotic inheritance performed well in the hot and humid coastal ecosystem.

Keywords: Coastal ecosystem, Crossbred pig, Growth traits, Litter traits

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Ecological impact of pig production systems in India through lifecycle assessment

Attupuram, N. M.*, De, K., Thomas, R., Mohan, N. H., Islam, R., Barman, K., Devi, S. J., Kar, P., Deb, R. and Gupta, V. K.
ICAR-National Research Centre on Pig, Rani, Guwahati -781131, Assam, India.
*nitin.attupuram@icar.gov.in

Sustainable development goals guided holistic thinking on the ecological footprints of production systems has resulted in the evolution of robust quantitative methodologies to assess the impact of the product-based system throughout its lifecycle. Life Cycle Assessment (LCA) has emerged as the state-of-the-art system analysis approach in this concern. Alongside India's ascend as the most populous country with an economy marching to prosperity, the issue of refused food and bio-waste utilization is an area of significance, where swine husbandry re-emerges as a promising sector to establish a circular economy. Realizing the sectoral growth trajectory also demands data-driven research on the carbon, water, and ecological footprints for assessing sustainability, which necessitated this research. We aimed to map hotspots along the value chain and recommend the best available practices for realizing the sectoral contribution to carbon neutrality and climate change adaptation. To achieve the objective, semi-intensive and intensive pig production systems were compared using ReCiPe midpoint 2016 (H) implemented in OpenLCA 2.0.1 using AGRIBALYSE®v301 datasets. The methodology was based on the LCA framework for assessing the environmental impact of products and processes (ISO 14040:2006). Impact categories were evaluated, such as freshwater ecotoxicity, freshwater eutrophication, terrestrial acidification, terrestrial ecotoxicity and water consumption. A cradle-to-gate lifecycle analysis revealed that feed production and manure management are the significant hotspots accounting for over 90% of environmental impacts. The results signified the impetus for technological interventions in feed production and manure management in prevailing pig production systems. Implementing efficiency in production, improving feed conversion efficiency, and adopting emerging manure management innovations are some of the best practices the research recommended for sustainable management and minimizing the environmental impacts of identified hotspots.

Keywords: Environmental impact, Climate change, Life cycle assessment, Pig farming, Pig value chain, Sustainability

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Comparative expression analysis of microRNAs targeting the PTEN gene in testes of indigenous, crossbred and exotic pigs

Meera, K.[1]*, Das, P. J.[2], Zaman, G.[3], Attupuram, N. M.[2], Deori, S.[1], Katiyar, R.[1] and Ghatak, S.[1]

[1]ICAR Research Complex for NEH Region, Umiam-793 103, Meghalaya, India
[2]ICAR-National Research Centre on Pig, Rani, Guwahati -781 131, Assam, India
[3]College of Veterinary Sciences, Khanapara, Guwahati -781 022, Assam, India

*meera.k@icar.gov.in

PTEN (Phosphatase and Tensin Homolog) is a critical regulator of the PI3K/AKT signaling pathway and is associated with various aspects of male fertility, including Sertoli cell proliferation, sperm production, sperm motility and testis size. Interestingly, PTEN expression is influenced by small non-coding miRNA. They bind to target mRNAs and cause either translational repression or mRNA deadenylation or decapping, thereby playing a pivotal role in modulating cellular processes and can significantly impact the reproductive performance and fertility of pigs. In this study, we investigated the miRNA expression profiles in the testes of three distinct pig breeds: Large White Yorkshire (LWY), Ghungroo, and crossbred (Hampshire × Ghungroo), with a specific focus on some miRNAs known to target the PTEN gene, *viz.* miR-130a, miR-142-3p, and miR-148a-3p. miRNAs isolated from the testicular tissue of the breeding boars were 3′-extended with a poly (A) tail. The polyadenylated small RNA samples were reverse-transcribed into small RNA complementary DNA. Polymerase chain reaction (PCR) of the miRNAs was done using miRNA-specific forward primer and universal reverse primer. The PCR-positive testes miRNAs were further validated by qRT-PCR, keeping miR-16 as the reference gene. Our results revealed breed-specific variations in miRNA expression patterns targeting the PTEN gene. miR-130a was down-regulated in Large White Yorkshire and crossbred pigs' testicular tissue than in tissue sourced from Ghungroo pigs. A significantly ($p<0.01$) downregulated miR-130a in the LWY pigs (Fold change = 0.07) in comparison to Ghungroo pigs was observed, while crossbred pigs exhibited a 0.5-fold downregulation in comparison to Ghungroo. miR-142-3p showed downregulation in LWY and crossbred pigs in comparison to Ghungroo. miR-148a-3p expression was significantly upregulated in indigenous (Ghungroo) pig testicular tissue than in exotic (LWY) and crossbred pigs. This raises the possibility of breed-specific regulatory mechanisms that may impact male fertility. Overall, this study concluded that miRNAs can be used as predictive fertility marker and has important implications for improving pig breeding programmes. This comparative analysis sheds light on the intricate regulatory networks governing testicular function across pig breeds and emphasizes the significance of miRNA-mediated post-transcriptional control in the context of reproductive biology. Targeted modulation of specific miRNA functions may be used as a novel approach for therapeutic intervention in managing infertility.

Keywords: Male fertility, miRNA, PI3K/AKT signaling, Sperm motility

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Assessment of water and energy usage in poultry slaughter and meat processing plant: A case study

Naveena, B. M.*, Banerjee, R., Muthukumar, M., Sen, A. R., Prasad, M. G. and Phanikumar, P.
ICAR-National Meat Research Institute, Chengicherla, Hyderabad- 500 092, Telangana, India
*Naveena.BM@icar.gov.in

The food processing industry is one of the major users of both energy and water in the manufacturing sector. Water and energy are extensively used in the meat processing industry to produce safe and wholesome meat products. However, the data on water and energy consumption during the primary and secondary meat and poultry processing in India is unavailable. Therefore, in the current study, we utilized a combination of portable and in-line meters, theoretical calculations, and data collection to determine the process-level water and electric energy usage in a primary and secondary chicken processing facility at the ICAR-National Meat Research Institute on Meat, Hyderabad, India, over one year from 1st August 2021 to 31st August 2022. During this period, 5,500 birds were slaughtered according to hygienic slaughter procedures in a semi-automatic poultry processing plant. Approximately 31,956 l of water was used at an average of 5.81 l per bird. The highest water consumption was recorded in May @ 8.50±0.25 l and the lowest in February @ 4.10±0.23 l per bird. Irrespective of the live bird size, the same amount of water was used during primary processing. Significantly higher water consumption was observed in the summer months. An average of 7.01±0.22 units of electricity per kg of the value-added chicken product was used with higher ($p<0.05$) consumption for fried/enrobed meat products (Enrobed eggs, wings, croquettes and cutlets). Using a meat mincer and bowl chopper would have resulted in higher water and electricity consumption in emulsion meat products. Preparation of chicken pickles consumed less ($p<0.05$) water and electricity relative to emulsion meat products. Value-added chicken products consumed an average of 30.7±1.25 l of water relative to mutton products with 51.2±1.82 l. Defeathering and scalding are two critical steps that consume greater amounts of water during primary poultry processing. The results of this study will enable the meat processing industry to assess and manage their water and energy usage, thus achieving long-term, sustainable growth. For producers to achieve long-term, sustainable development, conservation measures must be implemented to lower electricity, fuel, and water use.

Keywords: Electric energy, Poultry processing, Sustainability, Value added meat products, Water consumption

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Green extraction of collagen hydrolysates through valorization of poultry skin: Physicochemical, functional and microstructural properties

Judy, L., Banerjee, R.*, Naveena, B. M., Belore, B., Prasad, M. G., Koneti, P. B., Mishra, B. P. and Sowmya, P.

Meat Proteomics Lab, ICAR-National Meat Research Institute, Chengicherla, Hyderabad-500 092, Telangana, India

*rituparnabnrj@gmail.com

Sustainable, green technology for extracting collagen hydrolysates from poultry skin was optimized using ultrasound, an emerging non-thermal process to minimize the use of solvents and maximize the yield of target compounds. The present study focussed on the impact of an ultrasound-assisted process (UP, 250 W, 30 min) as a pre-treatment during collagenase enzyme hydrolysis for preparing collagen hydrolysates (CH). The CH produced through the traditional method (acid-alkali treatment and water-bath hydrolysis) was used as a control. CH derived from collagenase hydrolysis without ultrasound pre-treatment was designated as ET. Ultrasonication facilitates disruption of the cellular matrix, reduction in particle size, and mechanical effects, allowing greater solvent penetration into the matrix and enhancing the extraction yield in a shorter period than conventional methods. In this study, the application of ultrasound treatment positively affected the CH yield, which increased by 26.31% and 3.98% relative to the control and ET groups. Ultrasonication-induced structural changes in collagen hydrolysates resulted in a 68-92% increase in the degree of hydrolysis compared to other groups. The solubility (%) of UP treated sample was higher in acidic pH ranges of 2.0-4.0 and decreased sharply at the neutral pH, possibly due to the *pI* of collagen (pH 6-9). The solubility of hydrolysates affected both water-holding capacity (WHC) and oil-holding capacity (OHC) because high solubility indicates smaller molecular size, leading to a reduction in water and oil absorption. The WHC and OHC in UP-treated collagen hydrolysates were 1.26 ml per100 mg and 3.58 mg per 100 mg of protein, respectively. The foaming capacity and foam stability values of the ET and UP groups were higher than the control. Field emission scanning electron microscopy (FESEM, 300X) showed dense, uneven, and multi-layered aggregated structure of the control group, possibly because of dehydration during lyophilization. The ET group exhibited a disintegrated structure, while UP-treated samples revealed a more homogenous and orderly arranged structure than other groups. Compared with the control group, the peak intensity in amide I and II bands significantly decreased in the treated groups, indicating that ultrasonication weakened the crosslinking between protein molecules. In conclusion, ultrasonication alters the protein structure and function, which facilitates the enzyme's accessibility to the peptide bonds, and these findings provide new insights into the release of bioactive peptides from the collagen hydrolysates.

Keywords: Collagen hydrolysate, FTIR, Green extraction, Protein solubility, Ultrasound

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Floor space management in intensive duck production for growth and egg production

Giri, S. C.*, Padhi, M. K. and Sahoo, S. K.

Regional Station, ICAR-Directorate of Poultry Research, Bhubaneswar-751 003, Odisha, India

*scgiri12@rediffmail.com

Ducks are waterfowls and have tremendous potential for egg production compared to chickens. Khaki Campbell ducks are well known as good layer variety ducks, which can lay more than 300 eggs in a production year for three years. Commercial duck production under an intensive management system is hardly found in India. Attempts are being made to popularize large-scale duck farming for egg production through standardized methods and practices. Experiments were conducted to study the ideal floor space requirement of Khaki Campbell (layer variety) ducks at different stages of life for optimum growth and production. Growing ducks (606 nos.) of five-week ages were randomly divided into six groups of unequal numbers. Initially, they were housed in six rooms of equal dimensions with different floor space provisions ranging between 500 to 625 cm^2 per bird. Attaining 9^{th} week of age, the floor space per duck was increased (1200 to 1700 cm^2) till the 18^{th} week when the floor space per duck was further increased (1500 to 2000 cm^2) and was continued up to the age of 40 weeks. Iso-caloric and iso-nitrogenous diets were offered to the experimental birds, with standard management practices followed for the ducks. Growth performance (g), mortality rate (%), age at first egg in the flock (days), duck day egg production (%) up to 40 weeks age and egg analysis parameters were recorded during the experiment. Observation revealed floor space provision of 600 cm^2 (between 6-8 weeks), 1200 cm^2 (between 9-17 weeks) and 1600 cm^2 (between 18-40 weeks) is ideal for optimum growth and survivability of Khaki Campbell ducks under intensive system of management. However, significantly ($p<0.5$) higher egg production was recorded with the floor space provision of 2000 cm^2 per bird. Further, more space may be provided during the egg-laying period to keep the duck house clean and hygienic, which may be needed for long-term egg production.

Keywords: Egg production, Floor space, Growth, Khaki Campbell duck

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Study to determine optimum level of protein requirement for White Pekin ducks during layer stage

Sahoo, S. K.*, Giri, S. C., Padhi, M. K., Swain, B. K. and Naik, P. K

Regional Station, ICAR-Directorate of Poultry Research, Bhubaneswar-751 003, Odisha, India

*sahoosk4@rediffmail.com

Ducks are important birds after chickens in meeting the increasing population's protein requirements. White Pekin is the broiler variety of ducks, which can bridge the gap between the requirement and availability of good quality protein at a lower price. The maximum growth and production potential of the birds can be achieved through feeding balanced feed as per their requirements. However, very little information is available concerning the nutrient requirements of white Pekin ducks. Therefore, the study was conducted to determine the metabolizable energy and protein requirement of white Pekin ducks during the layering stage. For this, 108 female and 36 male white Pekin ducks were randomly divided into three groups, with six replicates in each group. Care was taken to distribute six females and two males in each replicate. Three experimental diets were prepared with varied levels of crude protein (CP), as 16%, 18% and 20%. All the diets were iso-caloric with 2700 KCal ME kg^{-1}. All the birds are reared in the intensive deep litter system with paddy husk as litter material. The respective feed was provided to the separate treatment groups, such as CP-16, CP-18 and CP-20 group *ad libitium* twice daily. The feed offered, and residue left were recorded daily to calculate the daily feed intake. Daily egg production and egg weights were recorded up to the 35th week. The egg quality parameters were recorded by breaking two eggs from each replicate at the 25th, 30th and 35th week. The average daily feed intake was 217.54 ± 0.79 g, 217.04 ± 1.95 g and 221.96 g in the CP-16, CP-18 and CP-20 groups, respectively, without showing any significant difference. The initial body weight in the 20th week was 2597.81 ± 35.57 g, 2541.15 ± 20.28 g and 2563.06 ± 18.64 g, and the final body weight in the 35th week was 2680.15 ± 31.25, 2632.39 ± 26.22 and 2694.73 ± 82.58 g, respectively in CP-16, CP-18 and CP-20 groups. The average duck day egg production was 49.16 ± 2.73, 53.25 ± 2.36, and 53.35 ± 1.42 and feed consumed per dozen productions was 7.08±0.39 kg, 6.48±0.26 kg and 6.57±0.19 kg, in CP-16, CP-18 and CP-20 groups, respectively without showing any significant difference between the groups. The number of eggs produced per bird from 20th to 35th weeks of age were 55.06 ± 3.06, 59.64 ± 2.64 and 59.75 ± 1.59, and the feed consumed per egg production was 589.93 ± 32.80 g, 539.75 ± 21.82 g, and 547.60 ± 11.60 g, respectively in CP-16, CP-18 and CP-20 groups. The differences between the groups were not statistically significant. This experiment concluded that the diet containing 18% CP and 2700 KCal ME kg^{-1} diet were optimum for White Pekin ducks during the layer stage.

Keywords: Crude protein, Duck, Layer, Metabolizable Energy, Requirements, White Pekin

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Adaptive capability of slow growing poultry as indicated by physiological and molecular responses in hot and humid climate and measures for acquired thermotolerance

Nibedita Nayak[1]*, Subrat Kumar Bhanja[2], Eaknath B. Chakurkar[3], Amiya Ranjan Sahu[1], Sanjeev Kumar[4], Chandrahas[4] and Atasha Delia D'Mello[1]

[1]ICAR-Central Coastal Agricultural Research Institute, Ela-403 402, Goa, India
[2]ICAR-Directorate of Poultry Science, Regional station, Bhubaneswar-751 003, Odisha, India
[3]ICAR-Central Island Agricultural Research Institute, Port Blair-744 101, Andaman and Nicobar Islands, India
[5]ICAR-Central Avian Research Institute, Bareilly-243 122, Uttar Pradesh, India

*drnibeditavet@gmail.com

A study was undertaken to evaluate the thermotolerance of CARI-Debendra poultry birds under prevailing temperature-humidity indices in a hot-humid climate, to identify polymorphism patterns in thermotolerant genes and their association with the expression profile of heat shock protein (HSP70) and GRP78 gene. The measures like thermal conditioning during the embryonic and early post-hatch period and feeding natural adaptogens were done to acquire thermotolerance. Two forty straight run CARI-Debendra birds were reared at THI=78 till 12 weeks. Restriction fragment length polymorphism was studied in 200 birds for HSP70 and GRP78 genes using *TaqI* and *HaeIII* to identify possible thermotolerance markers. Physiological parameters and expression profiling of thermotolerant genes and their association with production traits revealed higher expression of HSP70 in all tissues and GRP78 in breast tissues. In the second experiment, embryonic thermal conditioning (ETC) was done only from E11-16 at 39.5°C with RH 60-70% for 5 h day^{-1} under standard incubational conditions. Hatchability did not differ significantly between ETC (63.23%) and control (63.53%), but hatch weight (35.05 vs. 33.39) showed significant variation. Rectal and surface temperatures in the ETC group were +1.04 and +4.76% higher at the hatch. The herbal supplementation group showed a 7.5% increase in body weight at six weeks, while the heat conditioning group increased only 1%. Stress parameters, such as thyroid hormones (T4), potassium concentration, and the activity of creatinine kinase, were higher in the ETC group. In contrast, the H/L ratio and T3 concentration were less in the ETC group, indicating the acquisition of thermotolerance. Upregulation of the GRP78 gene in intestinal tissue in the ETC group in 12^{th} -week-old chickens revealed the tissue specificity of expression. Thermal conditioning and early post-hatch herbal supplemented group positively influenced the body weight, immune response and differential expression of molecular chaperons, thereby, productivity and thermotolerance ability in slow-growing birds. This study highlighted the adaptability of slow-growing backyard poultry in changing climatic scenarios while elucidating the know-how mechanism for acquired thermotolerance.

Keywords: Adaptability, Backyard poultry, climatic variability, Thermotolerance

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Harnessing drone technology for advancing animal agriculture

Salam Jayachitra Devi*, Attupuram, N. M., Satish Kumar, Juwar Doley, Mohan, N. H. and Gupta, V. K.
ICAR-National Research Centre on Pig, Rani, Guwahati-781 131, Assam, India
*salamjayachitradevi@gmail.com

Drone technology has emerged as a promising tool for enhancing various aspects of animal agriculture. Drones, also known as unmanned aerial vehicles (UAVs), offer a range of capabilities that can revolutionize traditional farming practices. This abstract provides an overview of the applications of drone technology in animal agriculture, highlighting its potential benefits and challenges. In animal agriculture, drones are primarily utilized for monitoring, data collection, and herd management. With advanced imaging systems, drones can capture aerial footage, providing farmers with valuable information about livestock health, behaviour, and grazing patterns. This enables early detection of diseases, injuries, or abnormal behaviours, allowing for timely intervention and improved animal welfare. Drones equipped with thermal cameras can also assist in identifying temperature variations in livestock, aiding in the prevention of heat stress or hypothermia. With their ability to navigate difficult terrains and access remote locations, drones can efficiently transport essential veterinary inputs to animal farms. The drones, specially designed for delivery purposes, will be suitable for carrying smaller loads of specialized animal medications or samples for testing. Furthermore, drones with sensors can gather data on environmental factors such as temperature, humidity, and air quality, which are crucial for maintaining optimal conditions in livestock housing facilities. This data-driven approach allows farmers to make informed decisions regarding ventilation, heating, and cooling systems, improving animal comfort and productivity. Additionally, drones can be employed in precision agriculture practices within animal agriculture. By utilizing specialized sensors and GPS technology, drones can efficiently analyze crop fields, assess forage availability, and identify areas requiring fertilization or pesticide application. This information can aid farmers in optimizing grazing management, reducing feed costs, and minimizing environmental impact. Despite the numerous benefits, particular challenges are associated with drone technology in animal agriculture. These include regulatory constraints, limited flight endurance, and the need for skilled operators. In conclusion, drone technology offers significant potential for improving animal agriculture by enabling enhanced monitoring, data collection, and precision management practices. Farmers can gain valuable insights, optimize herd health and productivity, and promote sustainable agricultural practices by leveraging drones. As technology advances and adoption becomes more widespread, we can anticipate a future where drones play a central role in transforming and improving animal agriculture.

Keywords: Animal welfare, Environmental data, Sampling, Thermal camera

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Identification of suitable food-fodder production systems for enhancing fodder productivity in arid region

Priyanka Gautam[1]*, Sahoo, A[1]., Sawal, R. K[1]., Lal, B[2]., Shantanu Rakshit[1] and Yadav, V. K.[1]

[1]ICAR-National Research Centre on Camel, Bikaner-334 001, Rajasthan, India
[2]ICAR-Indian Institute of Pulses Research, Regional Research Centre, Bikaner-334 006, Rajasthan, India

*Priyanka.gautam@icar.gov.in

Livestock rearing is an integral part of Indian agriculture. It plays a vital role in the rural economy, but farmers cannot allocate even a small portion of their land exclusively for fodder production in the cropping season. An integral approach of the fodder production system aims at obtaining grain and fodder concurrently in space and time to cater for the balanced nutrition of livestock was evaluated to increase the land productivity and ultimately increase the farmer's profit. Therefore, a field experiment was conducted with food and fodder crops *viz*., pearl millet, cluster bean and cowpea were intercropped in the row ratios of 2:2, 3:2 and 3:3, as legume and cereal intercropping, keeping pearl millet multi-cut fodder as base crop and compared with their sole stands also. Pearl millet was harvested once after 35 days of sowing as green fodder, giving space for the companion crops to grow better. AVKB1 of pearl millet, BL-4 of cowpea and RGC-1033 of cluster bean were the test varieties in the experiment. The fodder yield of individual crops was significantly higher in their sole stands; however, total fodder yield was higher in intercropping systems. Intercropping systems recorded 7.2, 41 and 39% higher fodder yield in pearl millet, cluster bean and cowpea over their sole stands, irrespective of row ratios. The intercropping of pearl millet + cluster bean recorded a 10% higher yield and 84.6% higher B: C ratio over pearl millet + cowpea, irrespective of row ratios. Intercropping of fodder crops and food crops will help augment forage productivity and quality, especially from marginally eroded lands that prevail in the arid region of Rajasthan.

Keywords: Cluster bean, Cowpea, Intercropping system, Pearl millet

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Nutritive value of cultivated grasses and *Cenchrus* tri-specific hybrid *vis-a-vis* their silage fermentation characteristics

Sultan Singh*, Tejveer Singh, K. K. Singh and Srinivsan, R.

ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284 003, Uttar Pradesh, India

*singh.sultan@rediffmail.com

Perennial cultivated grasses *viz*. Guinea (*Megathyrsus maximus*) and Napier (*Cenchrus purpureus*), along with *Cenchrus* tri-specific hybrid (CTSH), constitute good quality fodder for ruminants. Ensiling of these grasses provides quality fodder when the availability of green fodder is scanty. Tri-specific hybrid (TSH) developed from a cross among three *Cenchrus* species (*Cenchrus americanus* - Bajra, *C. purpureus* - Napier and *C. squamulatus*). It is a perennial multi-cut forage with high forage yield, high nutritional value and tolerance to drought. The green fodder yield of TSH is relatively higher (87 t ha^{-1}) than Guinea (85 t ha^{-1}) and Napier (74 t ha^{-1}). Information on the ensiling characteristics of CTSH is scanty. The present study evaluates the nutritional value of fresh (green) and ensiled (silage) grasses and their silage quality attributes. Grasses maintained at IGFRI Technology Demonstration Block, Jhansi, were harvested, chaffed and ensiled in plastic drums for 50 days. The crude protein content of green CTSH was higher (8.83%) than Guinea (7.01%) and Napier (7.70% DM), while cell wall constituents *viz*., ADF, cellulose and lignin were comparable amongst the grasses. Ensiled CTSH had lower NDF, ADF, cellulose and lignin than Napier. Green and ensiled grass's dry matter intake (DMI %), digestible dry matter (DDM %), total digestible nutrients (TDN %) and digestible energy (DE kcal g^{-1}) values were more or less similar, except relatively higher TDN and DE values of ensiled PTSH. The silage prepared from Napier, Guinea, and CTSH had DM contents between 22.60-33.94%. Ensiled grasses' pH ranged between 3.93 and 4.36, which is for excellent grade silage. The lactic acid contents were highest for CTSH silage (2.82% DM) and lowest for Guinea grass (0.80 % DM). The pH and lactic acid contents show that good to excellent quality silage can be prepared from these grasses to provide good quality fodder in the scarcity period to sustain the ruminant's production. Silage from CTSH was of superior quality to Guinea grass.

Keywords: Grasses, Nutritive value, Silage quality, Tri-specific hybrid

Theme: Livestock-based Transformation of Food Systems
Sub theme: Towards livestock production sector transformation

Utilization of inter subspecies heterosis for enhanced green and dry biomass of maize fodder

Singh, N. K.*, Priya Garkoti, Senthikumar, V., Shruti Kashyap, Thotla Naresh and Madhubala Kurmanchali

Department of Genetics and Plant Breeding, G. B. Pant University of Agriculture and Technology, Pantnagar-263 145, Uttarakhand, India

*narendraksingh2@gmail.com

Maize (*Zea mays*) is one of the crops of great value as food, feed and industrial raw materials, besides being most suitable for green fodder and silage on the ground of nutritional profile and high yield. Considering the net deficit in green and dry fodder availability, novel intervention is required to increase yield vertically since area expansion has little scope. Further, climate change and stresses remained an impediment between the genetic and realized yield potential of maize. Wild relatives of maize have many desirable traits, namely high biomass, tillering, and re-growth potential, apart from resistance to multiple diseases and resiliency to climatic change. With such initial observations, maize progenitor teosinte (*Zea mays* subspecies *parviglumis*) was investigated to develop high-yielding maize cultivars loaded with novel traits. One of the promising maize x teosinte F1, named as DFH-2, was evaluated during the *kharif* 2019, 2021 and 2022 in multi-locations trials along with national checks, namely COHM-8, J-1006 and African Tall. The DFH-2 had a green forage yield of 511.1 q ha^{-1}, whereas the checks, namely COHM-8, J-1006 and African Tall, produced 379.8, 434.1 and 355.4 q ha^{-1} yields. The DFH-2 thus had 34.56, 17.75 and 43.83% superiority over the three checks, respectively, in the North-West zone of the country. The dry matter yield of DFH-2 was 119.2 q ha^{-1}, which was 34.8, 29.9 and 56.7% higher over the three respective checks. The per day green forage and dry matter yield of DFH-2 were 8.39 and 2.0 q ha^{-1}, respectively and established significant edge over green forage yield of 6.37, 6.7 and 5.51 q ha^{-1} day^{-1} and dry matter yield of 1.39, 1.41 and 1.16 q ha^{-1} day^{-1} of the respective checks. The crude protein yield of DFH-2 (9.57 q ha^{-1}) also had a significant edge over 6.71, 8.34 and 5.77 q ha^{-1} crude protein of three checks. In agronomical trials, the DFH-2 had the advantage of 41.44, 44.52 and 61.54% in green forage and 42.57, 39.65 and 55.02% in dry matter yield over COHM-8, J-1006 and African Tall, respectively. ADF (%), NDF (%) and IVDMD (%) of DFH-2 were on par with checks. Apart from superiority in different parameters, the DFH-2 also had tillering and multi-cut attributes, making DFH-2 a unique maize cultivar worldwide. This is the first example of the use of wild relatives in the development of maize cultivars, and this novel breeding method may be of great significance in the maize fodder improvement programme.

Keywords: Forage maize, Maize x Teosinte F1, Multi-cut, Tillers

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Coarse wool based eco-friendly sapling bags for organic horticulture plant growth

Vinod Kadam*, Nilimesh Mridha, Seiko Jose, Ajay Kumar, Arun Kumar and Shakyawar, D. B.

Textile Manufacturing and Textile Chemistry Division, ICAR-Central Sheep and Wool Research Institute-304 501, Rajasthan, India

*vinod.kadam@icar.gov.in

Micro-plastic pollution in soil and marine life created havoc for the ecosystem. The presence of plastic is ubiquitous in every walk of life. Plastic bags used for tree plantation are a big nuisance to the environment, from the bag manufacturing to its disposal. It is not biodegradable and decomposable, which eventually adds landfill waste, consumes space and contributes to soil and marine pollution. In addition, such a plastic bag, except for holding the plant, does not assist in plant growth. Present research attempted to address this giant issue by using abundant and renewable livestock products. Due to its excellent moisture content and retention, indigenous wool fibre obtained from sheep has immense potential in agriculture and horticulture applications. Sapling bags were prepared using coarse wool woven and non-woven fabrics. Coarse wool comprised >40 µm fibre diameter and > 50% medullation (hollow air space at the centre of the fibre). The bags were prepared using needle punching and handloom technology. The areal density, thickness, and tensile strength of the bag were determined. An experiment was conducted for 30 days with watermelon seeds. The seed germination and plant growth performance were studied and compared with the conventional plastic bags. The plastic sapling bags yielded only 12% germination, while wool sapling bags showed germination of 41%. The plant growth performance after 30 days after sowing was analyzed. The plants in wool bags showed significant ($p<0.05$) improvement in plant height. The leaf area and the number of leaves were also found to be better in the eco-friendly bags compared to plastic bags. To summarize, wool sapling bags performed better compared the plastic bags. These environment-friendly bags are certainly a viable alternative to non-degradable plastic bags. Besides the tissue culture laboratories, the wool bag can be used for nursery plants, agriculture, horticulture, and forestry applications.

Keywords: Coarse wool, Livestock product, Seedling, Sheep, Sustainability

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Omega-3 fortified mozzarella cheese: A nutraceutical approach for enhancing food and nutrition security

Ankit Goyal*[1], Kalpesh Chaudhari[1], Beenu Tanwar[1], Manvesh K. Sihag[2] and Darpan K. Shah[1]

[1]Mansinhbhai Institute of Dairy and Food Technology, Dudhsagar Dairy Campus, Mehsana-384 002, Gujarat, India.
[2]College of Dairy Science and Technology, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana-141 004, Punjab, India

*ankit.ndri@gmail.com

Omega-3 fatty acids play a vital role in the development of infant brains, cognitive function optimization, and cardiovascular health in humans. However, Indian and Western populations face a deficiency in these essential nutrients due to limited consumption of fish and fish oil, which are primary sources of omega-3. Flaxseed oil, with its impressive α-Linolenic acid (ALA) content ranging from 45-56%, stands out as the richest plant-based reservoir of omega-3 fatty acid. Unfortunately, its highly polyunsaturated nature renders it unsuitable for cooking or frying, leading to the development of undesirable flavours during processing and storage. The present study introduces a novel approach to fortify mozzarella cheese by stabilizing flaxseed oil as an oil-in-water emulsion, using sodium caseinate as a microencapsulating agent. The emulsion was supplemented at 3%, 6%, and 9% in the cheese-making process. Results demonstrated no significant deviations ($p<0.05$) among the sensory acceptability of control, 3%, and 6% fortified cheese samples. However, the 9% fortified sample exhibited objectionable flavour and textural characteristics. Consequently, the 3% and 6% fortified cheese samples underwent a comprehensive evaluation of physicochemical parameters, including oxidative stability (peroxide value, Thiobarbituric acid value, p-anisidine value), free fatty acids, textural attributes, fatty acid profile, and sensory acceptability during a 28-day storage period at low temperatures (4-7°C). Both fortified cheese samples (3% and 6%) demonstrated sensorial acceptability and maintained oxidative stability throughout the storage period, with peroxide value and p-anisidine value well below the maximum permissible limits recommended by CODEX (2013). The fatty acid profile indicated that the 3% and 6% cheese samples retained approximately 1.0% and 1.65% ALA content, respectively, by the end of the 28-day storage period. This highlights that 100 g of 3% and 6% fortified mozzarella cheese could contribute to approximately 62.5% and 100% of the recommended daily allowance of omega-3 fatty acids, thus underscoring its potential in fortifying food and nutrition security, while offering significant value addition to the consumer's diet.

Keywords: α-Linolenic acid, Essential fatty acid, Flaxseed oil, Fortification, Mozzarella cheese

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Microbial smart Time-Temperature Indicator (TTI) for determining thermal abuse of packaged *Paneer*

Narender Raju Panjagari*, Gaurav Kr Deshwal, Saurabh Kadyan, Rashmi, H. M., Heena Sharma and Ashish Kumar Singh
ICAR-National Dairy Research Institute, Karnal, Haryana-132 001, India
*narender.p@icar.gov.in

Thermal abuse due to mishandling in the supply chain of dairy products is a common problem. In the present investigation, for the development of a biological (microbial) smart time-temperature indicator (TTI) for *paneer*, 14 isolates were obtained from the spoiled vacuum-packaged *paneer*. Out of these, four isolates were selected based on their different phenotypic attributes and changes in pH of skim milk at 25°C/4 days and 10°C/20 days. The 16s rRNA gene sequencing revealed these four isolates as *Enterococcus casseliflavus* (S2), *Bacillus cereus* (M5111), *Atlantibacter hermannii* (M5114), and *Enterococcus faecium* (M61211). Based on preliminary trials, the substrate media was formulated for the TTI development. It was found that the isolates S2 and M61211 were able to drastically decrease the pH of substrate media from 7.0 to 4.71 and 4.43, respectively. The working of TTI at different storage temperatures (5, 15, and 25°C) was assessed using 10^3-10^4 cfu ml^{-1} inoculum of culture isolates. No significant changes in pH and microbial counts were observed at a storage temperature of 5°C. While at 15°C, the pH of media decreased gradually to around 4.52-4.89 after five days, with a concomitant increase in microbial load to 7 log cfu ml^{-1} from an initial pH value of 6.92-7.02 and microbial count of 3 log cfu ml^{-1} at 0^{th} and 2^{nd} day. Likewise, the endpoint pH at 25°C reached after 30 h of incubation at 25°C. The microbial count at this temperature increased to 8 log cfu ml^{-1} from 3 log cfu ml^{-1} during this time frame. The association analysis of the colorimetric changes in the biological TTI was carried out with the quality attributes of the *paneer*. Based on the studies, it can be concluded that a biological smart TTI could be developed for monitoring the temperature abuse of *paneer* in the supply chain with good association with quality changes in the *paneer*.

Keywords: Colorimetric, *Paneer*, Smart Packaging, Supply chain, Time-temperature indicator

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Molecular epidemiology and pathology of lumpy skin disease outbreaks in Karnataka, India

Manjunatha Reddy, G. B.*, Sudeep, N., Chethan Kumar, H. B., Yogeshardhya, R., Chanda, M. M. and Gulati, B. R.
ICAR-National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), Yelahanka, Bengaluru-560 064, Karnataka, India
*gbmpatho@gmail.com

India has the largest cattle (192.5 million) and buffalo (109.85 million) population in the world (DAHD, 2019), and livestock contributes significantly to the national economy and provides livelihoods to millions of landless, small and marginal farmers. The recent emergence of Lumpy Skin Disease (LSD) caused substantial economic losses to the farming community, especially dairy farmers. Accurate and rapid diagnosis is necessary to implement any disease prevention and control measures. Therefore, in the present study, along with clinical and histopathological examination, we have demonstrated the circulation of genetically similar LSD viruses in different outbreaks in Karnataka. We collected 81 biopsy and scab samples, along with the clinical signs during the study period using a pretested survey tool. During the investigation, cases were classified as early, mid and late stage depending on the lesion scoring. The earliest clinical sign was high fever with nasal and ocular discharge followed by lymph node enlargement. In dairy animals, there was a sharp reduction in milk yield, and in the mid and later stages of the disease, varied-sized nodules were recorded, along with scab formation. Histopathology of skin lesions showed varied degree of mononuclear cell infiltration, especially dendritic cells, lymphocytes and macrophages in dermis and hypodermis. However, inclusion bodies were not be observed in second wave compared to third wave cases, which could be attributed to increased virulence in the recent outbreaks. The repetitive clinical samples were subjected to LSD virus isolation and the isolates (12) were subjected to sequencing and phylogenetic analysis. Significant variation among the isolates across the waves was closely related to the Kenyan origin of LSD virus. In conclusion, based on pathological studies, we observed variation in lesions, which needs further studies through whole genome-based approaches across different geographical regions in India.

Keywords: Buffaloe, Cattle, Diagnosis, Epidemiology, LSDV, Phylogenetic analysis

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Lumpy skin disease: Virus isolation and molecular characterization from cattle including antibody detection in buffaloes

Sarita Yadav*, Ashok Boaor, Parvina Devi, Nishu, Nisha Verma, Inderjeet Singh and Anil Kumar

ICAR-Central Institute for Research on Buffaloes, Hisar -125 001, Haryana, India

*drsaritanrce@gmail.com

Lumpy skin disease (LSD) is a re-emerging transboundary World Organisation for Animal Health (OIE) listed viral disease of cattle and water buffalo. Lumpy skin disease virus (LSDV) is enveloped and has a 151-kbp double-stranded DNA genome from the family *Poxviridae* (genus *Capripoxvirus*). The *Capripoxvirus* genus also comprises sheeppox virus (SPPV) and goatpox virus (GTPV), which are highly similar to LSDV. It is primarily transmitted through blood-feeding insect vectors, such as stable flies, mosquitoes, and ticks, but can also spread through direct contact with infected animals or contaminated objects and infected semen. Infected animals may exhibit mild or no clinical signs to severe form, progressing to fever, lymphadenopathy, skin nodules, ulceration, decreased appetite and decreased milk production. The P32 is a capripoxvirus-specific structural protein homologous to the P35 envelope protein of the vaccinia virus encoded by the H3L gene localized in the virus envelope. This major envelope protein, a cell surface binding protein of capriviruses that contains neutralizing epitopes, is strongly antigenic and binds virus particles to virus attachment sites on the surface of host cells. India is the largest milk-producing nation in the world, accounting for almost 20% of global milk production. Dairy farming is an integral part of rural livelihoods in India, particularly for livelihoods of small and marginal farmers. Molecular epidemiology of LSD is essential for understanding the spread and evolution of LSD virus, developing new treatments and control strategies and preventing future outbreaks. The study highlights the detection of antibodies against LSDV in buffaloes showing LSD characteristic mild skin nodular lesions, isolation and molecular characterization of the LSDV in cattle from field outbreaks in villages of Rajasthan under ICAR-Farmer FIRST Project and suspected LSD field outbreak in buffalo from Bathinda, Punjab during 2021 and 2022.

Keywords: Buffalo, Cattle, ICAR-Farmer FIRST, Lumpy skin disease

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Reproductive disorders in female dromedary camels of India

Shirish D. Narnaware[1]* and Rakesh Ranjan[2]

[1]ICAR–Central Coastal Agricultural Research Institute, Ela-403 402, Goa, India
[2]ICAR-National Research Centre on Camel, Bikaner-334 001, Rajasthan, India

*shirish.narnaware@icar.gov.in

In India, camels are the main livestock kept to sustain the livelihoods of pastoralists in arid regions. However, reproductive diseases are one of the major constraints for camel-producing communities and very little is known about common reproductive disorders in Indian dromedary camels. Therefore, this study aimed to identify the reproductive disorders in female dromedary camels and to diagnose the associated etiological agents. During the study period of three years, a survey of the health status of camels and collection of biological samples such as blood (n= 205), vaginal swabs (n= 28), placenta (n= 7) and aborted fetus necropsy tissue samples (n=23 cases) were carried out to investigate the etiopathology of reproductive disorders. The different reproductive pathologies recorded were abortion (8.92%), stillbirth (4.44%), dystokia (4.44%) and premature birth (4.44%). In abortion cases, the bacteria isolated were *Staphylococcus* spp. (5), *E. coli* (1), *Bacillus* spp. (2), *Streptococcus* spp. (1) and *Klebsiella pneumonia* (1). In stillbirth cases, the etiology was identified as *Staphylococcus* spp. (1) and *K. pneumonia* (1). The above isolates were also confirmed by PCR using specific primers. The DNA was also extracted from lung and placental tissues from aborted and stillborn fetuses, and PCR was carried out for the detection of common abortigenic pathogens such as Bovine herpes virus-1, *Neospora caninum*, *Brucella abortus*, Toxoplasma, Mycoplasma and Chlamydia species. However, all samples detected negative for these agents by PCR. For exploration of normal microflora of vaginal passage, vaginal swabs from 28 healthy adult female camels were also cultured on Nutrient Agar and Sabouraud Dextrose Agar plates, which revealed isolation of *Staphylococci*, *E. coli*, *Bacillus*, *Pasteurella* and *Corynebacterium* species as the major bacteria, whereas *Aspergillus* spp. and *Candida* spp. were the major fungi. These isolates were also confirmed by PCR using specific primers. Surveillance of pregnant and lactating camels of the farm and field (n= 215) for Brucellosis and Trypanosomiasis was also carried out, which revealed one sample positive for trypanosomiasis and four samples positive for brucellosis. In conclusion, this study provides an important insight into the incidence and etiology of different reproductive disorders in Indian dromedary camels, which will ultimately help clinicians in proper diagnosis and management of the reproductive disorders in dromedary camels.

Keywords: Abortion, Dromedary camel, Etiology, Reproductive disorders, Stillbirth

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Comparative efficacy of inorganic and nano forms of trace minerals (Cu, Zn and Mn) supplementation on recovery of subclinical mastitis in lactating dairy cows

Himani Tewari[1], Ayyasamy Manimaran[1*], Duraisamy Rajendran[2], Arumugam Kumaresan[1], Muniandy Sivaram[1], Mahavinod Angrasan, J. K. V.[1], Sakthivel Jeyakumar[1] and Heena Azad[2]

[1]Southern Regional Station (SRS), ICAR-National Dairy Research Institute (NDRI), Adugodi, Bengaluru-560 030, Karnataka, India
[2]Animal Nutrition Division, ICAR-National Institute of Animal Nutrition and Physiology, Adugodi, Bengaluru-560 030, Karnataka, India

*maranpharma@gmail.com; a.manimaran@icar.gov.in

The present study evaluated the comparative efficacy of inorganic and nano forms of trace minerals (Cu, Zn and Mn) on subclinical mastitis (SCM) recovery in crossbred cows. Nanominerals were synthesized by the chemical reduction method and characterized by DLS, SEM, EDS, TEM, XRD and FTIR techniques and the average particle size was found to be <100 nm. About 22 apparently healthy lactating HF crossbred cows were screened by milk Somatic Cell Count (SCC) and California Mastitis Test (CMT) methods, and cows were diagnosed as SCM (SCC ≥2 lakh cells ml^{-1}; n=14) or healthy (SCC ≤2 lakh cells ml^{-1}; n=8). SCM-affected cows were additionally supplemented with 100% recommended levels of inorganic trace minerals (Cu: 13 ppm, Zn: 60 ppm, Mn: 17.5 ppm; N=7) or 50% of recommended levels of nanominerals (*i.e.*, Cu: 6.5 ppm, Zn: 30 ppm, Mn: 8.75 ppm; n=7) for 45 days. The data were analyzed by linear mixed model using "R"-software. The expression profile of targeted inflammatory and anti-oxidant related genes in milk somatic cells was calculated in fold changes, keeping a healthy control group as standard. It is observed that supplementation of nanominerals resulted in a more significant reduction of SCC and CMT score than inorganic minerals-supplemented group, with no significant alterations on plasma Cu, Zn and Mn levels. Supplementation of nanominerals resulted in a significant reduction of intra-mammary infection (IMI) rate, particularly with *Staphylococcus* spp. TLR-2, TLR-4, TNF-α, IL-8, and SAA3 genes were up-regulated more in inorganic minerals supplemented cows, which is indicative of more IMIs than nanominerals supplemented cows. It is concluded that supplementation of 50% recommended levels of nanominerals had better efficacy on recovery of SCM-affected cows through significant reduction of udder inflammatory markers (CMT and SCC score), lesser IMI rate and inflammatory genes expression than inorganic minerals supplementation at 100% recommended level.

Keywords: Crossbred cows, Inflammatory genes, Inorganic minerals, Nanominerals, Subclinical mastitis

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Evaluation of prevalence, biofilm forming ability of *Escherichia coli* isolated from buffalo mastitis and its association with antibiotic resistance

Ashok Boora*, Sarita Yadav, Parveena Devi, Adesh Kumar, Rajesh Kumar Lohchab and Anil Kumar

ICAR-Central Institute for Research on Buffaloes, Sirsa Road, Hisar-125 001, Haryana, India

*drboora@gmail.com

This study aimed to determine the prevalence, antibiotic resistance pattern, extended-spectrum beta-lactamase production and biofilm-forming ability of isolated *Escherichia coli* (*E. coli*) strains from the mastitis milk of buffaloes. Out of 549 bacterial isolates from mastitis milk of buffaloes (*n*, animal level = 472) between 2019 and 2022, 43 *E. coli* strains were isolated, with an overall prevalence of 9.11 % at the animal level. The prevalence of *E. coli* was high in unorganized buffalo herds (11.36%) from villages of the Farmer FIRST project (ICAR-FFP) compared with organized buffalo farms (6.73%). The highest resistance was against Penicillin 43 (100%), followed by Ceftriaxone 18 (41.86%), Amoxycillin/Sulbactam 8 (18.60%) and Enrofloxacin 7 (16.27%). Additionally, all were sensitive to gentamycin 43 (100%), followed by Cefoperazone/Sulbactam 34 (79.06). Cephalosporins are frequently used antibiotics to treat bovine mastitis. However, their therapeutic effectiveness is being compromised by bacteria resistant to β-lactams. In the study, a total of 32 (6.78% %) extended-spectrum β-lactamase (ESBL) producing *E. coli* were isolated from mastitic buffalo milk (n=43/472). In total, 17 (39.5%) isolates were biofilm producers by microtitre-plate method. There was a statistically non-significant relationship between biofilm production and antibiotic resistance and between ESBL production and biofilm formation in *E. coli* strains ($p>0.05$). The study demonstrated a high occurrence of ESBL and biofilm-producing *E. coli* in buffalo mastitis milk, implementing a significant challenge to treat mastitis in buffaloes necessitates judicious use of antimicrobials and to explore potential therapeutic agents as substitutes for antibiotics to treat bovine mastitis effectively.

Keywords: Antimicrobial susceptibility test, Biofilm, Buffalo, ESBL, Farmer FIRST

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Detection of *Coxiella burnetii* infection in goats and animal handlers in Chhattisgarh and Odisha using real-time PCR through One Health approach

Binod Kumar Choudhary*, Mamta Choudhary and Soumya Dash

School of Crop resistance System Research, ICAR-National Institute of Biotic Stress Management, Baronda, Raipur-493 225, Chhattisgarh, India

*binods14@gmail.com

One Health is an integrated, unifying approach to balance and optimize the health of people, animals and the environment. Q fever is an emerging zoonotic disease caused by *Coxiella burnetii*. In clinically apparent infections, flu-like symptoms occur with lower respiratory tract infection in some of the cases. Around 2% of these acute infections persist and may give rise to fatal chronic localised infections resulting in endocarditis, ischaemic heart disease, hepatitis, and vascular disorders like aneurysm. In pregnant women, the organism is associated with stillbirths or spontaneous abortions. Ruminants, particularly small ruminants, act as the most important reservoir and sources of infection of Coxiella for humans. The objective of the study was to develop a real-time PCR assay for the detection of *C. burnetii* in livestock and humans. Using the One Health approach, a total of 1271 samples comprising of serum, milk and aborted foetus were collected from sheep, goat, cattle and animal handlers from Chhattisgarh and Odisha states of India. *Com1* gene encoding the outer capsular membrane protein has been reported as a marker gene for early detection of *Coxiella burnetii*. TaqMan PCR based detection method was used in this assay. *Coxiella burnetii* (RefSeq GCF_000007765.2) complete genome was used as a reference strain. *Com1* full-length cds and partial ESTs available in the NCBI database were aligned using ClustalX algorithm, and conserved sequences were targeted for designing primers and probes. A set of primers named Com1_F1 and Com1_R2 were used for cloning the Com1 synthetic construct of 440 bp. Com1 Fwd and Com1 Rev primers were used in TaqMan PCR for detection along with a TaqMan probe, named Com1 Probe. The prevalence of Q fever in sheep and goats of Chhattisagrh and Odisha was recorded to be 9.44% and 18.9%, respectively. The rate of prevalence in abortion cases was recorded to be 16%, whereas the rate of prevalence in serum samples of sheep and goat was found to be 11.50%. There are no systematic studies conducted on the occurrence of *C. burnetii* in goats in the country. A study conducted in northern India reported a prevalence of 6.13% of *C. burnetii* infection in goats with a history of reproductive disorders. In southern India, 5.64% of sheep and goats were reported to be seropositive for *C. burnetii* using ELISA.

Keywords: *Coxiella burnetii*, One Health, Q fever, Zoonosis

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Detection of *Mycobacterium bovis* infection in goats and animal handlers in Chhattisgarh and Odisha using real-time PCR

Mamta Choudhary *, Binod Kumar Choudhary and Soumya Dash

School of Crop Health Biology Research, ICAR-National Institute of Biotic Stress Management, Baronda, Raipur- 493 225, Chhattisgarh, India.

*chiyamum@gmail.com, Mamta.Choudhary@icar.gov.in

Bovine tuberculosis (BTB) is a chronic bacterial disease of animals caused by members of the *Mycobacterium tuberculosis* complex, primarily by *Mycobacterium bovis*, but also by *M. caprae*, and to a lesser extent *M. tuberculosis*. It is a major infectious disease among cattle and affects many other mammals, including humans, deer, goats, pigs, cats, dogs and badgers. *M. bovis* is also responsible for the zoonotic tuberculosis. Infection is mainly through inhalation or ingestion of the bacteria. Contaminated food and water can also be a source of infection. Cattle are considered to be the major reservoir *M. bovis*, and are the main source of infection for humans and other in-contact animals. Nevertheless, the disease has been reported in many other domesticated and non-domesticated animals. A total of 454 suspected clinical samples comprising of serum (n=261), milk (n=78) and aborted foetus from sheep and goats (n=115) were collected from cattle sheep, goat and animal handlers from Chhattisgarh and Odisha states of India. IS1081 has been reported as a multi-copy marker gene for early detection of bovine Tuberculosis caused by *Mycobacterium bovis*. TaqMan PCR based detection method was used in this assay. *Mycobacterium bovis* BCG str. Tokyo 172 Accession AP010918.1 complete genome was used as a reference strain. IS1081 full-length cds and partial ESTs available in the NCBI database were aligned using ClustalX algorithm and conserved sequences were targeted for designing primers and probes. A set of primers named IS1081_F1 and IS1081_R2 were used for cloning of the full-length IS1081 synthetic construct. IS1081 Fwd and IS1081 Rev Primers were used in TaqMan PCR for detection along with a TaqMan Probe named IS1081 Probe. The prevalence of *M. bovis* in overall samples of Chhattisagrh and Odisha states of India was recorded to be 26%. The rate of prevalence in abortion cases was recorded as 40%. There are no systematic studies conducted on the occurrence of *M. bovis* in animals in the country. It is worth noting that bovine tuberculosis is of global concern due to its impact on animal health, food safety, and public health. Efforts to control and eliminate *M. bovis* infection in animals are crucial for reducing the risk of human infections and ensuring the safety of livestock products.

Keywords: Bovine tuberculosis, *Mycobacterium bovis,* Tuberculosis complex, Zoonotic tuberculosis

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Challenges in Foot and Mouth Disease elimination in India and the way forward

Rabindra Prasad Singh*
ICAR-National Institute on Foot and Mouth Disease, Bhubaneswar-752 050, Odisha, India
*rabindra.singh@icar.gov.in

Foot and Mouth Disease (FMD) is considered to be one of the most economically important viral diseases of livestock globally. With a wide host range and multiple serotypes, FMD virus is associated with a long-lasting carrier stage in ruminants. The vaccinal immunity is short-lived and non-sterile. Further, the effect of vaccine and vaccination is complicated by the low stability of the vaccine, requiring a continuous cold chain. These factors, associated with high population density, unrestricted movement and mixed farming systems in India, further complicate FMD control efforts. In India alone, FMD was estimated to cause direct economic losses to the tune of `20,000 crore annually. Looking at its impact on livelihood security, nutritional security, livestock product and livestock-related trade, the Government of India has launched a vaccination-based FMD control programme, which is mainly vaccine and vaccination-driven, with not much focus on other contingency measures, such as biosecurity and movement control. The low level of stakeholder involvement and legal framework are other areas for improvement of the programme. The vaccine and vaccinations are also interrupted due to an irregular supply of desired quality vaccines, which affects the frequency and density of vaccination for achieving high herd immunity. The vaccine quality is also affected by last-mile cold chain requirements, an important parameter to be addressed. The control programme is further affected by porous international borders between Nepal, Bangladesh and Bhutan, which may allow frequent exchange of viruses. There has been a significant decline in the number of outbreaks due to the progressive implementation of disease control measures during the last two decades in India. This effort could have been further strengthened if combined with other contingency measures, including emergency response to outbreaks. Bringing down the number of outbreaks will require other contingency measures to be adopted, extensive stakeholder mapping and involvement, implementation of the legal framework in conjunction with the regional approaches and coordination with international organisations like WOAH and FAO of the UN. Strategic vaccination with a quality vaccine in preferential order of cattle, including stray cattle at high density and frequency followed by buffalo, pigs and small ruminants, will be required for impactful interventions. States and administrative units with nomadic populations of cattle, sheep and goats need to be given priority for vaccination of small ruminants. The movement of animals must be linked with the verified quality of vaccinations, especially in areas like Kerala and UTs of Kashmir, which have shown complex epidemiology due to the entry of livestock from neighbouring states and administrative units, resulting in outbreaks with multiple serotypes. Further, delay in adapting crucial technologies on vaccine strain change for fast-changing serotypes by the government and vaccine manufacturers and delayed adoption of useful technologies due to tedious regulatory approvals jeopardise effective control measures and allow the spread of FMD beyond control. Initial targets should be to avoid peaks of outbreaks by creating high herd immunity in combination with contingency measures, followed by interventions to bring FMD to zero level to achieve disease freedom with vaccination.

Keywords: Disease control, Foot and Mouth Disease, Vaccination

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Evaluation of infectious bursal disease-Immunecomplex (IBD-Icx) vaccine induced response in chicken with IBD specific maternal antibodies

Bhanukumar D. H.*, Shyma K. Latheef, Chandana M. S., Priyanshi Agarwal, Neha Dahariya, Chayna S. M., Aruna Kuniyal, Hari Abdul Samad and Dhar, P.

Division of Biological Standardization, ICAR-Indian Veterinary Research Institute, Bareilly-243 122, Uttar Pradesh, India

* shyma05vet@gmail.com

The poultry industry in India is the fastest-growing animal husbandry sector, ensuring nutritional and livelihood security for the population. Economically important viral infections are always a threat to the industry, among which Infectious bursal disease (IBD) is an important one. It is an acute, highly infectious and endemic viral disease affecting young chickens of 3-6 weeks of age, causing high mortality and immunosuppression in surviving chickens. The most effective means of controlling IBD is a robust vaccination program to elicit immunity from an early age. Still, high maternal antibody levels at an early age restrict the action of live vaccines. This drives the demand for new vaccine formulations like the IBD immune-complex (IBD-Icx) vaccine that can function in the presence of maternal antibodies. Studies on the mechanism of action of Icx vaccines are limited. Hence, we assessed the immune responses of two commercial IBD-Icx vaccines in chicks with high maternal antibodies against the IBD virus. Thirty-six White Leghorn chicks were randomly divided into three groups: Vac1 (vaccinated with IBD-Icx vaccine1), Vac2 (vaccinated with IBD-Icx vaccine2), and unvaccinated control group. Serum antibody titres were measured on days 0, 14, 28, and 42 using a commercial ELISA kit. Three birds from each group were sacrificed on these days for IBD viral load analysis through RT-qPCR. The RT-qPCR results revealed an increasing viral load from day 14 to day 28, peaking on day 42 in the bursa for both Vac 1 and Vac 2 groups. In the spleen, the viral load was lower on day 28 than on day 14 but increased again on day 42 in both groups. Furthermore, viral load was the highest in the spleen on day 14, whereas on days 28 and 42, the bursa exhibited higher viral loads than the spleen in both groups. These findings suggest an initial replication of the vaccine virus in the spleen before infecting the bursa. Serum antibody titre revealed elevated maternal antibodies in all groups on day zero. On the 14th, 28th, and 42nd days, antibody titres in the vaccinated groups exceeded those in the control group, with a peak level on day 14. The findings suggest that, unlike conventional live vaccines, the IBD-Icx vaccine can impart responses in chicks even in the presence of maternal antibodies and offer protection from early days.

Keywords: Antibody titre, IBD, Immune complex vaccine, Viral load

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Isolation, characterisation and adaptation of indigenous Infectious Bursal Disease Virus (IBDV) in cell culture

Chandana, M. S.*, Shyma K. Latheef, Asok Kumar, M., Chayna, S. M., Aruna Kuniyal, Priyanshi Agarwal, Bhanukumar D. H., Hari Abdul Samad, Prasad Thomas and Pronab Dhar

Division of Biological Standardization, ICAR-Indian Veterinary Research Institute, Bareilly-243 122, Uttar Pradesh, India

*shyma05vet@gmail.com

The poultry industry is one of the highly developed agro-industries in India, and its efficiency is equally comparable with other Western countries. Farming profits are being significantly affected by various poultry diseases. Infectious bursal disease (IBD) is one of the important viral infections that cause huge economic losses to the poultry industry worldwide. The causative agent is a double-stranded, segmented RNA virus, which primarily affects the bursa of Fabricius of young chicks, especially 3-6 weeks old. The disease is characterized by high morbidity, mortality and immunosuppression in surviving chicks. The most effective way to control IBD is vaccination. Presently, live vaccines based on foreign virus strains are widely used in India. Amidst the vaccination, IBD outbreaks are being reported in the country, necessitating new vaccines based on the indigenous IBD virus. Hence, the present study was carried out to isolate the IBD virus from infected chicks and its further characterization and adaptation in a suitable propagation medium. IBD virus isolate was obtained from the bursal tissue of infected chicks following confirmation by RT-PCR. The isolated IBD virus (IBDV) was characterized by assessing its pathogenicity in embryonated chicken eggs, susceptible chicks and nucleotide sequencing. Pathogenicity of isolated IBDV was assessed by inoculating 20% bursal suspension to the chicks of susceptible age group *via* intraocular, nasal and oral routes, and the chicks were monitored daily for the symptoms, which are specific to IBD. After 2-3 days, diseased birds showed symptoms such as dullness, depression, reluctance to move and whitish diarrhoea. On post-mortem examination of dead birds, lesions like haemorrhage on the thigh muscle, breast muscle and inflamed bursa with petechiae were observed. Further, molecular characterization of IBDV field isolate was done by nucleotide sequencing and phylogenetic analysis, revealing that the isolate has 95% similarity with other virulent isolates of Indian and Chinese origin. Results of the pathogenicity study and phylogenetic analysis suggested that Indian isolate can be categorized under virulent strains of IBDV. Isolate was then adapted in Vero cells, for which a 24 h old confluent monolayer of Vero cells was infected with 20% bursal suspension and continued serial blind passages. Since there was no visible cytopathic effect in initial passages, virus adaptation was confirmed with RT-PCR showing an amplicon of 132 bp specific to primers of VP2-hypervariable region. The cell culture-adapted virus is being further explored for developing indigenous vaccine strains against IBD.

Keywords: Adaptation, Cell culture, Characterization, Infectious Bursal Disease virus, Isolation.

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Co-circulation of multiple serotypes of Foot and Mouth Disease virus among susceptible animal population in India during 2021-2022

Rout, M.*, Dahiya, S. S., Subramaniam, S., Mohapatra, J. K. and Singh, R. P.

ICAR-National Institute on Foot and Mouth Disease, ICFMD, Arugul, Bhubaneswar – 752 050, Odisha, India

*drmrout@gmail.com

Transboundary animal diseases such as foot and mouth disease (FMD) severely constrain the progressive livestock enterprises in developing countries like India. During the year 2021, a relatively higher number of outbreaks of FMD were reported in most of the states, including the states of Karnataka, Odisha, Punjab, Maharashtra, Tamil Nadu and the Union Territory (UT) of Jammu and Kashmir. Other species like sheep, goats, and pigs were also affected in these states and UT, along with cattle. Clinical samples from the tongue/oral mucosa/foot or snout epithelium/saliva from respective species were collected and subjected to in-house serotyping ELISA and reverse-transcription multiplex PCR, where more than one serotype was detected in different states. To substantiate further, serotypes O and A were detected in the states of Karnataka, Odisha, Punjab, Maharashtra and Tamil Nadu, while in the UT of Jammu and Kashmir, all three serotypes (O, A and Asia 1) were detected. Thus, co-circulation of more than one serotype of FMD virus was reported in several states in different susceptible species. The involvement of multispecies is more likely as far as their susceptibility is concerned and the practice of animal husbandry prevailing in our country, where different species are co-reared and even co-housed in the same shed by the farming communities, along with the dynamic migratory flocks of small ruminants kept by the people of Jammu and Kashmir. Besides, delay in timely vaccination and waning of natural infection immunity leading to the observation of a surge in FMD incidences in a cyclic pattern is one of the possible reasons for such an increased number of FMD outbreaks involving multiple serotypes in a particular year. Therefore, this is not the appropriate time to use the monovalent vaccine in the country, even on a pilot scale, without a thorough critical analysis of such epidemiological information on the prevalence of FMDV serotypes.

Keywords: Co-circulation, FMDV, Outbreak, RT-mPCR, Typing ELISA

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Foot and Mouth Disease in mithun, yak, cattle-yak hybrids and cattle in the north-eastern states of India during 2021-2022

Rout, M.*, Garam, G. B., Rinchin Lama, Deka, P., Tripathy, J. P., Giri, P., Acharya, R., Subramaniam, S., Mohapatra, J. K. and Singh, R. P.

ICAR-National Institute on Foot and Mouth Disease, ICFMD, Arugul, Bhubaneswar – 752 050, Odisha, India

*drmrout@gmail.com

Foot and mouth disease (FMD) is one of the most infectious and contagious diseases of cloven-hoofed animals, including cattle, buffalo, sheep, goats, pigs, mithun and yaks. Three serotypes of FMD virus (FMDV) are prevalent in India. During 2021-2022, relatively higher numbers of FMD outbreaks were reported in the bovine population compared to preceding years, along with reports in mithun and cattle in a few states of the north-eastern regions of India. The FMDV serotype was identified using serotype differentiating antigen detection sandwich ELISA and RT-multiplex PCR on clinical samples collected from cattle (n = 5) and mithun (n = 11) of Arunachal Pradesh and Nagaland. The tests revealed that two samples from mithun and one sample from cattle were found positive for FMDV serotype O. Two samples from suspected cases of FMD in mithun from an organized farm in Nagaland were tested positive for serotype A. Serum samples collected at random and tested using 3AB3 non-structural protein ELISA revealed a higher FMD NSP antibody prevalence in cattle-yak hybrids (16.7%), followed by mithun (10.6%) and yak (3.8%). Mithun and yak, being semi-domesticated species, are allowed to mingle with cattle. Such close proximity in common habitats and grazing areas might have caused the spread of infection. Furthermore, because of their habitat in forests, yak and mithun are generally not vaccinated against FMD. The disease in cattle, buffalo and semi-domesticated populations of mithun and yak, as well as their hybrids in hilly north-eastern parts of India, is of serious concern. These species need to be vaccinated biannually and monitored for protection against FMD.

Keywords: Cattle, FMD, Mithun, NSP ELISA, RT-mPCR, Yak

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Assessment of antimicrobial activity of calves-origin lactic acid bacteria against predominant diarrhoea-causing pathogens and clustering to develop a multi-strain probiotics adjunct

Sachin Kumar, Nutan Chauhan, Tejshi Chauhan, Ashis Kumar Samanta* and Nitin Tyagi

Animal Nutrition Division, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India

*drashiskumarsamanta@gmail.com

Neonatal calf diarrhoea is a major cause of calf mortality. It is responsible for severe financial loss in the cattle industry worldwide, significantly impacting developing countries like India. Probiotics have been used as a substitute for antibiotics for the prevention and supportive treatment of calf diarrhoea. Therefore, the present study was aimed to assess the antimicrobial activity of twenty-two potential bacterial probiotic strains of calves-origin, comprising different lactic acid bacterial species (*Lactobacillus salivarius, Lactobacillus reuteri,* and *Enterococcus faecalis*) against five predominant diarrhoea-causing pathogens (*Salmonella arizonae, Salmonella typhi, Staphylococcus aureus, Escherichia coli* and *Bacillus cereus*) by agar spot method and well diffusion technique followed by clustering of the strains. Results showed that different probiotic strains inhibited the growth of entero-pathogens at variable strength. Among twenty-two probiotic strains, *Lactobacillus salivarius* RBL68, *L. salivarius* RBL62, *L. salivarius* RBL12, and *L. salivarius* RBL68 exhibited the most potent antimicrobial activity against tested pathogens. The antibacterial action of several lactic acid bacteria strains was categorized using clustering analysis. This work highlights the allure of using the examined lactic acid bacteria strains and/or their CFS as antimicrobial agents against diarrhoea-causing pathogens. Such new strains can be used as antidiarrhoeal agents for cattle calves. However, further *in vivo* studies are warranted to evaluate their efficacy and effectiveness as a supportive treatment for gastrointestinal disorders in young dairy calves.

Keywords: Antimicrobial activity, Calves-origin probiotics, Entero-pathogens, Neonatal calf diarrhea

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Testicular perfusion analysis using digital pulse wave Doppler ultrasonography in Shweta Kapila breed of indigenous cattle reared in their native tract under western coastal climate

Gokuldas, P. P.*, Krutika Shinde., Amiya R Sahu and Shirish D. Narnaware

[1]ICAR-Central Coastal Agricultural Research Institute, Old Goa-403 402, Goa, India

*Gokuldas.PP@icar.gov.in

The assessment of testicular perfusion and hemodynamics using digital Pulse Wave Doppler Ultrasonography can greatly contribute to understanding of thermoregulatory mechanisms and fertility status especially in farm animal species. The objective of the present study was to characterize major testicular perfusion parameters in the indigenous Shweta Kapila (SK) breed of cattle. The study was performed on six SK bulls (mean 5.25 ± 0.60 yrs, 4 to 6.5 yrs) reared in their native tract under a hot and humid coastal climate and raised in a semi-intensive production system. A digital colour Doppler ultrasound machine Logiq® Book XP (GE Healthcare, WI, USA), equipped with a multi-frequency linear array probe, was employed for the study. The scan depth was 10 cm for all the examinations, images were acquired at 5 MHz, and the sample volume was set to 1 mm. Optimal scan and pulse wave images were frozen and recorded for analysis and interpretation. Major pulse wave Doppler ultrasound attributes include Peak systolic velocity (PSV), End diastolic velocity (EDV) and Resistive index (RI) measured along the areas of the spermatic cord part of Testicular Artery (sTA), marginal part of the Testicular Artery (mTA) and intra-testicular branches of Testicular Artery (iTA). The mean Peak SV ranged from 4.98±0.02 to 12.01±0.26 m/s, while the mean EDV ranged from 3.72±0.03 to 5.09±0.16 m/s in different parts of the TA in screened SK bulls. Most of the attributes recorded in the various regions of the TA were similar in both the right and left testis. Significantly higher ($p<0.05$) values of Peak SV (12.01±0.26 m/s) were recorded in the spermatic cord part of TA. The PSV and the EDV measured in the TA along the spermatic cord were significantly ($p<0.05$) variable among the bulls and within individual bulls. Less variability of the Resistive index (RI) was observed for values measured in different parts of the TA in the same bull. Resistive index along the course of testicular artery could be a potential indicator for evaluating the breeding soundness and fertility status. The findings of the study could help generate useful information on testicular hemodynamics and normal reference values of testicular perfusion in indigenous SK bulls. Pulse wave Doppler imaging of the testicular vasculature can be exploited in breeding soundness examination. It can also be helpful in future diagnosis of fertility status and reproductive pathologies in bulls.

Keywords: Coastal Climate, Colour Doppler, Indigenous cattle, Testicular perfusion, Ultrasonography

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Expression patterns of genes related to intramuscular fat and fatty acid metabolism in Nellore and Deccani sheep breeds of deccan plateau region

Navya Pothireddy[1], Vishnuraj, M. R.[2*], Vijaya Rachel, K.[1], Baswa Reddy, P[2]., Aravind Kumar, N[2]. and Barbuddhe, S. B.

[1]Department of Biochemistry and Bioinformatics, GITAM School of Science, GITAM Deemed to be University, Visakhapatnam-530 045, Andhra Pradesh, India
[2]ICAR–National Meat Research Institute, Chengicherla, yderabad –500 092, Telangana, India

*vishnurajmr@gmail.com

Sheep meat is one of the most cherished commodities in the livestock-based food industry due to its appealing texture and flavour properties. Nellore (Meat type) and Deccani (Meat and Wool type) are the prominent sheep breeds in southern states like Andhra Pradesh and Telangana. The mutton industry is witnessing huge supply pressure for higher quantity and better eating qualities. This research aims to evaluate the expression patterns of genes related to intramuscular fat content (IMF) and fatty acid (FA) metabolism to achieve optimised eating quality of meat in Nellore and Deccani breeds. Although genes play a vital role in governing meat quality, intrinsic factors like breed, sex, and age will influence their expression. The novelty of this work is that, for the first time, blood was used to evaluate the expression trends of genes related to IMF and FA metabolism, which helps in predicting the meat quality in the preslaughter stage. We have analysed the expression trends of the IMF and FA metabolism genes (FASN, LPL, FABP4, ACACA, C/EBP, PPARG, DGAT1, SCD) in Nellore and Deccani sheep breeds of three different age groups (<6 months, 6-12 months, >12 months) fed under semi-intensive feeding regimes, using RT-qPCR. The key findings of this study were that all the transcripts related to IMF and FA metabolism were upregulated in the Nellore breed compared to Deccani breed, except the C/EBP, which was evident from the good flavour and eating qualities of the Nellore breed. The FASN, LPL, ACACA, PPARG, SCD, and DGAT1 genes are significantly upregulated in the animals of the 6-12 months age group, and FABP4 and C/EBP were downregulated with age, which can be connected to the optimum age for slaughtering the animal. FASN, LPL, and PPARG were upregulated in females and downregulated in males. FABP4, ACACA, C/EBP, DGAT1, and SCD were upregulated in males and downregulated in females. Our findings showed that the differential expression of these genes can be used in precision livestock farming and breeding programmes to select the animals with optimised meat quality.

Keywords: Fatty acid metabolism, Gene expression, Intramuscular Fat, Meat quality, Sheep meat.

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Pregnancy detection in ruminants using urinary metabolites

Ashok K. Balhara[1]*, Suman Sangwan[1], Phulia, S. K.[1], Sunesh Balhara[1], Vikram, R.[2], Hussain, M.[3], Vijay Paul[3], Sajjan Singh[1], Sarkar, M.[3] and Datta T. K.[1]

[1]ICAR-Central Institute for Research on Buffaloes, Hisar-125 001, Haryana, India
[2] ICAR-National Research Centre on Mithun, Medziphema-797 106, Nagaland, India
[3]ICAR-National Research Centre on Yak, Dirang -790 101, Arunachal Pradesh, India

*ashok.balhara@icar.gov.in

Detection of pregnancy in ruminants using urinary metabolites is a valuable tool that allows early and non-invasive diagnosis. Pregnancy causes physiological changes that lead to alterations in metabolic processes, resulting in the appearance of specific metabolites in urine that can be used as pregnancy markers. 1H NMR-based non-targeted metabolomics was performed on urine samples obtained in controlled experimental series from four ruminant species, *viz*., Karan-Fries crossbred cows, Murrah buffaloes, Mithun and Yak. Retrospective classification of urine samples according to pregnancy status based on transrectal ultrasonography followed by NMR spectral analysis revealed 169, 162, 270 and 220 metabolites in cows, buffaloes, Mithun and Yak, respectively. In multivariate analysis and based on assessing the importance of variables (VIP), amine metabolites from phenylalanine, tyrosine-tryptophan metabolism, and tryptophan metabolism were identified as the most important metabolites. There was wide variation in the abundance and type of metabolites among the animal species studied. Qualitatively, the majority (approximately 75%) of metabolites were similar in all animals. Subsequent bioinformatic analysis of the identified metabolites revealed that these metabolites originated from metabolic pathways involved in fetal growth, specifically kynurenine, 5-hydroxytryptophan, 3-hydroxykynurenine, quinolinate, tyrosine, glycolate, myo-inositol, and anthranilate. In addition, these metabolites are mostly precursors or products of the metabolism of aromatic amino acids. Preg D and PregDM are prototype pregnancy detection kits that use some differentially expressed urinary metabolites and may be useful for use under field conditions.

Keywords: 1H NMR, Mithun, Pregnancy detection, Ruminants, Urinary metabolites, Yak

Theme: Livestock-based Transformation of Food Systems
Sub theme: Livestock Products, Health and Support Sciences

Nutritional composition of mithun (*Bos frontalis*) milk reared under semi-intensive system

Devi, L. S., Jyoti Jawla*, Hanah, S. S., Vikram, R., Haque, N., Khan, M. H., Girish, P. S. and Mitra, A.
ICAR-National Research Centre on Mithun, Medziphema-797 106, Nagaland, India
*jyoti1@icar.gov.in

Mithun (*Bos frontalis*), a unique and semi-domesticated bovine species found in the North-eastern states of India, has long been a part of the local culture and ecosystem. The recent official recognition of mithun as a food animal by the Food Safety and Standards Authority of India (FSSAI) has opened up new opportunities for the commercialization of mithun milk and meat. The present study examined the composition and nutritional value of milk produced by mithun reared under a semi-intensive model. The study analyzed the milk's chemical composition, fatty acids, amino acids, minerals, and vitamin profiles using standard methods. The results showed that fresh mithun milk contained (mean ± SEM) 7.3 ± 0.48% fat, 10.28 ± 0.13% solids-not-fat, 4.0 ± 0.05% protein, 5.7 ± 0.08% lactose, and had a density of 1.20 ± 0.01 g ml^{-1}. Gas chromatography analysis revealed that the milk contained 69.08% saturated fatty acids and 30.82% unsaturated fatty acids. The most abundant fatty acids were palmitic, oleic, stearic, and myristic acids, while linoleic 18:2 (n-6) and linolenic acids 18:3 (n-3) were the most abundant polyunsaturated fatty acids. The study also found that mithun milk was rich in essential amino acids, with glutamic acid, lysine, proline, and isoleucine being the most abundant. In addition, mithun milk was found to have a high concentration of vitamins A, D, and E, as well as calcium. These nutrients are essential for growth and development, and their presence in mithun milk makes it a valuable nutritional source for children and pregnant women. The study concluded that mithun milk could serve as a nutrient-dense food and contribute significantly to the nutritional security of north-east India.

Keywords: Amino acids, Chemical composition, Fatty acid composition, North-east India, Nutritional security

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 5

Horticulture-based Transformation of Food Systems

Fruit and Plantation Crops

Vegetable and Tuber Crops

Spices, Ornamental & Medicinal Plants

Nutraceuticals and Value Addition

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Diversity of jackfruit (*Artocarpus heterophyllus*) accessions of Goa

Maneesha, S. R.[1*], Priya Devi, S., Mathala, J. Gupta[3] and Ramesh, R.[3]

[1]ICAR-Indian Institute of Spices Research, Kozhikode, Kerala- 673 012, India
[2]ICAR-Indian Institute of Horticultural Research, Bengaluru-560 089, Karnataka, India
[3]ICAR-Central Coastal Agricultural Research Institute, Old Goa-403 402, Goa, India

*Maneesha.sr@icar.gov.in

Jackfruit (*Artocarpus heterophyllus* L.) is one of the significant fruits of the West Coast region of India. The jackfruit germplasm of ICAR—Central Coastal Agricultural Research Institute, Goa, has 45 accessions, including 22 named varieties and 23 local accessions, covering 13 firm flesh types, nine soft flesh types, and one intermediate type. The local accessions had huge fruit size, shape, and colour variability. The fruit weight of these accessions varied between 1.09 to10.62 kg with a mean of 5.48 ±2.41 kg. Fruit length ranged from 29.04 to 47.53 cm with a mean of 39.20±4.79 cm, and the mean fruit circumference was 58.38±6.91 cm, which ran between 38.78 and 70.25 cm. The number of bulbs in the fruit varied between 25 to 200 with a mean of 96.70±43.90. The mean bulb weight was 24.51±7.21 g, whereas the minimum bulb weight was 14.70 g, and the maximum was 41.81 g. Bulb length ranged between 4.50 and 7.89 cm, and the mean was 5.65±0.98 cm. The mean bulb width of the jackfruit accessions was 3.49±0.62 cm, which ranged between 1.97 and 4.51 cm. Bulb thickness was 4.38±1.14 mm, ranging from 1.99 to 6.50 mm. The mean seed weight was 6.01±1.33 g, in the range of 4.09 to 8.66 g. Fruit weight had a highly significant positive correlation with bulb width in the correlation analysis. The number of bulbs and bulb length were positively correlated with high significance. Fruit length positively correlated with fruit weight, fruit width, and number of bulbs. Seed weight positively correlated with fruit weight and negatively correlated with bulb thickness. Principal Component Analysis (PCA) showed that PC1, with the highest eigenvalue of 2.29, explained the most variance in the germplasm (25.48%), and PC2, with an eigenvalue of 1.75, explained 19.40% of the variance. The first five principal components explained 81.25% of the variability of the accessions. Fruit weight and bulb width were found as the most critical traits imparting variability in the jack fruit germplasm of Goa.

Keywords: Correlation, Diversity, Germplasm, Goa, Jackfruit, PCA

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Novel lncRNA from stone apple (*Aegle marmelos L.*) regulate the gene expression profile under stress

Kishor, U. Tribhuvan[1], Twinkle Mishra[1], Simardeep Kaur[2], Avinash Pandey[1], Bhadana, V. P.[1], Shashi Bhushan Choudhary[3], A. Pattanayak[1] and Binay K. Singh[1,2]*

[1]ICAR-Indian Institute of Agricultural Biotechnology, Ranchi-834 003, Jharkhand, India
[2]ICAR-Research Complex for NEH Region, Umiam-793 103, Meghalaya, India
[3]ICAR-National Bureau of Plant Genetic Resources, Regional Station Ranchi, Jharkhand-834 003, India

*binay.singh@icar.gov.in

Stone apple (Aegle marmelos L.) *is* a subtropical fruit tree of the Rutaceae family. It holds prominence in traditional medicine in the Indian subcontinent. We developed a comprehensive transcriptome dataset in Stone Apple comprising 40,886 unigenes with an N50 value of 2,289 bp. We further functionally categorized the unigenes into biological processes, molecular functions, and cellular components and discovered 9,174 perfect simple sequence repeats (SSRs), 2,167 transcription factors (TFs) from 69 families, 415 transcription regulators (TRs) from 27 families, 19 miRNAs from 12 families, 16,811 potential long non-coding RNAs (lncRNAs), and six functional endogenous target mimics (eTMs) in distinct lncRNA-miRNA interactions across the unigenes. Intricate regulatory networks encompassing lncRNA, miRNA, and their cognate target mRNA highlighted multiple regulatory nodes, unraveling lncRNA-miRNA-mRNA associations and lncRNA/miRNA-driven gene expression control in stone apple. The comparison between the expression patterns of selected drought-related lncRNA and their cognate target mRNAs supported the above findings in stone apple in drought. The study significantly enhances our understanding of stone apple genomics and offers a foundation for future omics-based studies and deploying climate-resilient strategies in the species.

Keywords: Drought, Genomics, lncRNA, miRNA, SSRs, Unigenes

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Factors influencing hyperhydricity associated with *in vitro* regeneration of coconut

Shareefa, M.*, Sreelekshmi, J. S., Maya lekshmi, Rajesh, M. K., Anitha Karun and Regi J. Thomas
ICAR-Central Plantation Crops Research Institute, Regional Station, Kayamkulam, Alappuzha-690 533, Kerala, India
*hishareefa@gmail.com

Hyperhydricity previously known as vitrification is the most common physiological disorder associated with plant tissue culture. Hyperhydricity in tissue culture causes severe setback in term of effort, loss of material and financial resources. In commercial plant micropropagation, losses of up to 60 % of cultured shoots or plantlets have been reported due to hyperhydricity, which reflects the importance of this problem. It is characterized by development of translucent glassy appearance of shoots, thickened, turgid and brittle leaves. Meagre information is available on the probable reasons for development of hyperhydricity in coconut. Therefore, identification of the factors responsible for hyperhydricity is an important step needed to achieve a successful regeneration technique in coconut. Various factors like effects of medium, types and concentration of cytokinin, culture vessels, various gelling agents, sucrose concentration and subculture frequency were evaluated to study its influence on hyperhydricity in coconut. Among different gelling agents, gellan gum resulted in more multiple shoots (6.2), followed by Clerigar (5.77) which was on par. However, number of hyperhydric shoots was more in cultures grown in media containing Gellan gum (3.9) followed by Clerigar (1.87). During shoot elongation stage, quality score (3) worked out based on the appearance of hyperhydric and normal shoots was highest in Clerigar and lowest hyperhydricity was recorded in agar (21%) followed by Clerigar (25%). Among the different culture vessels tested, minimum microbial contamination and lowest hyperhydric shoots were recorded in cultures grown in conical flasks with special stoppers as compared to jam bottles with polypropylene lids and magenta vessel. This could be due to the presence of the special lid having inner 'S' shaped structure plugged with cotton which allowed gas exchange, whereas tightly closed vessels reduced gas exchange leading to accumulation of ethylene gas levels inside the culture vessel. It is often reported that high concentrations of ethylene in closed culture vessels are positively correlated with hyperhydricity. Also, in case of delayed subculturing, solid media in both jam bottle and magenta vessel gradually turned liquid as a result of change in pH of the medium and exhaustion of nutrients. The excess water absorption by plantlets in culture could be the reason for conversion of cultures into vitrified status. Occurrence of hyperhydricity can substantially be reduced by frequent subculturing and reducing the number of shoots per vessel. This study contributes to our understanding regarding the factors influencing hyperhydricity and measures to overcome the issue.

Keywords: Coconut, Culture vessel, Gelling agents, Hyperhydricity, Immature inflorescence culture

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Pre-harvest bagging of litchi bunches enhances fruit quality

Sunil Kumar[1*], E. S. Marboh[1], S. K. Purbey[1], Alemwati Pongener[1], G. L. Sharma[2], C. S. Maiti[3], V. K. Sharma[4], Prakash Patil[5] and Bikash Das[1]

[1]ICAR-AICRP on Fruits, ICAR-National Research Centre on Litchi, Muzaffarpur-842 002, Bihar, India
[2]ICAR-AICRP on Fruits, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur-492 012, Chhattisgarh, India
[3]ICAR-AICRP on Fruits, Department of Horticulture, SASRD, Nagaland University, Medziphema Campus, Medziphema-97 106, Nagaland, India
[4]ICAR-AICRP on Fruits, College of Horticulture and Forestry, Dr.YSPUH&F, Khaggal, Hamirpur, Himachal Pradesh, India
[5]ICAR-AICRP on Fruits, ICAR-Indian Institute of Horticultural Research, Bengaluru-560 089, Karnataka, India

*mehtasunil98@gmail.com

Pre-harvest fruit bagging has emerged as a practical approach to improve fruit's appearance and quality and reduce disease and insect infestations. ICAR-National Research Centre on Litchi, Muzaffarpur, developed the technique of bagging litchi bunches and tested and evaluated at different centers of ICAR-All India Coordinated Research Project on Fruits. In the present investigation, litchi bunches were bagged on the tree using non-woven polypropylene white bags at 15 (T1), 25 (T2), and 30 days after fruit set (T3) and non-woven polypropylene pink bags at 15 (T4), 25 (T5) and 30 days after fruit set (T6). Non-bagged trees were used as control (T7)–bagging of fruit bunches of litchi cv. Shahi, Rose Scented and Dehradun were performed under ICAR- AICRP on Fruits at Medziphema, Ambikapur, and Neri respectively, from 2019 to 2022. Based on the pooled data analysis, it was found that bagging of fruit bunches with polypropylene pink bags at 25 days after fruit set (T5) at Medziphema and Neri enhanced fruit yield per tree and individual fruit weight, which was on par with bagging of fruit bunches with polypropylene pink bags at 15 days after fruit set. It was also recorded that fruits bagged with polypropylene pink bags at 15 and 25 days after fruit set significantly reduced the sunburn, cracking, and borer infestation incidence over the control. Data revealed that fruit bunches bagged with polypropylene pink bags at 25 days after fruit set (T5) resulted in best quality fruits with the maximum TSS and fruit size and lower acidity with pinkish red to red colour fruits. However, at Ambikapur (Raipur), bunch bagging with non-woven polypropylene white bags 30 days after fruit set was found to be promising to improve the colour and quality of fruits with reduced cracking, sunburn, and fruit borer infestation.

Keywords: Fruit cracking, Peel Colour, Polypropylene bags, Sunburn, Yield

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Virome analysis of nursery plants of two Indian grapevine cultivars employing high throughput sequencing

Gopi Kishan[1,2*], Susheel Kumar Sharma[2] and Virendra Kumar Baranwal[2]

[1]ICAR-Indian Institute of Seed Science, Kushmaur, Mau-275 103, Uttar Pradesh, India
[2]Advanced Centre for Plant Virology, Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India
*gopi.kishan1@icar.gov.in

Grapevine (*Vitis vinifera* L.*)* is a vital cash crop that faces a considerable challenge from biotic stresses, especially viruses, which lead to significant yield losses. More than 100 viruses and viroids have been reported so far, including leafroll disease-causing adenoviruses, closterovirus, Shiraz disease, rugose wood complex-associated vitiviruses, stem pitting- associated foveavirus, and fanleaf degeneration disease associated nepoviruses. Identification of these viral spectra in clonally propagated perennial crops like grapevine can be done through a robust high throughput sequencing (HTS) approach and bioinformatics tools. Grapevines being clonally propagated pose a higher risk of transmitting viruses and viroids through infected propagating materials. Virome analysis can help detect the presence of several viruses in grapevines, and such plants need to be eradicated to prevent further spread of the infection. In the current study, virome analysis of sample pools and single plants of nursery plants of Super Sonaka and Anushka cultivars in India identified 18 viruses and five viroids. Grapevine virus D, grapevine virus H, and grapevine leafroll-associated virus-7 have been reported for the first time in India. Grapevine virus A & grapevine virus L (vitiviruses), grapevine leafroll-associated virus-3 & GLRaV-4 (ampeloviruses) were the most predominant in all the grafted nursery plants based on the number of contigs, depth of coverage, and copy number. Infection of the viruses obtained in HTS data was confirmed through wet lab-based RT-PCR and sequencing. Using *de novo* assembly and reference-based mapping, 43 complete/near-complete genomes of the above identified viruses and viroids were reconstructed from the sequenced grapevine samples. The phylogenetic analysis indicated the possible introduction of identified viruses by importing infected planting materials, possibly escaping quarantine. The study showed the importance of HTS in detecting known and unknown viruses in plant propagules of clonally propagated perennial crops.

Keywords: Clonal propagation, Grapevine, High throughput sequencing, Virome, Vitiviruses,

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Invasion of exotic whiteflies (Hemiptera: Aleyrodidae) in India: Biosecurity, challenges and biocontrol strategies

Selvaraj, K.*, Sumalatha, B. V., Shylesha, A. N. and Sundararaj, R.

Division of Germplasm Conservation and Utilization, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru-560 024, Karnataka, India

*K.Selvaraj@icar.gov.in

Exotic insects threaten human health, jeopardize food supplies, endanger valued crop plants, risk economic losses, and disrupt ecosystem functions. As these insects are dispersed beyond their native ranges, they escape population-regulating predators, parasitoids, and pathogens. More than 100 exotic insect species have been reported from India, of which whiteflies and mealy bugs constitute the maximum. Most alien species of whiteflies are accidentally introduced along with their host plant due to plant trade, the small size of whiteflies, their cryptic nature, and immature stages attached to the host plant. Exotic invasive whiteflies (Hemiptera: Aleyrodidae) in India cause direct and indirect yield losses in agriculture, horticulture, and forestry crop plants. Around 25 years ago, the spiraling whitefly, *Aleurodicus dispersus* Russell, invaded and established many economically important crops in India. Within five years, seven whiteflies invaded India *viz.*, solanum whitefly, *Aleurothrixus trachoides* on 37 plant species; rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* on 45 host plants; nesting whiteflies, *Paraleyrodes bondari* on 34 host plants and *P. minei* on 25 host plants; legume feeding whitefly, *Tetraleurodes acaciae* on five host plants; palm infesting whitefly (PIW), *Aleurotrachelus atratus* on four host plants and woolly whitefly, *Aleurothrixus floccosus* breeding on guava. These invasive species are native to the Neotropical region, and humans likely mediate the most insidious spread of these species in India through the movement of infested seedlings. Species of exotic whiteflies with similar habits co-exist in more or less the same niche and have a similar pattern of growth and development. The intensity of infestation of RSW on coconut, banana, and oil palm, the woolly whitefly on guava, and the palm infesting whitefly and nesting whiteflies on coconut was severe. The exotic parasitoid, *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae) on RSW and *E. cubensis* on PIW, a predator *Apertochrysa astur* (Banks) (Neuroptera: Chrysopidae) and the entomopathogenic fungus, *Isaria fumosorosea* Wize (Hypocreales: Clavicipitaceae) play a significant role in reducing the population of these invasives. Economic analysis of the impact of conservation and augmentation of *E. guadeloupae, E. cubensis* and foliar application of *I. fumosorosea* and extensive extension activities like awareness cum training on biocontrol strategies for management of these invasive indicated that about `9500 per ha crop protection cost and 900 ml of pesticides per ha are being saved. This study reports a significant expansion of the geographic and host range and the patterns of co-occurrence, damage, and economic impact of these exotic species in India and their natural enemies.

Keywords: Co-existence, Colonization, Establishment, Host plants, Invasion, Natural enemies

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Litchi stink bug (*Tessarotoma javanica*): An invasive pest of litchi

Ipsita Samal[1]*, Vinod Kumar[2] and Bikas Das[3]
ICAR-National Research Centre on Litchi, Mushahari, Muzaffarpur- 842 002, Bihar, India
*ipsita.samal@icar.gov.in

Litchi (*Litchi chinensis*) is an evergreen subtropical fruit tree of the family Sapindaceae. Many diseases and insect pests infest litchi during the development and maturity stages. Over recent years, the dynamics of litchi diseases have changed, and newer pests have been reported. Litchi stink bug (*Tessaratoma javanica*) has recently invaded pests in the litchi orchards of Bihar, where it can potentially wipe out litchi cultivation from the state entirely. Pest was introduced in Bihar in 2018 when it was observed in some orchards in Damodarpur and Mirzapur villages of Mehsi Block in East Champaran District of Bihar. It has spread to orchards in many districts from a few orchards in the beginning years. In August-September, litchi is in the vegetative phase, and stink bug infestation is discernible in orchards. It caused losses of up to 80-100% in various orchards. The life cycle comprises of eggs (12.80 days) (mostly of 14 eggs ranging between 10 and 16 eggs per cluster), four nymphal instars (first, second, third, and fourth instars 11.69 days, 7.23 days, 8.63 days, and 13.04 days respectively) and adult stages. This pest was also reported to severely affect some other host plants of the same family, including kusum trees (*Schleichera oleosa*) from Jharkhand, Mahua (*Madhuca indica*) tree from Chhattisgarh and on longan (*Dimocarpus longan*) and rambutan (*Nephelium lappaceum*). Current management strategies rely heavily on insecticide sprays and two sprays of Thiacloprid 21.7% SC (0.5 ml l^{-1}) along with Fipronil 5% SC (1.5 ml l^{-1})/Profenophos 50% SC (1.5 ml l^{-1}) per liter of water. ICAR-National Research Center on Litchi, Muzaffarpur has recommended Lambda Cyhalothrin 5% EC (1.5 ml l^{-1}) with Chlorfenapyr 10% EC (1.0 ml l^{-1}). Although the biology and detailed life cycle of *T. javanica* were studied, and biocontrol agents, including egg parasitoids like *Anastatus bangalorensis* and *Anastatus acherontiae*, and entomopathogenic fungi like *Paecilomyces lilacinus* and *Beauveria bassiana* may have potential to manage the stink bug, only a few studies so far have been conducted. Thus, there is a need to understand the problems currently faced by litchi growers to emphasize ecological engineering promoting natural biological control.

Keywords: Biological control, Invasive pest, Litchi, Stink bug

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Transmission and real time detection of viruses (ApMV and ApNMV) associated with mosaic disease of apple (*Malus domestica*)

Sajad Un Nabi*, Javid I. Mir, Wasim H. Raja, Abas Shah, M., Muneer A. Sheikh, Salwee Yasmin, Shugufta Parveen, Om Chand Sharma

ICAR-Central Institute of Temperate Horticulture, Srinagar-191 132, Jammu and Kashmir, India

*sajad_patho@rediffmail.com

Among viral diseases, apple mosaic disease (AMD) is an economically crucial viral disease associated with apple cultivation, having widespread distribution and a significant threat to the apple industry worldwide. The mosaic symptoms pattern on the leaves has a direct bearing on the plant's photosynthetic ability, reducing it upto 46% and thereby reducing the fruit yield by 20-30%. Earlier, only apple mosaic virus (ApMV) was found to be associated with AMD. During the present study, we have applied high throughput sequencing of mosaic-infected apple cultivars. The results confirmed the association of a new virus ApNMV individually or in association with ApMV. To validate the results further, the presence of ApMV and ApNMV in various commercially grown cultivars showing mosaic symptoms were tested. The results showed that the association of ApNMV with mosaic disease was more common than ApMV. However, given the strong correlation between the ApNMV distributions among various cultivars, it is likely that ApNMV is a major cause of the mosaic symptoms in Indian apple cultivars. Reverse Transcription-Polymerase Chain Reaction (RT-PCR) and Reverse Transcription-Quantitative Polymerase Chain Reaction (RT-qPCR) were carried out to detect and quantify both the viruses in various plant parts of apple trees during different seasons. Both ApMV and ApNMV were seen in all the plant parts during the spring season using RT-PCR. Both viruses were detected only in seeds and fruits during summer, whereas in leaves and pedicel during autumn. The RT-qPCR results showed that during spring, the ApMV and ApNMV expression was higher in leaves, whereas in summer and autumn, the titer was highest in seeds and leaves, respectively. The leaves during spring and autumn, whereas seeds during summer season, can be used as detection material *via* RT-PCR for early and rapid detection of ApMV and ApNMV. Transmission was undertaken for ApNMV in mixed infection with ApMV, through grafting and budding, as both viruses are difficult to transmit *via* mechanical inoculation in apples. Eight and three rootstocks were used for grafting and budding respectively with scion wood from ApMV and ApNMV infected apple cultivar Golden Delicious. Development of mosaic symptoms was scored over time and symptoms were first seen on two rootstocks MM106 and MM111 after 60 and 280 days after grafting and budding respectively. The comparative transmission efficiency of mosaic associated viruses was found more in grafted plants (61.5%) than budded plants (25%) on three rootstocks studied in both approaches. Both the viruses were confirmed from grafted/budded plants through conventional RT-PCR using ApMV and ApNMV specific primers. Our results demonstrated that grafting/budding inoculation methods efficiently transmit both viruses (ApMV and ApNMV).

Keywords: Apple, Detection, High Throughput Sequencing, Mosaic, Transmission, Virus

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Tachinid research in india: Miles to go? A status report

Ramya, R. S*, David, K. J and Gandhi Gracy, R.

ICAR-National Bureau of Agricultural Insect Resources, Hebbal, Bengaluru-560 024, Karnataka, India.

*ramya.ento@gmail.com

With over 8600 described species worldwide and perhaps an equal number still undescribed, Tachinidae are considered to be among the most species-rich and morphologically diverse families of Diptera and represent the largest clade of insect parasitoids outside Hymenoptera.

The tachinid fauna of the Oriental region is much more diverse than indicated by its described species. It is known that there are many undescribed species in India. The last comprehensive cataloging work on this group in the Oriental region was by Crosskey (1976) who published "A Taxonomic Conspectus of the Tachinidae (Diptera) of the Oriental Region". Unfortunately, Indian contributions in the revisionary studies and newly described species in this fascinating group have been sparse in recent decades, which is glaringly dismal, given the biodiversity potential of our country. The number of described species from India after Crosskey's colossal publication is bleak, *i.e.*, 11 in the last 45 years. However, as a silver lining, this implies a horizon of opportunity for researchers to work on such a less-studied group. In our studies, we have reported new records of the following tachinids. *Senometopia* sp. recorded for the first time from *Pelopidas agna* (Lepidoptera: Hesperiidae), a pest of rice. *Trigonospila transvittata* was recorded for the first time from Tamil Nadu and southern India. *Senometopia quarta* (Baranov) reared from *Perixera* sp. (Lepidoptera: Geometridae), an inflorescence pest of cashew, was recorded for the first time from India. The genus *Aneogmena* was recorded for the first time in Maharashtra. *Aryrophylax cinerellus* Mesnil, which was reared from *Maruca vitrata*, was recorded for the first time from India. Expeditions and revisionary studies are to be revamped to augment the knowledge of Indian Tachinidae. Nuclear protein-coding genes outperform in insect phylogenetic analyses, and three such genes, MCS, MAC, and CAD are identified for their phylogenetic informativeness for studying Tachinidae. This illustrates the need to move ahead from the utilization of traditional genes like CO1 and 28S rDNA, to the use of the newly and specifically developed genes for phylogenetic studies to throw more light on the evolutionary relationships of an agriculturally important group of insects such as tachinids.

Keywords: Diversity, India, Parasitoid, Tachinidae

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Physiological approaches for improved post-harvest quality of fruits and vegetables under varied environments

Jeyakumar, P.*, Srividhya, S. and Rajeswari, V.

Department of Crop Physiology, Directorate of Planning and Monitoring, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India

*jeyakumar@tnau.ac.in

Fruit and vegetable production is potentially confronted by climate variability, especially drought, extreme temperatures, light, and salinity. Any post-harvest research must focus on maintaining quality and extending the shelf-life of crop produce between harvest and consumption, thus reducing post-production losses. The post-harvest treatments should be combined with appropriate management of storage temperatures, and there are several methods to prolong the storage life and to preserve the fruit quality. Application of plant growth regulators before and after harvest is one of the significant approaches in post-harvest management. Amino-ethoxy vinyl glycine (AVG) and 1-methyl cyclopropene (1-MCP) potentially extend the post-harvest storage life of horticultural crops. The hormone ethylene is involved in a wide range of physiological processes, including positive and negative effects depending on the desired use of crop produce. Among the positive effects, ethylene stimulates climacteric fruits' ripening process, resulting in desirable flavors, color, and texture. To avoid the detrimental effects of ethylene on vegetable and fruit quality and prolong their storability, the inhibition of ethylene biosynthesis and the removal of ethylene surrounding fruit and vegetables should be ensured. The biosynthesis and action of ethylene can be blocked by chemical compounds that modify ACS and ACO activities, blocking receptor sites, diversion of SAM through polyamine biosynthesis, or through ethylene removal. Some examples for ACS inhibitors are aminoethoxyvinylglycine (AVG) and aminooxyacetic acid (AOA), while α-aminoisobutyric acid (AIB) is a compound that depresses ACO activity. High rates of CO_2 have been inhibiting both enzymes and as an antagonist of ethylene action. The detrimental effects of ethylene on fruit and vegetables during post-harvest storage can be minimized at ethylene biosynthesis level using the pre-harvest application of AVG and the post-harvest application of polyamines. At receptor level, 1-MCP has been found as a potential ethylene antagonist in extending shelf-life and maintaining fruit and vegetable quality. The discovery of 1-MCP that inhibits ethylene perception by competitively binding to ethylene receptors is a breakthrough in controlling ethylene responses of fruits and vegetables. Research at Tamil Nadu Agricultural University in recent years exhibited promising effects of 1-MCP in specific concentrations for banana, mango, and papaya and AIB for banana. The new insights on ethylene biosynthesis, perception, and action will also help in the development of sustainable post-harvest technologies.

Keywords: Climate change, Ethylene action, Post-harvest physiology, Tropical fruits

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Price spread of coconut in Kozhikode District of Kerala, south India

Preethi, V. P.* and Anusree Padmanabhan, P. S.

ICAR-Central Marine Fisheries Research Institute, Ernakulam North P.O., Kochi, 682 018, Kerala, India

*preethipremvp@gmail.com

Marketing is predominant in agricultural development and is as important as production to any producer. Thus, an efficient marketing system can increase producers' income levels and enhance consumers' satisfaction. The marketing of coconut needs further attention in Kerala, as it serves the lives of more than 80% of the people in the state. This study was mainly focused on understanding the nature of the marketing channels, marketing costs, margins, price spread, producer's share in the consumer's rupee, and efficiency in the marketing of coconut in the Kozhikode District of Kerala. The results indicate that coconut was marketed majorly in the form of copra till the last few years. However, during the last 5 to 6 years, 70% of the produce being marketed was raw nuts due to a lack of storage facilities and fluctuating prices. Most wholesalers in the study area sell raw nuts in the Coimbatore market, Tamil Nadu, where they get comparatively a reasonable price. Four major marketing channels were identified in the study area (*i.e.*, I. Producer–Village Trader–Wholesalers–Retailers -Consumer, II. Producer–Wholesalers–Retailers–Consumer, III. Producer–Retailers–Consumer, IV. Producer–Copra Makers–Oil Millers -Wholesalers–Retailer–Consumer). Among these channels, channel III was the most efficient marketing channel, with a high-efficiency index of 5.2, low marketing costs (2.80), and a high producer's share in the consumer's rupee (88.24%). Around 30% of the sample respondents depended on this channel as the retailers in the local markets assured a fixed market for their produce at reasonable market prices. Around 37.5% of the farmers in the study area depended on village traders who purchase raw nuts in the non-husked form directly from farmers at one rupee more than the market price and bear all the costs, such as those incurred for transportation, loading, and unloading and de-husking which contributed more than 80% of the total marketing costs. Therefore, the most common marketing channel identified was channel I. However, it has a low-efficiency index of 3.9, higher marketing costs (8.40), and a lower producer's share in the consumer's rupee (77.14%), implying a high price spread. However, value addition at the farm level may help the producers secure a higher proportion of the final product price and reduce the price spread.

Keywords: Coconut, Marketing channel, Marketing cost, Price spread

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Impact of balanced and customized nutrient solution through enhanced efficiency fertilizers (EEF) on productivity, quality, soil health and climatic resilience in horticultural crops

Murlee Yadav*, Arvind Kulkarni, Naresh Deshmukh and Mahesh Girdhar

Mahadhan Agritek Limited, Sai Hira Building, Mundhwa Road, Pune – 411 036, Maharashtra, India

*murlee.yadav@dfpcl.com

Balanced crop nutrition ensures the application of fertilizers on 4R principles, *i.e.,* right ratio, right dose, right method, and right time, which results in the sustenance of soil health and an increase in crop productivity. It also enhances the tolerance of crops against abiotic and biotic stresses. However, as per the current scenario, farmers across the country are using nutrient ratios with huge variability, such as 3.5:1.8:1 in Maharashtra to 61.7: 19.2: 1 in Punjab against the ideal balance of 4:2:1. The nutrient response ratio is going down from 13.4 in the 1960s to 3.7 as of 2017 due to imbalanced and indiscriminate use of fertilizers, lesser use of organics, multi-nutrient deficiency, poor soil health and use of low-efficiency fertilizers resulting in low Nutrient Use Efficiency (NUE) and thereby lower productivity and poor quality of produce. Mahadhan Agritek Ltd. (MAL), conducted multilocation trials in the states of Maharashtra, Karnataka, Gujarat and Rajasthan for the development of Crop and Stage Specific Customized Water Soluble Fertigation Grades along with complete package using 20: 80 principle of nutrient ratio (soil *vs.* fertigation) for Grapes, Tomato, Pomegranate, Banana, Melons, Citrus, Potato, Sugarcane, Chilli and other fertigated crops. These Grades or complete package solutions were launched under the brand name "SOLUTEK" in 2020-21 for Grapes, Tomato, Pomegranate and in 2023-24 for Banana under the Solutek fertigation solutions, 80% nutrients go through Solutek Grades and 20% nutrients go through soil applied Enhanced Efficiency Fertilizers (EEF) powered by Nutrient Unlock Technology which are mentioned as: (A) Customized Water Soluble Grades for Fertigation: i. Solutek Grapes (Grade 1: 15:28:06+TE, Grade 2: 6:34:17+TE and Grade 3 6:00:37:16+TE); ii. Solutek Tomato (Grade 1:17:14:09+TE, Grade 2:13:12:19+TE and Grade 3 : 09:08:28+TE); iii. Solutek Pomegranate: (Grade 1: 08:44:07+TE, Grade 2: 10:22:20+TE and Grade 3: 5:10:35+TE), iv. Solutek Banana (Grade 1: 14:26:13+TE, Grade 2: 08:27:22+TE and Grade 3: 07:00:40+TE) and (B) Soil Applied Bulk fertilizers (Common for all crops): Enhanced Efficiency Fertilizers viz., Croptek 9:24:24 and Bensulf SUPERFAST. Overall, 'Solutek Solutions' in horticultural crops are not only increasing farmer's income by enhancing their crop productivity, quality and saving in input cost but also making their farm operation easy and convenient. 'Solutek Solutions' also help to improve the NUE significantly, saving significant quantity of nitrogen (62-67%) along with minimum percentage of amide nitrogen.

Keywords: Climatic resilience, Nutrient management, Productivity, Quality, Soil health

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Bottom-up effect (HPR) on plant-insect interaction in underutilized horticultural crops for sustainable production

Shravan Manbhar Haldhar*

Department of Entomology, College of Agriculture, Iroisemba, Central Agricultural University, Imphal-795 004, Manipur, India

*haldhar80@gmail.com

Plants and insects have been living together for more than 350 million years. In co-evolution, both have evolved strategies to avoid each other's defence systems. This evolutionary arms race between plants and insects has resulted in the development of an elegant defense system in plants that can recognize the non-self-molecules or signals from damaged cells, much like animals. It activates the plant's immune response against the herbivores. Differences in genotypes of plant characters may affect insect-plant herbivore interactions, and variations in genotype traits are responsible for modifying the bottom-up effects. Recent evidence shows that the simultaneous occurrence of abiotic and biotic stress can positively affect plant performance by reducing the susceptibility to biotic stress, a positive sign for pest management. Plant responses to these stresses are multifaceted and involve copious antibiosis, physiological, antixenotic, molecular and cellular adaptations. Plants with antibiosis characteristics, such as flavonoids, phenols, tannins and alkaloids, may cause reduced insect survival, prolonged development time, decreased size, and reduced new-generation fitness. Quality and quantity of constitutive secondary metabolites production is species and cultivar-specific and can be expressed as the signature of a particular plant or species and leads to host-plant resistance. Hence, such plant resistance mechanisms have been effectively and widely used for managing insect pests in fields of underutilized crops. Natural defenses are mediated through plant characteristics that affect insect biology, such as mechanical protection on the surface of the plants (*e.g.* hairs, trichomes, thorns, spines and thicker leaves) that either kill or retard the development of the herbivores. This phenomenon of host plant resistance to insects can be exploited to develop resistance crop cultivars, which readily produce the inducible response upon mild infestation and can perform as one of the integrated pest management strategy for sustainable crop production.

Keywords: Allelochemicals, Antixenosis, Insect, Host plant resistance, Underutilized crops

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Fruit and Plantation Crops

Smart food production: Future of Indian horticulture

Sonika Jaryal*, Sharma, M. K., Sundouri, A. S., Amit Kumar, Satpal, Rozin Khan and Saklain Mulani

Division of Fruit Science, Faculty of Horticulture, *Sher- e- Kashmir University of Agricultural Science and Technology, Shalimar – 190 025, Jammu and Kashmir, India*

*sonikajaryal250@gmail.com

Horticulture which includes cultivation of fruits, vegetables, spices and floriculture, has long been a key addition to the agricultural output of India. However, a transformation to more intelligent, effective production techniques is required to tackle the difficulties of climate change, resource limitation, and the need to fulfil the rising food demands of a growing population. Smart food production in Indian horticulture involves the integration of cutting-edge technologies such as precision agriculture, IOT devices, and data analytics. These tools enable farmers to monitor crop health, optimize irrigation, and manage pest control more effectively, ultimately leading to higher yields and resource conservation. This change places sustainability at the forefront, with an emphasis on organic farming, decreased chemical use, and environmentally friendly packaging. Sustainable gardening practises are a crucial market driver since consumers are increasingly looking for healthier and more environmentally friendly food options. Additionally, the adoption of cutting-edge cultivation techniques like hydroponics and vertical farming is gaining steam. These techniques enable year-round production in controlled environments while using less land and water. Adopting these innovations will not only ensure food security but also establish India as a world leader in environmentally friendly horticultural techniques.

Keywords: Food security, Precision farming, Organic, Smart horticulture

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Effect of growth regulators on dormancy breaking and yield in elephant foot yam *Amorphophallus paeoniifolius* (Dennst.) Nicolson

R. Muthuraj*, Saravanan Raju, Byju, G. and Jaganathan, D.

ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram-695017, Kerala, India.

*drrmuthuraj29@yahoo.co.in

Among the tropical tuber crops, elephant foot yam *Amorphophallus paeoniifolius* (Dennst.) Nicolson, is an important tuber crop grown in India that can adapt well to different climatic conditions. These tubers are consumed as vegetables after thorough cooking and chips are made out of these starch rich tubers. It is vegetatively propagated through corms and cormels. Freshly harvested corms cannot be used as planting material due to the presence of dormancy for a period of 3-4 months. The new sprout emerges from the corm after completion of dormancy breaking. Keeping this in view, the experiment was conducted at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram during 2016-17 and 2017-18 to study the effect of different growth regulators on dormancy breaking to induce early and uniform sprouting in elephant foot yam. There were fifteen treatments and were replicated thrice. Elephant foot yam corms were subjected with different treatments *viz.,* GA_3 100 ppm (T_1), GA_3 200 ppm (T_2), IAA 100 ppm (T_3), IAA 200 ppm (T_4), Thiourea 0.5% (T_5), Thiourea 1% (T_6), Potassium nitrate 0.5% (T_7), Potassium nitrate 1% (T_8), Carbon disulphide 40 ml @ 100 kg corm fumigated (T_9), Carbon disulphide 80 ml @100 kg corm fumigated (T_{10}), Combination of GA_3 200 ppm + Thiourea 0.5% (T_{11}), Cow dung slurry (T_{12}), Heat treatment for corm exposed at 40°c (T_{13}), Water treatment (T_{14}) and Control (T_{15}). After the treatment corms were planted in the field and recommended package of practices were followed in the experiment. The results revealed that elephant foot yam corm treated with carbon disulphide 80 ml @ 100 kg corm fumigated treatment produced higher uniform sprouting with 87.50 and 99.50% at 15 and 30 days after planting followed by carbon disulphide 40 ml per 100 kg corm fumigated, which produced sprouting of 85.50 and 96.50% at 15 and 30 days after planting. The plant growth parameters were also promoted with greater plant height (68 cm), stem girth (22 cm) and canopy spread (89 cm) recorded in carbon disulphide 80 ml fumigated treatment, followed by GA_3 200 ppm treatment at 60 days after planting. Significantly higher corm yield (21.82 t ha^{-1}) was obtained in the carbon disulphide 80 ml fumigated treatment, followed by carbon disulphide 40 ml fumigated treatment (17.50 t ha^{-1}) and GA_3 200 ppm treatment (16.96 t ha^{-1}). Carbon disulphide 80 ml fumigated treated corms produced significantly higher number of corms (17580 ha^{-1}), followed by GA_3 200 ppm treatment (15750 ha^{-1}). This technology is highly useful for seed entrepreneurs as it breaks the dormancy and saves 3-4 months time.

Keywords: Elephant foot yam, Dormancy breaking, Growth regulators, Planting materials

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Garden pea *Pisum sativum L.* as a new host for pineapple mealybug, *Dysmicoccus brevipes* Cockerell (Hemiptera: Pseudococcidae)

Gotyal, B. S.*, Choudhary, J. S., Joshi, S., Ramya, R. S., Lekhana, N and Shivakumara, K. T.

[1]ICAR-National Bureau of Agricultural Insect Resources (NBAIR), Bangaluru-560 024, Karnataka, India

*gotyalento@gmail.com

Garden Pea *Pisum sativum* L. belongs to the family Fabaceae and is widely cultivated throughout the world. The area under pea cultivation is 8.09 million ha with 16.21 mt production. India is in fourth position in the area of cultivation and fifth in terms of production and it is being grown in all the Indian states, mainly in Himachal Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Punjab, Haryana, Karnataka, and Bihar. Insect pests are one of the major biotic factors for the low productivity of pea in India, where its productivity is recorded less than 2.00 t ha^{-1}. A survey was made in the last week of November 2022 and pea plants showing dark circles on the stem near the ground surface with yellowing and wilting symptoms were noticed at ICAR-Research Complex for Eastern Region, Farming System Research Centre for Hill and Plateau Region, Ranchi, Jharkhand. Investigation on the presence of mealybugs on roots of infested pea plants was carried out and observations were recorded. It is observed that nymphs and adults were able to suck the sap from the roots of pea plants and the base of the stem near the soil surface. The mealybug infested roots were observed with dark circles and plants showing wilting symptoms. The infestation of mealybugs were observed in the month of November 2022 with 5% plant infestation in the early crop growth stage, where as the maximum of 45% infestation was recorded in the month of August 2022. Approximately 8-10 pea plants showing wilting symptoms were uprooted, observed the presence of the mealybugs on the roots. Mealybugs were collected from the four locations in the garden pea field and preserved in 70% alcohol then shipped to ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, for morphological and molecular identification. The adult female mealybugs were identified as *Dysmicoccus brevipes* Cockerell through morphological characters and also identity confirmed with molecular characterization using partial (658 bp) mtCO1 gene (Accession nos. OQ924104, OQ942254, OQ955830 and OQ992639). Both morphological and molecular studies indicate that the identity of the pineapple mealybug *D. brevipes* observed infesting pea in different locations of garden pea field, in Ranchi. For the first time this mealybug species is reported on garden pea as its new host plant. The observed level of damage indicates that this mealybug is a potential injurious pest and new threat to garden pea. Further detailed studies are needed to clarify its pest status, spread and to develop effective pest management strategies.

Keywords: Damage symptoms, *Dysmicoccus brevipes,* Identification, New host, *Pisum sativum*

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Detection, identification and chemo-sensitivity of seed borne pathogens in vegetable crop seeds

Tripathi, A. N.*, Tiwari, S. K., Singh, S. K. and Behera, T. K.

ICAR-Indian Institute of Vegetable Research, Varanasi-221305, Uttar Pradesh, India

*antripathi_patho@rediffmail.com, Atma.Tripathi@icar.gov.in

Seeds are basic input of vegetable production. Seed samples of different vegetable crops were subjected under incubation method for seed health evaluation to detect seed-borne/ seed-transmitted pathogens. Surface sterilized seeds of selected vegetable crops were plated @ 10 seeds on each Blotter Paper, Potato Dextrose Agar and Nutrient Agar petriplates. Seeded petriplates were incubated at 24±2 °C for 7-21 days. The incubated seeds were examined on the 8th day of incubation under stereo-binocular microscope at 6 to 50 x magnification and light compound microscope for detection and identification of seed borne pathogens. Seed health status of 226 seed samples of conserved/ stored seeds of brinjal (103), chilli (10), tomato (4), winged bean (90), dolichos bean (12), French bean, cowpea, pea, cabbage, bottle gourd, ash gourd, sponge gourd of vegetable crops were evaluated for seed health. Fungal pathogens were identified on the basis of habitat characteristics on blotter paper and colony morphology on Potato Dextrose Agar (PDA) however seed borne bacterial pathogens were identified on the basis of cultural characteristics on Nutrient Agar. Important seed borne fungal pathogens namely *Phomopsis vexans, Curvularia lunata, Alternaria, F. oxysporum, Macrophomina phaseolina* on brinjal; *Colletotrichum dematium, Alternaria spp., Fusarium solani* on chilli; *Alternaria* spp., *F. oxysporum* on tomato; *A. brassicae, A. brassicola* on cabbage and cauliflower; *Fusarium* spp., *Didymella brayoniae* on bottle gourd; *Macrophomina phaseolina, Phoma* sp., *Colletotrichum, Phomopsis, Fusarium* on cluster bean; *Sclerotinia sclerotiorum, Fusarium, M. phaseolina, Colletotrichum* on Indian bean, *Sclerotinia sclerotiorum* on French bean; *Fusarium, Alternaria* spp., *Macrophomina phaseolina* on cow pea and *A. pinnodes*, *A. pisi*, *B. cinerea*, *F. moniliforme*, *S. sclerotiorum* on pea were recorded. However, seed borne bacterial pathogens *viz*., *Xanthomonas axenopodis* pv *vesictoria* on brinjal (11%) and tomato (10%); *Xanthomonas compestris* pv *compestris* on cabbage (10%), *Pseudomonas* spp. on winged bean (33%) were recorded. Seed transmission of pathogens is the most important mode of long distance dissemination of pathogens. In view of this commercially available chemical, bio-agents and botanicals were applied as seed treating agents in bottle gourd (Kashi Ganga) @ 500 ppm kg^{-1} seed in which kurax (botanical) and azoxystrobin (23.5% SC) was found effective for enhancement of seed germination percentage up to 91.66% and 95% respectively, with comparison to control (70%). However, seed treatment with botanical namely phytotonic spotless, azadirachtin (nimbecidine) 0.03% EC and liquid micronutrient fertilizer have completely inhibited seed germination. Present study highlights various indicative aspects on this topical area are of paramount importance for vegetable seed pathologist towards profiling of seed borne pathogens and safer seed treatment for management of seed borne diseases (pathogens) for safe trans-boundary movement of seeds (seeds without border).

Keywords: Characterization, detection, incubation method, Seed-Pborne pathogen, seed treatment.

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Advance heat tolerant potato hybrids evaluation for yield and quality parameters for West-Central India

Murlidhar Sadawarti[1*], Gupta, V. K.[2], Samadhiya, R. K.[1], Singh, S. P.[4], Vinod Kumar[3], Subhash Katare[1], Singh, Y. P[1] and Dharminder Verma[3]

[1]Dept. of Agriculture , ICAR-Central Potato Research Station, Gwalior-474 006, Madhya Pradesh, India
[2]Dept. of Agriculture, ICAR-Central Potato Research Institute Campus, Meerut-250 110, Uttar Pradesh India
[3]Dept. of Agriculture, ICAR-Central Potato Research Institute, Shimla-171 001, Himachal Pradesh, India

*murlidharsada@gmail.com

Field trial was conducted under AICRP (Potato) at ICAR-CPRI, RS Gwalior MP during 2017–18, 2018–19 and 2019–20 with advanced potato hybrids viz. HT/7-1105, HT/7-620 and HT/7-1329 along with controls Kufri Lima, Kufri Surya, Kufri Khyati and Kufri Lauvkar in RBD with 3 replications during second week of October every year. Emergence among hybrids and varieties was >85.0%. Plant vigor was higher in Kufri Lima (4.4) followed by HT/7-1329 and Kufri Surya (4.0). At 60 days, all the hybrids except HT/7-620 recorded significantly higher tuber dry matter over Kufri Khyati (15.0%). At 75 and 90 days, 2 hybrids and controls except Kufri Khyati recorded significantly higher dry matter over hybrid HT/7-620 (17.4% for 75 days and 18.1% for 90 days). Total tuber yield of Kufri Lima (23.5 t ha^{-1}) followed by hybrid HT/7-1329 (23.4 t ha^{-1}) at 60 days at same level of GDD (Growing degree days) of 1134, Kufri Lima (32.4 t ha^{-1}) followed by Kufri Khyati (30.2 t ha^{-1}) and hybrid HT/7-1329 (29.4 t ha^{-1}) at 75 days at same level of GDD (Growing degree days) of 1291 and Kufri Lima (36.6 t ha^{-1}) followed by hybrid HT/7-1329 (35.6 t ha^{-1}) at 90 days at same level of GDD (Growing degree days) of 1426 recorded significantly higher or at par total tuber yield respectively than other controls/hybrids. Hybrid HT/7-1329 and Kufri Lima at 60, 75 and 90 days recorded highest economic return over other hybrids and varieties. Hence, Hybrid HT/7-1329 and variety Kufri Lima found to be most suitable for cultivation under early planting of hot prone areas of West-Central India for getting highest remunerative prices.

Keywords: Field trials, Hybrids, Potato, West-Central India

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Source and sink manipulation effects on physiological characters and yield of cucumber (*Cucumis sativus L.*) grown under polyhouse condition

Maharaj Singh* and Pradeep Kumar

ICAR- Central Arid Zone Research Institute, Jodhpur-342 003, Rajasthan, India

*maharaj.singh@icar.gov.in

Source-sink ratios were modified in cucumber (*Cucumis sativus* L.) by defoliation and deflowering to investigate the assimilation and role of assimilate supply and demand in regulating fruit growth. Plants of the cultivar Fadia and Gurka (52-32) F1 grown under polyhouse condition were subjected to 0%, and 50% defoliation and 50 and 100% deflower. Plants with 0% defoliation and deflower were treated as control. Defoliation treatments were given at the plant height of 1 foot when most of the plant were in full flowering stage. Defoliation and deflower of the plants significantly increased plant height, leaf and total plant dry weight, different physiological traits *i.e.*, SLA, NAR, and LAI relative to the fruited control. The maximum plant height was recorded with treatment T4 (50% defoliation and 100% deflower) in Fadia and T2 (100% deflower) in Gurkha variety. The maximum nodes per plant were counted with treatment T3 (50% defoliation) in Fadia and T4 (50% defoliation and 100% deflower) in Gurkha. Plant dry weight harvest was decreased with defoliation and deflower in Fadia while Gurkha showed increase in plant dry weight with defoliation and deflower. The leaf area index (LAI) and net assimilation rate (NAR) increased with defoliation and deflower treatment and its maximum value were recorded with treatment T2 (100% deflower) while specific leaf area (SLA) was maximum with treatment T4 (50% defoliation and 100% deflower). These different physiological traits showed positive correlation with fruit yield and fruit yield increased with defoliation and deflower treatment. Maximum Fruit yield in Fadia and Gurkha was recorded with treatment 100% deflower did at initial stage of growth. This treatment showed 22% increase in fruit yield in Gurkha and 15.9% in Fadia over control. In summary, preventing early fruit set by removing early flowers helps plant to grow healthier and later on ensure proper assimilate supply for good plant yield under greenhouse condition.

Keywords: Cucumber, Deflower. Defoliation, Source-sink ratio

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Insights into ogura cytoplasmic male sterility system expediting breeding of Indian cauliflower

Saurabh Singh*, Dey, S. S., Reeta Bhatia, Srija Priyadarsini, Raj Kumar and Behera, T. K.

Department of Vegetable Science, College of Horticulture and Forestry, Rani Lakshmi Bai Central Agricultural University, Jhansi-284 003, Uttar Pradesh, India

*horticulturesaurabh@gmail.com

Ogura-type cytoplasmic male sterility (Ogu-CMS) has been widely used in the hybrid breeding industry for cruciferous vegetables. CMS is a category of male-sterility resulted from a genomic conflict between the mitochondrial and nuclear genomes. Ogu-CMS was first discovered in Japanese radish and is now widely applied in the breeding of Brassicaceae crops including Indian cauliflower. Cauliflower (*Brassica oleracea* var. *botrytis* L.) is an important member of vegetable Brassicas grown worldwide. It has been an important contributor in human diet. Mitochondrial markers can be used to differentiate diverse mitotypes as well as cytoplasms in angiosperms. In India, during the last three decades, a large number of CMS-based breeding lines/material have been generated in Indian cauliflowers by repeated backcrossing or somatic hybridization by exploiting various CMS sources. In this context, the present investigation highlighted the utility of organelle genome-based markers in distinguishing cytoplasm types in Indian cauliflowers. Further, the CMS and doubled haploid (DH) based hybrid were developed and evaluated for different phenotypic and yield related traits. The three CMS lines Ogu118-6A, Ogu33A, Ogu34-1A were identified as good general combiner for developing early maturity hybrids. Less than unity value of σ^2A/D coupled with σ^2gca/σ^2sca indicated the predominance of non-additive gene action in the expression of studied traits. The cytoplasmic effects on varying nuclear-genetic backgrounds rendered an array of floral abnormalities like reduction in flower size, fused flowers, splitted style with the exposed ovule, absence of non-functional stamens, and petaloid stamens. These floral malformations caused dysplasia of flower structure affecting female fertility with inefficient nectar production. The finding provides an important reference to ameliorate understanding of mechanism of cytonuclear interactions in floral organ development in Brassicas. The results pave the way for expediting hybrid breeding of Indian cauliflowers and strengthening indigenous hybrid industry.

Keywords: Cauliflower, Cytoplasmic male sterility, Doubled haploid, Heterosis, Mitochondrial DNA markers

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Seed village programme for quality planting material production in Chinese potato

Muthuraj, R.*, D. Jaganathan, Sheela Immanuel and Byju, G.

ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram-695 017, Kerala, India

*drrmuthuraj29@yahoo.co.in

Chinese potato is one of the important minor tropical tuber crops grown in India. The tubers resemble potato in appearance and are consumed as vegetable after cooking The tubers contain 31-33% dry matter and 18-20% starch with a characteristic flavour which is preferred by the consumers due to 0.05-0.12% essential oils. The non-availability of quality planting materials at the time of planting continues to remain as a major stumbling block in the fast spread of high yield varieties and their adoption by the farming community. Small and marginal farmers are often at a disadvantageous position in adopting the agricultural technology related to genetic enhancement of production potential of Chinese potato. Hence, seed village programme has been attempted through action research in farmers' fields of Tirunelveli and Tenkasi districts of Tamil Nadu during 2018-2019 to 2020-2021 for enhancing the availability of quality planting materials for cultivation by farmers. A total of 50 farmers who had interest in taking up scientific interventions were selected for quality planting material production of Chinese potato. Improved variety of Chinese potato 'Sree Dhara' and critical inputs were supplied to the farmers for establishing demonstration plots under Seed Village Programme. Quality planting material of Chinese potato 'Sree Dhara' was supplied during the crop season from ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram to the farmers for proving its technical feasibility and economic viability. Field inspection of seed village demonstrations plots were conducted by multidisciplinary team from ICAR-CTCRI comprising scientists for ensure the health status of planting material. During the period quality planting materials and critical inputs were supplied to the farmers for establishing demonstration plots under Seed Village. Monitoring the seed crop, training to the farmers and field visit were carried out during the crop growth period. Random harvesting sample were collected from farmer field. The mean yield of the improved variety 'Sree Dhara' under seed village programme was found to be 5.06 t plot^{-1} (25.30 t ha^{-1}) which can fetch a gross income of ₹ 2.02 lakhs (₹10.12 lakhs ha^{-1}) if it is sold as seed tubers @ ₹40 per kg. A total of 252.25 t of seed tubers were produced by 50 seed growers in Tenkasi and Tirunelveli in five years. Which can cover an area of 1210 ha with 50% of produced seed tubers. Harvested tubers were distributed to the neighbouring farmers for establishing seed villages for meeting the demands of good quality planting materials of improved variety 'Sree Dhara' in the village. Seed village programme is continuing in Tenaksi and Tirunelveli districts of Tamil Nadu for improving the livelihood of the farmers through technological interventions. Large areas are expected to be covered under 'Sree Dhara' in the coming years for enhancing farm income and also to sustain the production of Chinese potato.

Keywords: Chinese potato, Farmers, Quality planting material, Seed village programme

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Superiority of F_1 hybrids over parents for fruit yield and its component traits in okra *Abelmoschus esculentus (L.)* Moench

Limbani, H. B.* and Mehta, D. R.

[1]Department of Genetics and Plant Breeding, College of Agriculture, Junagadh Agriculrural University, Junagadh-362 001, Gujarat, India

*limbani.hari101@gmail.com

The present investigation was conducted on heterosis for earliness related traits and fruit yield per plant in okra. Thirty-six F_1 hybrids were generated by half diallel (excluding reciprocals) mating design. These F_1 hybrids along with nine parents were evaluated in randomized block design with three replications during three seasons *viz*., *Early kharif* 2021 (E_1), *Kharif* 2021 (E_2) and *Late kharif* 2021 (E_3) at Instructional farm, Junagadh Agricultural University, Junagadh (Gujarat). The observations were recorded on five randomly selected plants from each plot for growth and fruit yield parameters *viz*., days to first flowering, days to first picking, days to last picking, number of pickings and fruit yield per plant (g). The highest standard heterosis was observed in AOL-12-59 x GO-2 in E_1, EC 169513 x GO-2 in E_2 and AOL-12-59 x VRO-6 in E_3 for days to first flowering; HRB-55 x GO-2 in E_1, EC 169513 x GO-2 in E_2; and HRB 108-2 x GO-2 in E_3 for days to first picking; IC 90107 x VRO-6 in E_1, IC 90107 x EC 169513 in E_2 and E_3 for days to last picking; HRB 108-2 x JOL-11-1 and EC 169513 x AOL-12-59 in E_1, IC 90107 x EC 169513 and IC 90107 x GO-2 in E_2 and IC 90107 x JOL-11-1 in E_3 for number of pickings and EC 169513 x GO-2 in E_1, HRB 108-2 x AOL-12-59 in E_2 for fruit yield per plant. The top five heterotic cross combinations *viz*., HRB 108-2 x AOL-12-59, HRB 108-2 x HRB-55, EC 169513 x GO-2, IC 90107 x EC 169513 and HRB 108-2 x EC 169513 were identified as desirable heterosis for fruit yield and other earliness related traits in one or another environment in okra.

Keywords: Fruit yield, Half- diallel, Heterosis, Okra

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Screening of brinjal (*Solanum melongena L.*) genotypes for tolerance to brinjal fruit and shoot borer

Pratap A. Divekar, Shailesh K. Tiwari* and Sarvesh Mishra

Division of Vegetable Improvement, ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India

*tiwarishail@gmail.com

The Brinjal Fruit and Shoot Borer (BFSB) (*Leucinodes orbonalis* Guenee) is a major and devastating pest that poses a significant threat to brinjal (*Solanum melongena* L.) production, causing substantial yield losses worldwide. Developing brinjal varieties with resistance to this pest is a sustainable and effective approach to mitigate the damage caused by the BFSB. This study aimed to assess the resistance levels of diverse brinjal germplasm lines representing diverse genetic backgrounds and geographic origins, against the BFSB and identify potential sources of resistance for brinjal breeding programs by observing their relative level of resistance under controlled conditions and involving the artificial infestation of plants with BFSB eggs and larvae at ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh. The parameters like percent shoot and fruit infestation caused by BSFB, number of infested shoots, the extent of fruit damage, larval survival and plant vigor and the further damage scale reported was selected for screening the different brinjal genotypes. The results of the screening revealed two lines exhibiting a high degree of tolerance, as evidenced by a low number of infested shoots, minimal fruit damage, and reduced larval survival. These were Selection-10, a promising line derived from Uttara showed least shoot (20.1 (29.8%)) and fruit (12.7 (6.4%) infestation, and the genotype CHBR-2, which showed higher shoot infestation (38.4 (32.2%) but lower fruit infestation (18.7 (21.4%). These resistant lines presented promising yield influencing features that could be harnessed for future breeding efforts aimed at enhancing resistance in commercially viable brinjal varieties/hybrids. Moreover, correlations between morphological traits and resistance are being explored for providing insights into potential markers for resistance selection. In contrast, susceptible germplasm lines displayed significant damage caused by the Brinjal Fruit and Shoot Borer, highlighting the urgency of incorporating resistance traits into breeding programs to ensure sustainable brinjal production. The higher shoot and fruit infestation was observed in the genotypes Punjab Sadabahar, Kashi Taru, Kashi Sandesh, Pant Rituraj and Kashi Uttam. The findings of this study emphasize the importance of germplasm diversity in sourcing resistance traits and lay the groundwork for the development of brinjal varieties with enhanced resistance to the BFSB. This research contributes to the identification of brinjal germplasm lines with varying degrees of resistance to the Brinjal Fruit and Shoot Borer. The genotypes Selection-10 and CHBR-2 can be utilized in the resistance breeding program against BSFB. The results underscores the potential of harnessing genetic diversity to develop brinjal varieties that can withstand the damaging effects of this pest. The resistant germplasm lines identified in this study hold promise for future breeding efforts and underline the significance of integrated pest management strategies for sustainable brinjal production.

Keywords: Brinjal, Brinjal Fruit and Shoot Borer, Germplasm, Screening for tolerance, *Solanum melongena*

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Influence of plant density and deblossoming on zombi pea (*Vigna vexillata*): An underutilized nutritious vegetable

Srija Priyadarsini*, Alok Nandi, Maniyam Nedunchezhiyan, Pushpajeet Choudhari, Saurabh Singh and Ajoy Pattnaik

Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar-751 029, Odisha, India

*srijapriyadarsini1226@gmail.com

Vigna vexillata belonging to the family Fabaceae is a potential and under-exploited legume known by several names *viz*., tuber cowpea, zombi pea and wild cowpea. This legume is distributed in major continents like Africa, Asia, Australia and America. Southern Africa and South-East Asia are reported as primary and secondary centres of diversity, respectively. In India, it is found in the hilly-subhilly tracts of peninsular India and in the Himalayan region. Protein content in tubers of *Vigna vexillata* was recorded up to eightfold higher than that in sweet potato and tapioca. It is a climate-resilient legume and reported as a source of biotic and abiotic stresses tolerance. In this context, a study was conducted at the ICAR-Central Tuber Crop Research Institute, Regional Centre, Bhubaneswar, during the winter season of 2021-22 in order to analyse the effects of plant density and deblossoming on performance of tuber cowpea. The trial was laid out in the Split plot design with 8 treatments and 3 replications. There were 4 levels of spacings (S_1-45 cm ×15 cm, S_2- 45 cm × 30 cm, S_3- 60 cm ×15 cm and S_4- 60 cm ×30 cm) in the main plot and 2 levels of deblossoming (F_1-flower removal and F_2-flower retention) treatments in the sub plot. Results revealed that maximum final plant height (69.03 cm), leaves/plant (11.13) and branches/plant (13.10) were observed in S_4. Highest leaf area/plant (545.95 cm^{-2}) was observed in S3. Maximum tuber length (16.17 cm), tuber girth (16.08 cm), fresh tuber weight (322.39 g), dry tuber weight (107.08 g), tubers/plant (2.6) and tuber yield/plant (121.85 g) were found in case of S_4. Highest tuber yield (150.85 q ha^{-1}) was obtained at the closest spacing S_1 (45 cm x 15 cm). Deblossoming resulted in maximum final plant height (72.45 cm), plant girth (3.31 cm), branches/plant (13.72), leaves/plant (11.81), leaf area/plant (592.62 sq.cm.), tuber length (16.07 cm), tuber girth (16.39 cm), tubers/plant (2.47), fresh weight of tuber (363.02 g), dry weight of tuber (124.55 g), tuber yield/plant (129.94 g) and tuber yield ha^{-1} (120 q ha^{-1}). Among the interactions, maximum tuber yield/hectare was produced in S_1F_1(158.14 q ha^{-1}).

Keywords: Agro-morphological traits, Deblossoming, Plant density, Tuber vegetable, Zombi pea

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Farmer participatory demonstration on site specific nutrient management in chinese potato cultivation in Tamil Nadu

D. Jaganathan*, Byju, G. and Muthuraj, R.

ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram-695 017, Kerala, India

*djaganathtn@gmail.com

Chinese potato *Plectranthus rotundifolius* (Poir), Spreng, is one of the important minor tropical tuber crops grown in India and the tubers resemble potato in appearance, consumed as vegetable after cooking which has an aromatic flavour and delicious taste. It grows well under tropical and sub tropical conditions. The tubers contain dry matter (31-33%) and starch (18-20%) with a characteristic flavour due to essential oils (0.05 to 0.12%). It is mainly cultivated in Kerala (Thrissur, Palakkad, Kasaragod and Kannur), Tamil Nadu (Tirunelveli, Tenkasi, Tuticorin, Virudhunagar and Kanyakumari) and in tribal settlements throughout the country. Chinese potato has high yield potential per unit area and is highly profitable and remunerative crop for the farmers. The ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI), Thiruvananthapuram, has developed climate smart practices *viz*., Site Specific Nutrient Management (SSNM) in Chinese potato for major growing states of India for enhancing the productivity and profitability. The on-farm experiments and trials of these technologies have given significant results with regard to tuber yield, quality of tubers, saving of fertilizers and reduction in cost of cultivation. Owing to this success, farmers' participatory demonstrations on SSNM in Chinese potato *var.* Sree Dhara were conducted for two consecutive years during 2021-2022 and 2022-2023 crop season involving partners' *viz*., Chinese potato growers, scientists/staff of ICAR-CTCRI, officials of state department of horticulture and media, through action research in farmers' fields of Tenkasi and Tirunelveli districts of Tamil Nadu. Customized fertilizer formulation developed based on SSNM technology and foliar liquid micronutrient formulations were applied along with the recommended package of practices. Skill development of farmers on climate smart practices and farm advisory visits were conducted for monitoring the growth and yield performance. The yield and overall economic impact of SSNM in Chinese potato demonstrated in both the districts of Tamil Nadu revealed that there was 12.79% yield increase in SSNM fields (19.05 t ha^{-1}) over farmers' practices (16.92 t ha^{-1}). Similar trend was observed in SSNM fields for gross income (11.75%), net income (16.38%) and benefit cost ratio (7.65%) in comparison to farmers' practices. Total cost of cultivation for SSNM fields was ` 1.25 lakh $ha^{-1}$ and for the farmers' practices it was `1.20 lakh ha^{-1}. The productivity and profitability of Chinese potato cultivation with SSNM increased significantly over the farmers' practices. Farmers opined that SSNM resulted in robust vegetative growth of the plants, absence of nutrient deficiencies, higher yield, good shape and size of tubers and increase in the weight of tubers. Strengthening the partnership/linkages with stakeholders, issuing of soil health cards, promotion of participatory research and extension advisory services will ensure sustainability of Chinese potato farming in Tamil Nadu and in other states of India.

Keywords: Chinese potato, Climate smart, Farmer participatory demonstration, Site Specific Nutrient Management

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Performance of improved varieties of cassava in two agro-ecological units of Kerala, south India

Muthuraj, R.*, James George, Sunitha, S. and Sheela, M. N.

ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram-695 017, Kerals, India

*drrmuthuraj29@yahoo.co.in

Cassava is an important source of energy in the diet of tropical countries of the world. It has enormous potential in India for food security and industrial uses due to its ability to grow in marginal and waste lands where other crops do not survive. Commercial planting of cassava is done from stem cuttings and because of the low multiplication rate as compared to cereals and pulses, the high yielding varieties released in the research institute takes many years to reach the farmers. Over the years, clonal multiplication degenerates the planting material, reduce tuber yield drastically and renders the cultivation of cassava uneconomical. An attempt was made to see performance of improved varieties of cassava in Mattathur grama panchayat of Thrissur district which falls under Northern laterites Agro Ecological Unit 11 (AEU11) and Vellamunda panchayat of Wayanad district under Wayanad Central Plateau Agro Ecological Unit 21 (AEU 21) of Kerala. The programme was implemented under the project on Development of Tuber Crops financed by Govt. of Kerala during 2014-15 and 2015-16 undertaken by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala. Hundred farmers were selected from Mattathur Krishi Bhavan of Thrissur District and fifty farmers from Vellamunda Krishi Bhavan of Wayanad district area. Quality planting materials of improved varieties of cassava from ICAR-CTCRI viz., Sree Jaya, Sree Vijaya, Sree Pavithra, CTM 820 and CTM 806 were distributed to farmers for covering an area of 10 cents of each, thus covering a total of 6 ha area. The cultivation of cassava was carried out the under the guidance and the direct supervision of ICAR-CTCRI Scientists under rainfed conditions. Farmers got an average tuber yield 5.40 kg and 3.70 kg per plant with an average number of tubers 6.30 and 4.68 per plant in Mattathur and Vellamunda respectively. Improved varieties of cassava produced significantly higher average tuber yield of 66.67 t ha^{-1} and 45.68 t ha^{-1} at Mattathur and Vellamunda respectively. In both the location farmers could also produce 1.50 lakhs stems of improved varieties of cassava from 6 ha area within one season which were distributed to neighboring farmers and near by districts for covering an area 60 ha.

Keywords: Cassava, Farmers, Multiplication, Quality planting material

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Protected agriculture for enhancing farmers' income in coastal region

Singh, R. K.*

Hydrology and Engineering Division, ICAR-Indian Institute of Soil and Water Conservation, Dehradun-248 195, Uttarkhand, India

*Rajesh.Singh@icar.gov.in

Traditional crop husbandry today is not considered as a chosen profession by youth due to high risk, low profitability, high level of drudgery, and low level of self-esteem. Though, protected cultivation is capital intensive but has potential not only to increase the productivity of vegetables by many folds but also improves the quality of vegetables with higher input use efficiencies. Apart from controlling microclimate other objectives of greenhouse farming are maintaining the right carbon dioxide levels, water, controlling pests and providing plant nutrients in right amount. In India, the area covered under protected agriculture including mulching is 2.15 lakh ha. Rice, spices, plantation and vegetable crops are the main crops of the coastal region. Rice equivalent yield (REY) of rice-rice cropping system ranged from 7.5 to 9.5 Mg ha^{-1} whereas REY of rice-vegetable system is between 14 and 15 Mg ha^{-1}. The yield gap of 0.5 to 2.6 Mg ha^{-1} exist in traditional cropping practices. The goals of "Produce More with Less" and "More Crop per Drop" can be realized by adoption of greenhouse technology. The naturally ventilated bamboo framed greenhouse has been designed for high rise vegetable production for coastal region. The greenhouse has the gutter height of 4.57 m (15 ft) to maintain a uniform greenhouse-microclimate and to avail maximum space for crop (cucumber, tomato) growth. The roof angle of 19.26° was provided to ensure good water drain-off during the rainy season. In addition, bamboo side hoe keys were used to break the centre of gravity (cg) of wind loads acting on the side column, allowing it to withstand wind speeds of up to 140 km/h. The area cover under the greenhouse was 740 m^2. The dead load, live load (300 N/m^2) and wind load (IS: 875 (Part 3)-1987) were considered in structural analysis of different bamboo greenhouse members viz. side columns, middle columns, bottom chord, grits, top purlins, middle purlins and end purlins, principal rafter and struts. Force analysis revealed that the bending stress due to wind load is 72.27 MPa on the side column (outer diameter = 95 mm and wall thickness 10 mm) which was within permissible limit of bending strength of Kalak bamboo (80.1 MPa). Cost of construction, including foggers and drip system was Rs. 800 m^{-2}. Tomato, capsicum and cucumber crops can be taken in the naturally ventilated greenhouse. Soilless cultivation offers a better control of plants nutrition and diseases due to its capability to control water availability, pH and nutrients concentration in root zone. Nematode problem and other soil borne diseases were completely eliminated in soilless culture. The most common types of media used was cocopeat (also referred as coco soil) which is natural fibre made of coconut husks. Fruit yield for tomato, cucumber and capsicum were 140–180, 150–180 and 70–80 quintal per 1000 m^2, respectively and overall B:C ratio of 2.4 was obtained for the production system. It is possible to get back the investment on greenhouse within a period of 2 years.

Keywords: Coastal region, greenhouse, cropping system, soilless cultivation

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Horticultural Crops: Potential for developing functional foods and nutraceuticals

John Zachariah, T.*, Sivranjani and Nirmal Babu, K.
ICAR-Indian Institute of Spices Research, Kozhikode-673 012, Kerala, India
*zacjohntj@gmail.com , nirmalbabu30@gmail.com

The primary responsibility of a diet is to provide enough nutrients to meet metabolic requirements while giving the consumer a feeling of satisfaction and well-being. Functional food contains bio-active components which are extra nutritional constituents that typically occur in small quantities that are primarily believed to give health benefits beyond their nutrient content. Bio-active components like polyphenols, polysaccharides, flavonoids, peptides, and saponins offer versatile health-promoting properties. Horticultural crops such as fruits, vegetables, plantation crops and spices are excellent store house of nutraceuticals which need to be exploited as functional foods so as to reap more benefits for the same crops based on their potential. Nutraceuticals are the substances which are not traditionally recognized nutrients but which have positive physiological effects on the human body. Nutraceuticals include different kinds of products such as dietary supplements, functional beverages, genetically engineered foods, herbal/ protein/ minerals/vitamin supplemented products and other processed products. Eating habits and trends in food production and consumption, coupled with changing life styles, have health, environmental and social impacts. Diet has implications on gut health, overgrowth and imbalance of intestinal microbial flora, and consequent health issues. Functional foods are the foods that provide benefits beyond basic nutrition and play a positive role in reducing or minimizing the risk of certain diseases, enhancement of immunocompetence, improving health and well being. Contributory factors and health benefits are discussed in detail.

Keywords: Bio-active components, Fruits, Functional foods, Nutraceuticals, Vegetalbles, spices

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Vegetable and Tuber Crops

Intercropping of seed spices with pomegranate (*Punica granatum*)

Meena, S. S.*, Lal, S., Meena, M. D., and Sharma, Y. K
ICAR- National Research Centre on Seed Spices, Tabiji, Ajmer- 305206, Rajasthan, India
*ssmnrcss5@yahoo.com

The traditional farming systems, currently in vogue in semi-arid and arid regions of the country, are largely subsistence in nature and are need based. Besides, they are not necessarily efficient in utilization of resources for a given location. This leads to loss of precious natural resources. Sustainability and profitability of framing systems particularly of marginal and small holding facing serious challenges due to declining trend of per capita low availability and shrinking size of operational holdings. To overcome this a field experiment was carried out during 2016-17 to 2019-20 at ICAR-NRC on Seed Spices, Ajmer to investigate the response of intercrop combination (seed spices with pomegranate) for increasing productivity, sustainability and profitability. The experiment comprises of 11 treatments *viz*., Fenugreek + Pomegranate, Coriander + Pomegranate, Nigella + Pomegranat, Anise + Pomegranate, Ajwain + Pomegranate, Sole Fenugreek, Sole Coriander, Sole Nigella, Sole Anise, Sole Ajwain and Sole pomegranate are laid in randomized block design with three replications. Results based on three years pooled data revealed that, out of the eleven different treatments, sole crops treatments alone recorded highest yield compared to inter crop treatments, however after perusal of data related to economics of production it was observed that fenugreek + pomegranate inter cropping was found most remunerative as it recorded highest net returns and B: C ratio (Rs.2, 52580 and 2.45). Thus inter cropping of fenugreek with pomegranate is suggested for getting higher net return and B: C ratio, higher system productivity and profitability.

Keywords: Intercropping, Pomegranate, Profitability, Seed spices, System productivity

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Constraint analysis of seed spice farmer in Rajasthan

Meena, M.*, Shiv Lal, Meena, R. D., Choudhary, N., Jangid, C. K. and Triphati, G. K
ICAR-National Research Centre on Seed Spice, Ajmer-305206, Rajasthan, India
*Murlidhar.Meena@icar.gov.in

Research and development in agriculture witnessed significant progress in delivering advanced technologies. This has brought significant changes in agriculture and spices as well in terms of increased production and productivity. But these technologies are of little relevance if it doesn't reach to farmers' level. The slow pace of dissemination and lower adoption of available technologies by farmers is the major challenges in agriculture today. To study such challenges in spice farming a study was conducted during 2021-22 by ICAR-NRCSS Ajmer. A questionnaire containing sixty constraints classified into five categories as Input constraints, Technological constraints, Marketing constraints, Financial and mechanical constraints and Administrative constraints was prepared. A primary survey of more than 160 seed spice growers from Ajmer, Jaipur, Nagaur, Badmer and Jhunjhunu districts of Rajasthan was carried out to identify the major constraints in seed spices cultivation. Constraints identified were ranked following the relevancy rating technique. The high cost of labour during the peak season, High and rising cost of chemical fertilizers and High cost of improved variety seeds were identified as the top three Input constraints. Lack of awareness and knowledge of new technologies, Lack of insect and disease resistant varieties and Lack of pest and disease management knowledge was identified as the top three technical constraints faced by farmers. Lack of minimum support price in seed spices, High price fluctuations and Lack of market information were identified as the top three marketing constraints. Inadequate crop insurance coverage, High cost of agricultural machinery and Lack of awareness about various departmental subsidy schemes were identified as the top three Financial and mechanical constraints. Lack of technical guidance from extension staff, Less effort and favouritism by extension personnel, shortage of trained manpower for technology transfer and young generation having low interest in spice farming were identified as top Administrative constraints. The study highlighted calls for higher mechanisation in seed spices, MSP in seed spices, dedicated markets for spice and deployment of more extension personnel for the transfer of technologies.

Keywords: Constraint, Rajasthan, Seed spice

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Insecticidal activities of *Lantana camara L.* leaf essential oil against cigarette beetle *Lasioderma sericorne*

Aisha, K. P., Visakh, N. U. and Berin Pathrose*

Department of Agricultural Entomology, College of Agriculture, Kerala Agricultural University, Thrissur-680 656, Kerala, India

*berin.pathrose@kau.in

Cigarette beetle *Lasioderma serricorne* (Coleoptera: Anobiidae), is a major pest infesting stored spices, tobacco and other food products. Management of stored product pests relies heavily on fumigants and other chemical pesticides, leading to the development of insecticide resistance and residue of pesticides in agricultural commodities. An ecofriendly management option suggested for managing storage pests is the use of essential oils because of its contact fumigant, and repellent toxicity. *Lantana camara* L., a flowering plant species belonging to the family Verbenaceae is a noxious weed that grows readily in tropical and subtropical habitats. It is an evergreen shrub that spreads rapidly by its abundant seed and shallow crown buds. The leaves of this weed can be valorised for the production of essential oil based biopesticide for the management of storage pests. Our study aimed at extracting and characterising the essential oil from the leaves of *L. camara* and to evaluate its bioactivity against *L. serricorne*. The essential oil extracted (yield of 0.24 ± 0.014%) from the leaves of *L. camara* was chemically characterized by gas chromatography-mass spectrometry (GC-MS). GC-MS characterization revealed that caryophyllene (69.96%), isoledene (12.1%), and copaene (4.11%) are the major chemical constituents of *L. camara* leaf essential oil. The essential oil was found to have high fumigant toxicity (at 24 h, LC_{50} 4.14= mg/L air and at 48 h, LC_{50} =2.50 mg/L air), contact toxicity (at 24 h, LC_{50} = 0.48% and at 48h, LC_{50}=1.36%), and repellency (36.6%, 52.3%, 57.4%, 59.8%, 66.2% repellency at a concentration of 0.1, 0.2, 0.3, 0.4 and 0.5%, respectively) against *L. serricorne*. The potent bioactivity of essential oil from the leaves of a noxious weed opens up the possibility of utilising the plant to produce biopesticide for the management of *L. serricorne*.

Keywords: Cigarette beetle, Contact toxicity, Essential oils, Lantana camara, Lasioderma serricorne

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Nutritional and phytochemical profiling of potential edible flowers with scope for value addition

Sheron Fernandez*, Simmy, A. M., Shajma, N. B., Lakshmi, P. S., Shilpa, P., Aswathi, S. V. and Rashida, C. K.

AICRP on Floriculture, Department of Floriculture and Landscaping, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur-680 656, Kerala, India

*sheron.fernandez@kau.in

Human palette cherishes novel food items which are of natural and varied origin. Substitution of artificial colours with those from natural origin can create a great impact in food industry. Edible flowers are one among the novel foods which is gaining tremendous attention in these days of changing food habit. Even though flowers are rich source of minerals, antioxidants, vitamins, fibres etc., some flowers are toxic to human beings making the choice of these flowers in our diet complicated. Flowers are a good source of carbohydrates, dietary fibre, crude proteins, flavonoids, ascorbic acids, fatty acids and minerals. They are also rich sources of phytochemicals having antioxidant, anti-cancer, anti-inflammatory, anti-diabetic, anti-cholesterol, anti-viral properties. Hence a study has been conducted to observe the mineral constituents, crude fibre, total phenol, anthocyanins as well as anti-nutritive factors like tannins, oxalates and nitrates. The flowers selected include Ashoka (*Saraca ashoka*), Bauhinia sp. (*Bauhinia purpurea, Bauhinia blakeama*), Cassia (*Cassia fistula*), Gulmohar (*Delonix regia*), Pogostemon (*Pogostemon benghalensis*), Tephrosia (*Tephrosia purpurea*), Celosia (*Celosia argentea*), Tagetes sp. (*Tagestes erecta, Tagetes patula*), Cosmos (*Cosmos sulpheurus*), Balsam (*Impatiens balsamina*), Gomphrena (*Gomphrena globosa*), Lotus (*Nelumbo nucifera*) and Water Lily (*Nymphaea odorata*). The results revealed that Pogostemon had high mineral content, mainly calcium (7.74 mg 100 g^{-1}), iron (1.65 mg 100 g^{-1}), zinc and phosphorous. While the *Tagetus sp* had high flavonoid content 266.57 mg 100 g^{-1} l^{-1} and protein content 11.79%. Tannin content of ornamental flowers ranged between 7.50 to 65.20 mg 100 g^{-1}. Oxalate content was found to vary from 26.25 to 676.38 mg per 100 g of DW of the flowers. Nitrate content varied between 6.95 to 242.68 mg 100 g^{-1} DW of the flowers. Crude fibre, proteins, phenols and monomeric anthocyanin content of analysed flowers also gave promising results.

Keywords: Antinutritive factors, Edible flowers, Nutritive content, Phytochemicals, Value addition

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Studies on drying characteristics and quality evaluation of cloves (*Syzigium aromaticum*)

Jayashree, E.*, Alfiya, P. V., Anees, K. and Murali Manohar, P.
ICAR-Indian institute of Spices Research, Kozhikode- 673 012, Kerala, India
*jayasree.iisr@gmail.com

The clove of commerce is the dried aromatic fully grown unopened flower buds of the clove tree (Syzigium aromaticum) belonging to the family Myrtaceae. Cloves have been used in India since ancient times as a culinary spice. Clove is also used in medicine as carminative, stimulant and digestive and the oil is used as ingredient for many tooth pastes and mouth washes. The present work was aimed to determine the drying characteristics of cloves and to evaluate the quality of dried clove. The fresh cloves were collected from farmers field near Thottilpalam at Kozhikode District. About 500 g of clove buds were spread on a perforated stainless steel tray and the experiments on drying were done in a convective hot air type dryer at four different temperatures ie. 45, 50, 55 and 60°C until a constant mass was obtained. The dried cloves were evaluated for various physical and biochemical quality characteristics. The drying characteristics curves were drawn and the data was fitted to different drying models. The experimental data for moisture loss was converted to moisture ratios and fitted to five thin layer drying models to describe the drying process mathematically. The results were compared for their goodness of fit in terms of coefficient of determination (R^2), root mean square error (RMSE) and mean square of deviation (c^2). The Two-term exponential was found most suitable to describe the drying process of mace. Drying of clove was completed in 76, 72, 54 and 48 h when dried at 45, 50, 55 and 60°C, respectively. The quality analysis of the dried clove revealed that maximum retention of essential oil content (11.2%) and oleoresin content (16.90%) was obtained when clove was dried at 55°C.

Keywords: Drying, temperature, Model, Moisture ratio, Spice

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Ornamental flowers: Potential for future food and health, an investigation

Simmy, A. M.[*], Sheron Fernandez, Shajma N. B., Rashidha, C. K., Aswathi, S. V. and Shilpa, P.

AICRP on Floriculture, [2]Department of Floriculture and Landscaping, College of Agriculture, Vellanikkara, Kerala Agricultural University, Kerala, India.

*simmy.am@kau.in

Edible flowers are one such component among the novel foods which are gaining tremendous attention among people nowadays worldwide. Edible flowers are flowers that can be eaten and can be preserved for future use using techniques such as drying, freezing, or steeping in oil. They can be used in jellies, salads, soups, syrups, and many other dishes. Even if the nutritional and medicinal value of some of the edible flowers has been evidenced through various experiments and surveys, more and more flower sources are to be explored. The present preliminary study is focused on the analysis of nutritional and antinutritional properties of selected flowers belonging to shrubs and climbers, viz., *Hibiscus rosa-sinensis*, *Hibiscus acetosella, Malvaviscus arboreus, Ixora coccinea*, *I. singaporensis*, *I. duffy, Melastoma malabathricum, Eranthemum capense, Abelmoschus moschatus subsp. tuberosus, Bougainvillea glabra, Pavetta indica, Clitorea ternatea* and *Jasminum sambac*. Physiochemical properties such as iron, calcium, zinc, phosphorus, and fiber content, phytochemical constituents such as total flavonoid and total phenol content and monomeric anthocyanin, and anti-nutritional factors such as oxalates and tannins were analyzed. The results of the investigation showed that flowers are good sources of minerals like Iron (0.13–0.41mg/100g), Calcium (0.17–5.8 mg 100 g^{-1}), Zinc (0.03–0.62 mg 100 g^{-1}), and Phosphorus (0.67–5.13 mg 100 g^{-1}), fibers (0.09 – 2.95%), phenols (138.79–1654.25 mg 100 g^{-1} GAE), and flavonoids (33.66–213.36 mg l^{-1} Gallic acid) and monomeric anthocyanin (0–175.24 mgl c3 g eq). Antinutritional factors like tannin (2.75- 44.25 mg 100 g^{-1} TAE) are also present in these flowers. Further studies are needed to explore different types of nutrients and phytochemicals in these flowers. There is enough scope for value addition of these flowers into food as well as nutraceuticals.

Keywords: Anthocyanin, Edible flower, Phenol, Phytochemical, Tannin

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Unveiling the genetic integrity of *in vitro* induced micro rhizomes and their progenies in ginger: Implication for sustainable cultivation

Sharon Aravind*, Chaithanya, K. C., Nisthar, E., Kandiannan, K., Mukesh, S. S. and Sheeja, T. E.

ICAR-Indian Institute of Spices Research, Kozhikode-673 012, Kerala, India

*sharonrvnd@gmail.com

Ginger is primarily propagated through rhizomes and availability of disease-free planting materials as well as the desiccation of seed materials during storage are the major constraints limiting its productivity. The micro rhizomes of the ginger variety IISR Varada were induced *in vitro* from multiple shoots that had been regenerated after four subcultures. The shootlets were then inoculated into a micro rhizome induction medium consisting of basal MS with sucrose (9%), agar (7 g l^{-1}), and BAP (0.5 mg l^{-1}) and incubated for 180 days. The micro rhizomes of 2.0- 2.5 g weight and 2-3 cm length were harvested from the culture bottles, acclimatised and planted in grow bags, which constituted the first-generation plants (V_1). The harvested rhizomes were stored in the cold room and served as seed material for the next generation (V_2). The performance evaluation of the first and second-generation progenies revealed the successful establishment of first-generation micro rhizomes in grow bags and second-generation micro rhizomes in the field. The mean fresh rhizome yield (495.45 ± 40.41 g) per plant and mean rhizome thickness (2.13 ± 0.04 cm) were superior in second-generation plants when compared with first-generation grow bag plants (377.70 ± 40.41 g mean fresh rhizome yield with 1.70 ± 0.04 cm mean rhizome thickness). The mean plant height (87.43 ± 2.31 cm) was more in first-generation plants (V1) as compared to the second-generation plants (V2) (74.85 ± 2.16 cm). Whereas, more number of tillers (26.26 ± 1.50), leaves (22.90 ± 0.93), length (24.56 ± 0.69 cm) and width of leaves (2.67 ± 0.07cm) were produced in second-generation plants (V2) than the first-generation plants (V1). The *in vitro* induced micro rhizomes were screened using SSR and ISSR markers and compared with the mother plant, various stages of subcultures (5-8) and subsequent generations (V_1 and V_2). Five SSR primers (ZOC 11, ZOC 28, ZOC 92, ZOC 98, ZOC100) and five ISSR primers (IS 02, UBC 813, UBC 840, UBC 857, ISSR 02) were used for the study. A total of 343 bands were produced, with sizes ranging from 100-3100 bp. Comparison of two generations of progenies of micro rhizomes with mother plant and *in vitro* subculture stages revealed monomorphic nature and true-to-type status of micro rhizome derived plants under *in vitro* as well as in field conditions. The above protocol is thus validated to be very useful for micro-propagation, germplasm conservation and genetic transformation studies in ginger and related species.

Keywords: Genetic transformation, Germplasm conservation, Ginger, *In vitro*

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Commercial farming of African marigold in Ernakulam District: Towards enhancing farmer's income during Onam festival

Shoji Joy Edison* and Shinoj Subramannian

ICAR-KVK Ernakulam of Central Marine Fisheries Research Institute, Narakkal, Ernakulam, Kerala, India

*shojijoy@gmail.com

Onam is the state festival of Kerala and demand for flowers is at it's peak during this season. It is estimated that daily requirement of flowers during Onam is 6 to 10 tons per day. At present, lion share of the flower requirement comes from neighbouring states. The preference in Onam market is for yellow and orange African marigold, globe amaranth, oleander, chrysanthemum and rose. Among these, farmers of Kerala prefer farming yellow and orange African marigold (*Tagetes erecta* L.). Marigold is cultivated in an area of around 247 ha in Kerala. Approximately 20,000 marigold plants can be accommodated in 1 ha and the crop duration is 105 days. One plant yields 200-250 g flowers that amounts to productivity of 4 to 5 ton/ ha. This productivity is low compared to the productivity of 8-10 ton/ha in neighbouring states. The yield gap can be managed by adopting appropriate package of practices and timely cultural operations. Floriculture being a new introduction, farmers require training and technology backstopping. Hence, the KVK Ernakulam conducted a series of training programmes in the district during the years 2022-23 and 2023-24 wherein total of 375 farmers got trained on marigold production technology. Alangad, Karumallur, Nayarambalam, Kottuvally and Pallippuram were the areas in Ernakulam district selected for floriculture demonstrations. Wetland fallow area of 34 ha could be covered by floriculture during the year 2023-24. Farmers were advised to plant the seeds by 10th May so that transplanting can be done by the first week of June in order to get crop at the right time for the Onam season. Farmers were also advised to go for hybrids instead of low yielding open pollinated varieties. Timely pinching (removal of apical bud to initiate lateral sprouts) to induce more flowering was recommended. The bacterial wilt disease incidence was 11%. The farmers were advised to remove affected plants and apply dolomite at the rate of 100 g m^{-2} to surrounding plants in addition to spraying of 0.2%. Copper oxy chloride solution and drenching of 0.3% bleaching powder. Average productivity recorded was 4.6 t ha^{-1}. Farm gate marketing was encouraged and the farmers got a farm gate price of Rupees 120 kg^{-1} whereas the average retail price during Onam season was Rupees 80/Kg. The total cost of cultivation per ha was `1.8 lakhs and the benefit cost ratio was 2.4. Flower crops like globe amaranth, oleander and small red rose can also be recommended along with African marigold in order to enhance the marketability due to availability of colour choices.

Keywords: African marigold, Commercial farming, Floriculture, Kerala, *Tagetes erecta*

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Optimization of process parameters for spray dried ginger-lime juice powder using RSM and physicochemical evaluation of the dried powder

Alfiya, P. V.*, Jayashree, E., Jinto Sebastian and Thankamani, C. K.
ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India
*alfiya.pv@icar.gov.in

Optimization of process parameters of spray dried ginger-lime juice powder was performed using response surface methodology. Based on preliminary studies, ginger extract containing 20% lime juice was diluted to 1.5 times with distilled water with required levels of maltodextrin (independent variable) was used as the feed liquid for spray drying. The drying experiments were performed according to a second-order Box-Behnken design (BBD) with three factors at three levels: maltodextrin concentration (20, 25 and 30 %), inlet air temperature (130, 150 and 170°C), and blower speed (2100, 2200 and 2300 rpm). The response variables were moisture content of the powder (%), yield of the powder (%) and solubility (%). Bulk density and tapped density of the spray dried ginger – lime juice powder samples varied from 315 – 425 kg m^{-3} and 555 – 683 kg m^{-3} respectively. Carr index and Hausner ratio of the samples varied in range of 26 – 31.2 and 1.2 – 1.4 respectively indicating the powders to be highly cohesive with intermediate flowability. Moisture content of the powder varied from 2.12 – 4.36 %. Porosity and hygroscopicity varied from 0.63 – 0.764 and 53.16 – 54.41% respectively. Water solubility and water absorption index of the ginger lime juice powder varied from 83.2 – 93.6 % and 0.99 – 1.07 respectively. Essential oil and oleoresin content of the optimized sample varied form 0.2 – 0.4 and 2.6 – 3.5% respectively. Hygroscopicity of the powder varied from 52.51 and to 54.41 %. Dispersibility of the powder varied in range of 0.726 to 0.855. Water solubility of the powder varied from 68.85 to 92.2 %. Water absorption index of the powder varied from 1– 1.04.

Keywords: Bulk density, Carr index, Hausner ratio, Water absorption index, Water solubility

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

IISR-DNA fingerprinting facility: Crafting the genetic score of spice symphony

Mukesh Sankar, S*., Vijesh Kumar, I. P., Divya, P. S., Shivakumar, M. S., Gobu, R. and Sheeja, T. E.
ICAR-ICAR-Indian Institute of Spices Research (ICAR-IISR), Kozhikode, Kerala, India
*mukesh.genetics@gmail.com

The ICAR-Indian Institute of Spices Research (ICAR-IISR), houses the world's largest repository of spices, comprising more than 5000 accessions. Within the facility, researchers have developed suitable molecular marker systems to identify parental lines, landraces, and wild relatives, alongside released varieties, enforcing proprietary rights over major spice varieties and germplasm. By combining morphological and DNA-based markers, a dependable methodology has been established to differentiate varieties to ensure their authenticity, thus reinforcing intellectual property rights concerning germplasm and varieties. In this context, IISR-DNAFF has facilitated varietal registration through CVRC, affirming the distinctiveness of over 30 spices varieties *via*., DNA profiling over the past five years. Additionally, the facility has created unique qRT-PCR expression-based biomarkers *viz*., *CIPKS11*, *CIPAL2*, *ClOMT2*, and *ClOMT3*– catering to qualitative traits like curcumin in turmeric. The facility also detects potential adulterants in cinnamon using two SNP-based nucleotide substitutions at *rbcL* loci, effectively distinguishing *Cinnamomum verum* (true cinnamon) from *C. cassia* (Chinese cinnamon). A similar approach for identification of adulterants such as wild pepper berries (*Piper galeatum* and *P. attenuatum*), powdered papaya seeds, or paprika in black pepper and adulterants of turmeric such as *C. zedoria* and cassava starch are currently available. Furthermore, the center has devised ISSR markers for distinguishing true All spice *viz*., *Pimenta dioica* from a related species, *Pimenta racemosa*, and various nutmeg cultivars, that are commercially important. DNAFF also facilitates farmer's in authentication of their varieties as well as for certification of licensed varieties of spices under commercial production. A dedicated effort is directed towards developing DNA barcodes for different Indian black pepper varieties, differentiating them from potentially inferior quality lots from Srilanka and Vietnam following whole genome-based approach. This initiative is expected to support the legacy of Indian spices in international trade. Moreover, the facility has progressed in formulating molecular protocols encompassing DNA extractions from spice crops, DNA marker optimization, fingerprinting, and gene cloning. It has significantly contributed to the education of more than 25 researchers and students during past five years, thereby substantially enhancing the facility's value and impact. The facility is open for similar services to researchers in crops other than spices too.

Keywords: DNA barcoding, DNA profiling, IISR-DNAFF, Molecular markers, Spices

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Valorisation of leaf waste of *Curcuma angustifolia* as a bio-insecticide against cigarette beetle *Lasioderma serricorne*

Angel Paul, Visakh, N. U. and Berin Pathrose*

Department of Agricultural Entomology, College of Agriculture, Kerala Agricultural University, Thrissur-680 656, Kerala, India

*berin.pathrose@kau.in

Botanical biopesticides, which are derived from plants or plant extracts, have a wide range of uses in agriculture, horticulture, and pest control. These biopesticides are valued for their relatively low environmental impact and reduced toxicity to humans and non-target organisms. *Curcuma angustifolia* is a rhizomatous medicinal herb belonging to the family Zingiberaceae. The plant is used in various traditional remedies for ailments, including stomach discomfort, diarrhea, and more. After the harvest of rhizomes, the other plant parts, like leaves, are discarded as waste. The discarded leaves can be valorised by extracting essential oil that can be a potent source of biopesticide for managing insect pests of storage, such as cigarette beetle, *Lasioderma serricorne*. The leaves collected after the rhizome harvest were subjected to hydrodistillation, yielding 0.39±0.02% (v/w) of essential oil. The GC-MS characterization of extracted essential oil revealed that curzerenone (25.32%), α-Elemenone (13.59%), and eucalyptol (11.58%) as the major components present in the oil. The essential oil was tested for its contact, fumigant and repellent toxicity against *L. serricorne*. The study's findings indicate that the test insect displayed significant repellency when exposed to various concentrations of *C. angustifolia* essential oil. Specifically, the repellency percentages observed at different essential oil concentrations were 45.5%, 51.5%, 57.5%, 60.3%, and 62.6% repellency at a concentration of 0.1, 0.2, 0.3, 0.4, and 0.5%, respectively. It also showed better contact toxicities (at 24 h, LC_{50}= 0.22% and at 48h, LC_{50}= 0.12%) and fumigant toxicities (at 24h, LC_{50}=10.8 mg l^{-1} air and at 48 h, LC_{50}=7.09 mg l^{-1} air). Thus, it was found that the oil extracted from the waste leaves of *C. angustifolia* have potential as a biopesticide against the storage pest *L. serricorne*.

Keywords: Cigarette beetle, Contact toxicity, Curcuma angustifolia, Essential oils, Fumigant toxicity

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Future of Indian cardamom, farmers, and farming in the cardamom hill reserves (CHR), Kerala, India

Murugan, M.*, Anil Kuruvila, Thomas George, Indira Devi, P., Sachu, S. S. and Alan, J. S.
Cardamom Research Station, Kerala Agricultural University, Pampadumpara, Idukki—685 553, Kerala, India
*muthupeyan@gmail.com

A farmers' survey was carried out to understand what is afflicting (present realities) in Indian cardamom, farmers and farming in the CHR hot spot, Kerala. Globally, Indian cardamom [*Elettaria cardamomum* (L.) Maton] is one of the few most valued spices because of its uniqueness in aromatic, spicy, pungent, and sweet lemony characteristics of its capsules. The utility of cardamom has been expanding to every country; thereby, envisaging a greater scope for higher demand and requirement by major importing countries. Intrinsic chemical quality of cardamom produced in southern India is superior to others. The export concentration indices showed that cardamom exports were getting increasingly concentrated in few export markets over the last many years. One of the most stable markets for India's cardamom exports till 2017-18 was Saudi Arabia that India lost because of pesticide residue issues which has to be resolved to regain our export market. EU and the US market have been lost because of pesticide residue load in cardamom. Exports of cardamom are also getting diversified to the UK and the US as well Asian countries like Japan and Bangladesh, for which also, India needs to formulate specific policies for promotion of export oriented production. Results of the Policy Analysis Matrix revealed that the Indian cardamom was less competitive in the international market, but the country has comparative advantage in production over other countries. Reducing the cost of production and improving the quality of cardamom could enhance the competitiveness of Indian cardamom in the international market. International demand for quality cardamom is expanding; therefore, the future potential is immense. Total cost of production in the sample farms (180) varied from ₹11, 91,837 ha^{-1} to ₹3, 13,174 ha^{-1}, with an average cost of cultivation of ₹5,94,666 ha^{-1}. Input cost on labors (36%), chemicals (33%) and manures and fertilizers (33%) contribute the most. Despite the higher cost of cultivation, cardamom farming was found to be profitable. The asymmetric increase in surface air temperature (maximum and minimum) coupled with other weather and environmental factors play critical role in cardamom pollination, phenology, physiology and yield. Increased incidence and intensity of pests and diseases will be more likely in the coming years due to ongoing climatic change.

Keywords: Climate, Export, Indian cardamom, Market price, Pesticides, Sustainability

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Biochemical diversity of leaves and fruits from *Garcinia* species

Krishnapriya, N. P.* and Anees, K.

Division of Crop Production and Post Harvest Technology, ICAR-Indian Institute of Spices Research, Kozhikode-673 571, Kerala, India

*krishnakpkichus@gmail.com

Garcinia, a member of Clusiaceae family, has a wide range of therapeutic applications. It may prevent fat deposition, inflammations, tumours and dermatitis. This species is also well known for its wide varieties of phytochemicals. *Garcinia* species such as *Garcinia gummi-gutta* (L.) Robs., *Garcinia indica* (Thouars) Choisy., *Garcinia kydia* Roxb., *Garcinia Xanthochymus* Hook. f., *Garcinia celebica* L. *Garcinia lancifolia* L. were selected for the biochemical profiling. The current study, for the first time reports the biochemical profiling of both the fruits (separately for pericarp, pulp & seed) and leaf at various developmental stages (mature and immature). Biochemical parameters such as Hydroxy citric acid (HCA) content, antioxidant activity (DPPH), contents of carbohydrate, protein, crude fat, ash content, moisture content, total flavonoids, total phenols were studied. Dried samples were used for analysis of crude fat and ash. All the other analysis was done using fresh samples. HCA content of the fruit rind from test species varied from 1.42% to 9.4 %. Carbohydrate content variation was 1.68 -3.73% (mature leaf) and 0.49 to 3.49% (immature leaf). The maximum carbohydrate was observed in pericarp for *G. celebica* L and *G. gummi-gutta* (L.), while it was maximum fruit pulp for *G. indica*, *G. kydia*., and *G. lancifolia.* Flavonoid content in leaves was maximum in *G. xanthochymus* (0.835%) and minimum in *G. lancifolia* (0.128%). Except in case of *G. indica*, young leaves exhibited less flavonoids than mature leaves. The fruit analysis of flavonoid content revealed that *G. xanthochymus* in both mature and immature form had significantly higher amount of falvanoids (mature-2.25% immature-2.05%), while it was minimum in case of *G. lancifolia* (mature-0.26% immature-0.29%). It was worth to note that immature pulp of *G. xanthochymus* did not contain flavonoids. Except in cases of *G. celebica* and *G. xanthochymus* polyphenol content was more in mature leaf than that of young leaves. In all the tested species, seed contain significantly higher amount of polyphenol when compared to pulp and pericarp. Maximum polyphenol content was observed in *G. celebica.* Protein partitioning among the three fruit parts was found to be positively skewed toward seed in all the species. The knowledge about the variation in biochemical parameters is a starting point for nutraceutical applications of this high value compounds for future studies.

Keywords: Biochemical analysis, *Garcinia,* Hydoxy citric acid

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Orchids of India: Time to start claiming its legitimate place, ICAR-NRC for Orchid's perspective

Sankar Prasad Das*, Suman Natta, Siddhartha Sankar Biswas, Chandan Gowda, H., Kalaivanan, N. S., Dipankar Saha, Ashok Kumar and Lakshman Chandra De

ICAR-National Research Centre for Orchids, Pakyong-737 106, Sikkim, India

*Sankar.Das@icar.gov.in; Director.nrco@icar.gov.in

India is home to 1256 orchid species belonging to 155 genera, out of which 388 species are endemic to this part of the globe. Today orchids are occupying a prime position in global floriculture owing its explicit diversity in flower shape, size and colour; long shelf life, year round production of different species. The advancement of orchids to become one of the top 10 flowers in the world was due to the tremendous development in inter-specific and inter-generic hybrids of orchids, advancement of micro-propagation techniques and optimization of controlled growing conditions for economically important genera for year round production of cut flowers and potted flowering plants. Today global cut flower trade alone generates revenue of US $ 28,891.5 million and expected to grow up to US $ 47,965.5 million at a CAGR of 5.8% by 2030. Orchids represent 10% of the total global cut flower trade, left aside the huge turnover of potted orchids and legal and illegal orchid species trade. India, unlike most established orchid growing countries globally such as Thailand, Netherland and Taiwan; can grow all types of orchids: temperate, sub-tropical and tropical, very successfully owing to its agro ecological diversity. In spite of that India's share in orchids trade is negligible. Considering the scope and potential of Orchids in the country, ICAR-National Research Centre for Orchids, Pakyong, Sikkim was established by ICAR on 5th October, 1996 based on the recommendations of the Planning Commission during VIII Five Year Plan. Keeping the aspiration of the Government and the country as whole, the ICAR-NRCO has the following perspective to put orchids of India in its much deserving and awaited place to harness the potential of this sector. (1). NRCO should act as National custodian of orchid genetic resources, breeding pipelines & economically profitable and sustainable production technologies. (2). To conserve orchid resources of India; collection, characterization and evaluation for economic utilization. (3). To develop marketable hybrids, preferably new inter generic / inter specific combinations of indigenous orchids and production of quality planting material. (4). To develop complete POP of production, protection and post-harvest handling to produce quality flower / potted plants at competitive cost. (5). To work closely with the stake holders to establish viable and sustainable orchid value chains in the country. In the present paper the road map for putting orchids of India to its deserving place in the global orchid trade will be discussed.

Keywords: Cut flower, Floriculture, Micro-propagation, Orchids

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Enhancing vase life of *Dendrobium* cut flowers through carbendazim-mediated metabolic inhibition

Siddhartha Sankar Biswas*, Suman Natta, De, L. C. and Das, S. P. *

[1]ICAR-National Research Centre for Orchids, Pakyong, Sikkim-737 106, India

*siddssac20475@gmail.com, Sankar.Das@icar.gov.in

The quest for extended vase life in premium cut flowers is a paramount concern, as it directly influences consumer satisfaction and market demand. *Dendrobium* hybrid cut flowers, renowned for their captivating form and vibrant hues are no exception to this pursuit. Altered properties of the vase solution play a pivotal role in dictating the longevity of cut flowers. This study was undertaken to augment the vase life of *Dendrobium* Emma White cut flowers using diverse chemical solutions, encompassing six distinct treatments: T_1 (Control)–Double distilled water, T_2–500 mg l^{-1} $Al_2(SO_4)_3$ (AS_{500}), T_3–0.1 M oxalic acid solution (OA), T_4–0.1 M NaOH solution (NaOH), T_5–200 mg l^{-1} Carbendazim solution (C_{200}), and T_6–400 mg l^{-1} Carbendazim solution (C_{400}). Remarkably, the cut flowers subjected to the C_{400} treatment exhibited a notable ~ 6.6% and 6.5% elevation in relative fresh weight, a striking ~113% and 138% surge in vase solution uptake rate, and a compelling ~38% and 37% reduction in metabolic activity at 12 and 15 days of the study, respectively, when compared to the control treatment. The C_{400} solution further demonstrated an absence of fungal growth, coupled with an astonishing 444% decrease in bacterial population and an exceptional 700% reduction in osmotic potential compared to the control treatment. Consequently, the flower spikes immersed in the C_{400} treatment boasted a prolonged state of freshness, distinctly surpassing their counterparts subjected to other treatments. As a culmination of these findings, the flower spikes treated with C_{400} showcased an impressive 28.7, 17.7, 16.3, 17, and 7.8% extension in vase life over those treated with the control, AS_{500}, OA, NaOH, and C_{200} solutions, respectively. In summation, the application of 400 mg l^{-1} carbendazim emerges as a compelling strategy to enhance the vase life of dendrobium hybrid cut flowers. This result holds significant promise for the floricultural industry, offering a means to cater to the desires of consumers and further elevate the appeal of these exquisite floral specimens.

Keywords: $C_{400,}$ Dendrobium, Metabolic inhibitors, Orchids, Vase life

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Orchid elegance in a bottle: Exploring *in vitro* flowering

Anu Seng Chaupoo, Siddhartha Sankar Biswas, De, L. C., Suman Natta, Dipankar Saha, Chandan G. H. and Das S. P.*
ICAR-National Research Centre for Orchids, Pakyong—737 106, Sikkim, India
*siddssac20475@gmail.com; Sankar.Das@icar.gov.in

In vitro flowering is an enchanting phenomenon which unfolds within the confined space of tissue culture bottles under meticulously aseptic conditions. While flowers are undeniably among nature's most captivating creations, orchids, with their distinctive and alluring blossoms, occupy a prestigious place among the world's most traded cut flowers. The study of *in vitro* flowering in orchids opens the door to a realm where flower induction and morphogenesis are meticulously scrutinized within a controlled environment. This innovative approach offers a unique opportunity to delve into the intricate details of orchid flowering, from the inception of blossoms to the development of floral organs and their eventual senescence. The protracted juvenile phase that orchids often endure can be significantly abbreviated through the magic of in vitro flowering. This reduction in the juvenile phase not only accelerates the orchid breeding process but also presents *in vitro* flowered orchids as exquisite tokens of admiration for orchid enthusiasts. It is aimed to provide a panoramic view of the captivating world of *in vitro* flowering in orchids and systematically evaluates the documented successes in this fascinating endeavor, shedding light on the potential benefits and applications of this remarkable phenomenon. Orchid lovers, researchers, and horticulturists will find *in vitro* flowering to be a captivating subject that promises to enhance our understanding of orchid biology and revolutionize orchid cultivation practices.

Keywords: Flower induction, Flower morphogenesis, *In vitro* flowering, Orchids, Tissue culture

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Biodiversity informatics and global knowledge inclusiveness: Windows of web-accessible interfaces on orchid biodiversity and conservation

Dipankar Saha*, Suman Natta, Siddhartha Sankar Biswas, De, L. C., Ashok Kumar, Kalaivanan, N. S., Gowdah, Chandan and Sankar Prasad Das

ICAR–National Research Centre for Orchids, Pakyong-737 106, Sikkim, India

* dipankar_icar@yahoo.com

The incremental growth in human population alongside associated economic activities is obviously having huge impact on global environment as the ecosystem has its capacity to provide natural resources against the growing resource consumption pattern. In this context biodiversity (being one of the basic natural resources) in the form of information and knowledge based indicators cum indexes are of utmost importance to be developed, launched and updated through web-accessible interfaces having a varied architecture available through IP compliable open license windows for the policy makers and end users for an effective management and usage in the context of science-technology-society matrix plugin with environmental sustainability. Tools, techniques and protocols deployment in generating these indicators are in great need now to have the authentic data on biological collections, ground truth surveys, automated sensors, molecular data and academic literature of historical importance. Synthesized information of these basic data needs refinement and these process is the subjectivity of biodiversity informatics which encompasses a life cycle consisting of planning, collection, certification, description, preservation, discovery, integration, and analysis aiming for global knowledge inclusiveness. As orchids been commercialized as ornamental plants within the trade involving several distinct types of markets and consumer like the species with attractive flowers, admired for their unusual growth habits, miniature size, scent, patterned leave etc and the larger portion of orchid trade involves artificially propagated plants and cut flowers cultivated in commercial greenhouses, often of hybrids in a small number of genera, the relevance of biodiversity informatics applications are of immense significance for the present and future. This paper is an attempt to envisage the every intricate sub-sets of these domains for effective abridgment through deriving a categorical resonance of scientific cum technological applications aiming for a better global knowledge inclusive society on orchid biodiversity and its conservation.

Keywords:, Biodiversity Informatics, Conservation, Orchid Biodiversity, Science-Technology-Society

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Chemoprofiling of essential oils and curcuminoids of three *Curcuma* species

Leela, N. K.*, Rizwana Fathima and Jayarajan, K.

ICAR-Indian Institute of Spices Research, Marikunnu P.O., Kozhikode-673 012, Kerala, India

*nkleela@gmail.com

The genus *Curcuma*, (Zingiberaceae) contains more than eighty species of rhizomatous herbs, many of which have significant value as medicines, dyes and spices. *C. amada* Roxb., *C. aromatica* and *C. caesia* are three *Curcuma* species known for their culinary and medicinal properties. *C. amada* (mango ginger) rhizome resembles ginger externally, but has mango-like odour and is mainly used for pickling and food processing. *C. aromatica* Salisb. and *C. caesia* Roxb. are used in the traditional medicines and complementary therapies for treatment of various ailments. The present study was carried out to compare the chemical composition of the volatile components of rhizomes and leaves of these species grown at ICAR-IISR research farm and to study the influence of extraction conditions on the yield and composition of essential oil. The essential oil was extracted from rhizomes and leaves, under neutral, acidified and alkaline conditions. The components of the oil were characterized by GC-MS; 32-36 constituents were characterized in each oil. The results indicated that in *C. amada* rhizome the essential oil yield increased from 1.2% to 1.4% and 1.7% under the influence of acid and alkali. In the case of leaf oils and rhizome oils of other sources there was no significant change. However, quantitative variation in the volatile constituents was observed. The rhizome oil of *C. amada* was mainly constituted by myrcene (63-71%) and beta-pinene (3.5-8.6%) where as curzerenone (12.9-17.5%), germacrone (13.6-13.9%) and furanodienone (11.7-14.7%) dominated in the leaf oil. 1,8-cineole, camphor, β-elemene, isoborneol, germacrene-B and furanogermenone formed minor components of leaf oil. α-Pinene, t- ocimene, perillene, caryophyllene and curcumenol represented that of rhizome oil. The composition of rhizome oil was distinctly different from that of leaf oil. This is the first report of the leaf oil composition of *C. amada*. The *C. aromatica* rhizome oil was dominated by camphor (16-18%), curdione (6.3-11.4%), furanogermenone (1.3-7.5%), 1,8-cineole (4.0-8.0%) and isoborneol (5.9-6.7%) whereas its leaf oil oil was mainly constituted by 1,8-cineole (15-16%), camphor (11.0-11.7%) and curdione (5.0-11.9%). Camphene, linalool, limonene, borneol, β- elemene, curzerene and neo curdione contributed to the group of minor components of both leaf and rhizome oils. Partial conversion of curdione to its isomer was noticed during distillation of *C. aromatica* leaf oil under acidic conditions. Dominant components of *C. caesia* rhizome oil were curzerenone (12.8-20.5%), furanogermenone (9.2-13.6%), 1,8-cineole (4-9.4%) and curzerene (4,0-5,8%) while its leaf oil was chiefly represented by furanodienone(10.9-15%), curzerenone (8.2-11.5%), furanogermenone (5-9.4%), β- farnesene (5.5-6.9%) and curzerene (2.6-5.7%). Camphor, isoborneol, borneol, isobornyl acetate, germacrene D, germacrone and furanodienone were present as minor components in both oils. HPLC analysis revealed that curcuminoids, the major pigments of turmeric were present at very low level in the rhizome extracts; total curcuminoids were in the range of 8.8-14mg/100 g, the prominent being curcumin.

Keywords: Chemoprofiling, Curcuminoids, *Curcuma*, Essential oils, Rhizomatous herbs

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Propagation of two wild edible ferns of Sikkim Himalayas for conservation and sustainability

Smriti Chettri[1]*, Manivannan, S.[2] and Sujata Upadhyay[1]

[1]Department of Horticulture, School of Life Science, Sikkim University, Gangtok-737 102, Sikkim, India

[2]Department of Horticulture, School of Life Science, Central University of Tamil Nadu, Neelakudi, Thiruvarur- 610 005, Tamil Nadu, India

*smritichettri1107@gmail.com

In the Himalayan region of Sikkim, wild edible ferns are recognised as nutrient-rich indigenous vegetable with a high commercial value, but the diversity of species and populations are threatened by unsustainable collection and consumption, increasing social pressures, habitat degradation, and climate change. *Ex situ* conservation can be an effective strategy for preventing the loss of genetic diversity, but it involves the development of techniques to conserve these fern germplasm. Due to the lack of effective propagation techniques which is the first step for the conservation of various wild edible ferns, the present study was conducted. As part of our ongoing efforts to protect these species through cultivation, two edible ferns, *Diplazium spectabile* and *Diplazium maximum* were propagated using rhizomes in hydroponics and soil, and spores in soil. The present study was conducted in the greenhouse of the Department of Horticulture at Sikkim University, Gangtok, Sikkim, for two years under the Factorial Completely Randomized Design (CRD) design. During the growth period, growth metrics such as germination %, germination duration, harvest time, length and weight of the crozier, and leaf per rhizome were recorded in hydroponic culture and soil culture. The research on hydroponics and soil culture has yielded some promising results, and it may be effective for mass multiplication and conservation of ferns.

Keywords: Edible fern, *Ex situ* conservation, Hydroponics, Nutritional security, Propagation

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Spices, Ornamental & Medicinal Plants

Response surface methodology and genetic algorithm guided ultrasonication based resin assisted purification of anthocyanin

Anindita Paul[1,2*], Anirban Dutta[1,3], Abhishek Mandal[1,4], Aditi Kundu[1] and Supradip Saha[1]

[1] ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India

[2]ICAR-Central Tobacco Research Institute, Rajahmundry-533 105, Andhra Pradesh, India
[3] ICAR-National Institute of Secondary Agriculture, Ranchi-834 010, Bihar, India
[4]ICAR-Indian Institute of Horticultural Research, Bengaluru-560 089, Karnataka India

*aninditapaul20@gmail.com

In recent past, ultrasound (US) assisted adsorption and desorption technology is getting popularized in pigment purification. Anthocyanin is one of the water-soluble plant-based pigments which have versatile demand in the pharmaceutical as well as nutraceutical world due to its inexpensive source of natural antioxidants. US accelerates adsorption efficiency by faster mass transfer from adsorbate to adsorbent than conventional shaking. However, US treatment can damage the macroporous resin by mechanical compression, and therefore proper adjustment is required to avoid negative impact during the process of sorption. There are very few reports reports on US assisted purification processes of plant-based polyphenols. In the present investigation, black carrot derived anthocyanin rich extract was examined for ultrasonication assisted adsorption (UAA) onto optipore L-493 ion exchange resin. The equilibrium time reached faster in case of ultrasonication than conventional shaking. To optimize the UAA parameters, Box–Behnken design (BBD) was used to evaluate the effects of amplitude, time and resin (g) to extract (mL) ratio, on the efficiency of ultrasonication based adsorption of anthocyanin. The advantages of genetic algorithms (GA) approach over other optimization methods, is that it allows the best solution to emerge from the best of prior solutions. UAA of anthocyanin was achieved to desired adsorption (90.2%) and at faster rate than conventional technique with ultrasonic amplitude of 36 %, time of 9 min and resin to extract ratio of 1:45 which was optimized by response surface methodology (RSM) followed by genetic algorithm (GA) approach. According to the second order polynomial quadratic model ($Y = 1.324 X_1 - 0.065X_7 - 3.847 \times \text{ramp}\ (11.925–X_2) + 0.566 \times \text{ramp}\ (69.391– X_3)71.073$; $R^2 = 0.921$, Adj-$R^2 = 0.895$ and predicted $R^2 = 0.761$) established by hybrid approach of RSM-GA, time is the most important factor influencing the ultrasonication assisted anthocyanin adsorption process followed by ratio of resin to extract and amplitude. Moreover, exposure of high US energy for longer time affects the surface integrity and thereby diffusivity of anthocyanin from and to the adsorption site. These RSM-GA approaches were first ever projected to optimize and foresee the ultrasonic assisted anthocyanin adsorption on macroporous resin. Therefore, resin-based adsorption technology can foresee to be established on an industrial scale which have rarely been systematically optimized.

Keywords: Anthocyanin, Genetic algorithm, Macroporous resin, Purification technology, Response surface methodology

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Nutraceuticals and Value Addition

In-depth study of floral bio-active constituents and antioxidant potential of *Papilionanthe teres* (Roxb.)– An endangered and endemic orchid species

Suman Natta[1*], Nasiruddin Shaikh[2], Ekatpure Sachin[2], Nishant Deshmukh[2], Tshering Chomu Bhutia[1], Chandan Gowda, H.[1], Dipankar Saha[1], Somnath Mandal[3], Kaushik Banerjee[2], Siddhartha Sankar Biswas[1], Lakshman Chandra De[1], Kalaivanan, N. S.[1] and Sankar Prasad Das[1*]

[1]ICAR-National Research Centre for Orchids, Pakyong-737 106, Sikkim, India

[2]National Referral Laboratory, ICAR-National Research Centre for Grapes, Pune, Maharashtra, India

[3]Department of Biochemistry, Uttar Banga Krishi Viswavidyalaya, Cooch Behar-736 165, West Bengal, India

*SUMAN.NATTA@icar.gov.in; Sankar.Das@icar.gov.in

Papilionanthe teres is an endangered and endemic medicinal orchid species having beautiful pink flowers grown in the reserve forests areas of North Eastern Himalayan states like Sikkim, Arunachal Pradesh and Assam. The plant is a widely recognized in the remote areas of north-east region of India, due to traditional herbal medicinal application for treatment of diabetes, fever, heavy menstruation, eye inflammation, hypertension, carve-depression and abdominal pain. The present study aimed to explore the *P. teres* orchid flowers for their medicinal and antioxidant potential. The in-vitro antioxidant activity such as total antioxidant activity, DPPH, ABTS, metal chelation activity of *P. teres* flower was studied through UV-vis spectrophotometer to explore their medicinal potential. The bioactive compounds such as phenolics, anthocyanins, vitamin E and amino acids were estimated through GC-MS, LC-MS/MS, micro-minerals through ICP-MS, and non-targeted bioactive compounds through LC-HRMS. It was found that bio active phenolics such as caffeic acid, p-coumaric acid, trans-cinnamic acid, quercetin, anthocyanins like malvidin, petunidin was reported. The quantification of amino acids showed the presence of lysine and other few essential amino acids in the flowers of *P. teres*. The analysis of total 11 minerals through ICP-MS has showed the presence of essential minerals such as calcium, magnesium, iron and zinc. The antioxidant potential such as total phenol (11.71 mg 100 g^{-1}), flavonoids (18.6 mg 100 g^{-1}), total antioxidant activity, DPPH (IC_{50}: 366 µg ml^{-1}), ABTS (IC_{50}: 205.67 µg ml^{-1}) and metal chelation activity were explored. The study of non-target compounds through LC-HRMS and GCMS, has reported a total of more than 50 major bio-active compounds of phenolics, flavonoids derivatives. The presence of potential bioactive metabolites, namely phenolics, anthocyanins with antioxidant potential suggests its suitability as potential functional food ingredients. Therefore, our study revealed that the flowers of *P. teres* orchid species contain significant bioactive compounds. This finding will highlight the importance of collecting, conserving, and promoting the use of these medicinal orchids among local farmers for sustainable commercial purposes.

Keywords: Antioxidant, GC-MS, Medicinal, *Papilionanthe teres*, Phenolics

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Nutraceuticals and Value Addition

Extraction and characterization of bioactive constituents from seeds and peel of ten pomegranate varieties grown in arid region

Saurabh Swami*, Mahesh Kumar, Meghwal, P. R., Akath Singh and Om Prakash

ICAR-Central Arid Zone Research Institute, Jodhpur-342 003, Rajasthan, India

*saurabh.swami@icar.gov.in

Pomegranate fruit is a rich source of beneficial bioactive compounds and antioxidants. There is huge demand of pomegranate juice because of increasing health consciousness of consumers. Pomegranate peel and seeds are by-products left after juice extraction. Pomegranate peel contains tannins and several polyphenolic compounds which act as antioxidants. Pomegranate seed oil contain rare conjugate linolenic acid (punicic acid) which show activities against inflammation and metabolic syndromes. In the present study, characterization of ten pomegranate varieties was done in terms of their seed oil yield, peel tannin content and juice anthocyanin and antioxidant activity. The maximum seed oil yield was found in Bhagwa followed by Ruby and Jodhpur Red. Similarly, maximum juice anthocyanin content was in Bhagwa, JSM and Ruby. Peel tannin content was found maximum in JSM, Ruby and Jodhpur Red.

Keywords: Antioxidants, Pomegranate seed oil, Pomegranate waste, Punicic acid, Tannins

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Nutraceuticals and Value Addition

Orchids in nutraceuticals, cosmeceuticals and fast-moving consumer goods (FMCGs): Panorama on world trade and a prospective outlook of sustainable development goals

Dipankar Saha*, Suman Natta, Siddhartha Sankar Biswas, L. C. De, Ashok Kumar, Kalaivanan N. S., Gowdah, Chandan and Sankar Prasad Das

ICAR–National Research Centre for Orchids, Pakyong-737 106, Sikkim, India

*dipankar_icar@yahoo.com

Orchidaceae being one of the largest families of flowering plants are widely traded for a variety of purposes like ornamental plants, medicinal products, ingredients in cosmetics including food and supplements at many different scales. These include a number of greater-scale commercial and non-commercial trades which involve a considerable usage of wild plants as medicines, materials for weaving, ornaments, food and natural dyes etc. Little research is going on some emerging commercial usage of orchids targeting perfumes and cosmetic products. As the global trade is intensifying, there is a growing concern on survival of considerable numbers of orchid species, and there lies a gaps in our understanding on orchid ecology *vis-a-vis* trade dynamics. Consumer's preferences and choices are an important yardstick for trade but information cum data gaps in assessing the conservation status, ecology and studies on harvests are having equal importance. In view of the current unacceptable nature of trade ecosystem which is raising concerns on sustainable future of orchid biodiversity and commerce, there are various schools of thoughts emerging which need to be re-looked in every regional context. Researchers opine that there is a possible proposition to facilitate a legal system of trade even in some wild orchid species. Few researchers also stressed on growing plants in greenhouses or shade houses or a kind of semi-wild cultivation in natural niches associated with those plant types targeted for domestic trade. Although invariable compliance with the definition as per the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) need to be followed. Historically, it is also a fact that there exists very little dialogue between scientists, traders, growers and policy makers, and there lies the importance of every sincere effort to have recurrent discussions among these groups to create an atmosphere of synergy among all the stakeholders of this functional loop to motivate everyone to follow the bio-legislative matrix of the region and the world. This analysis is an effort to have a deeper insight towards regional and global trade involving variety of products of commerce, with a glimpse on trades of varied nature. It is the need of the time to have a detailed discourse on trade practices and conservation of orchids.

Keywords: CITES, Conservation, FMCGs, Global trade, Orchid

Theme: Horticulture-based Transformation of Food Systems
Sub theme: Nutraceuticals and Value Addition

Development of technology for preservation of tender coconut water

Neelofar Illias Kutty and Manojkumar T. S.*

ICAR-Krishi Vigyan Kendra, ICAR-Central Plantation Crops Research Institute, Kasaragod-671 124, Kerala, India

*manojkumar.ts@icar.gov.in

In India, the coconut tree (*Cocos nucifera*) is grown in 20,96,720 ha and produces 23,798 million nuts per year. Coconut plays an important role in contributing to India's GDP by about 15,000 crore rupees, and 72% of worlds total production is from India. Tender coconut or the young tough green coconut offers nutritious, pleasantly sweet water mostly known as coconut juice. It offers a jelly-like fresh white flesh with a very nutty sweet flavour. Tender coconut water is a natural source of electrolytes, minerals, vitamins, complex carbohydrates, amino acids and other nutrients. The natural carbohydrate content is between 4-5% of the liquid solution. This makes coconut water particularly suitable for the burgeoning sports drink market. It has caloric value of 17.4 per 100 g. The process for preservation of bottled tender coconut water as a carbonated RTS was standardized and commercialized at ICAR-Krishi Vigyan Kendra ofCentral Plantation Crops Research Institute, Kasaragod. The process involves clarification, pasteurization, homogenization, addition of permitted acidulants, mixing with aerated water, bottling and refrigerated storage. The nutritional and microbial characteristics and sensory attributes were analysed. The product gives a shelf life of upto six months under refrigerated condition. The technology was transferred by CPCRI to 20 entrepreneurs.

Keywords: Acidulants, *Cocos nucifera,* Clarification, Pasteurization, Preservation

XII AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 6

Aquaculture & Fisheries-based Transformation of Food Systems

Aquaculture Systems & Fisheries

Genetics, Health & Nutrition

Processing, Value Addition, Quality Control & Social Sciences

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Growth, survival and production of nutrition sensitive small indigenous species (SIS) mola carplet (*Amblypharyngodon mola)* in carp-SIS poly-culture system

Rashmi R. Das[2], Francois Rajts[1], Sourabh K. Dubey[2*], Kalpajit Gogoi[2], Saurava K. Biswal[3], Arun Padiyar[2], Suresh Rajendran[2], Shakuntala H. Thilsted[4], Chadag V. Mohan[4], Ben Belton[4,5]

[1]Independent consultant
[2]WorldFish India
[3]Biswal Aquatech, India
[4]WorldFish Malaysia
[5]Michigan State University, USA

*s.dubey@cgiar.org

An experimental case study was conducted to evaluate the production of the nutrition sensitive species, mola, *Amblypharyngodon mola* in a carp-SIS polyculture system (small indigenous species) in farmer's field. A total of 14 farmers from 40 farmers succeeded in producing mola along with Indian major carps (IMCs). The seeds of mola were produced by induced breeding at Biswal hatchery by using the synthetic hormone WOVA-FH at a dose of 0.5 ml per kg body weight. A total of 4 kg (male and female) brooders were induced breed to produce around 1 million spawn which were stocked in a nursery pond for further rearing upto fry size. After 25-30 days, the fry were harvested and stocked in farmer's ponds after proper acclimatization. The mola seeds were stocked along with IMC seeds. All the water quality parameters were within optimal range for freshwater aquaculture. The study also evaluated the first maturity and fecundity of female mola stocked in this polyculture system. The production system was divided into two distinct systems; the spawn stocking system and the fry stocking system. There was no significant difference ($p<0.05$) in production between two systems. The production was only dependent upon the productivity of ponds (mainly the plankton density). The harvest of mola was done after 6-8 months of culture. The highest production was achieved in a SHG adopted pond at Tirtol block (F1) followed by F3, F4. The average weight of female and male ranged from 5.09 ± 0.72 to 5.79 ± 0.78 and 1.92 ± 0.187 to 2.03 ± 0.19 g respectively. The maturity stage was observed within 2-3 months from the date of stocking. The absolute fecundity of mature female ranged from 4000- 6000 per female (1200 g^{-1} body weight). The absolute fecundity ranged from 964.12 ± 436.49 g^{-1} body weight to 1227.98 ± 491.63 g^{-1} body weight in female of spawn stocked ponds; while in fry stocked pond it ranged from 932.76 ± 410.40 to 1195.69 ± 451.65 g^{-1} body weight. The production of mola ranged from 0.25 kg m^{-2} to 0.23 kg m^{-2} in spawn stocked ponds and 0.22 to 0.19 kg m^{-2} in fry stocked ponds.

Keywords: *Amblypharyngodon*, hatchery, induced breeding, mola, WOVA-FH

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Breeding of small freshwater indigenous prawn *Macrobrachium dayanum* under captivity

Gupta, M.*, Kumar, A., Singh, R., Kumar, S., Singh, A. K., Hamdani, I., Nishad, C. and Sarkar, U. K.
ICAR-National Bureau of Fish Genetic Resources, Lucknow – 226 002, Uttar Pradesh, India
*monika_gupta22@yahoo.com

Macrobrachium dayanum (Henderson, 1893) is one of the small freshwater prawns of commercial significance and is included in the list of the most cultivable prawns of the world. It is widely distributed throughout the freshwater bodies of southern Asia including India, Nepal, Myanmar, and Bangladesh. It is a highly sought after species of small freshwater prawn due to its high nutritional quality, unique taste and is a potential source of food to tackle the malnutrition in India. The total dependence on natural resources to meet the existing market demand leads to ecological pressure on this valuable indigenous germplasm. Therefore, the present study was undertaken to evaluate the reproductive potential of small freshwater prawn, *M. dayanum* under captivity. Wild stock of *M. dayanum* of 35-65 mm, weighing 0.91-1.84 g were collected from the Gomti River to undertake its breeding in captivity. The successful breeding of *M. dayanum* was achieved under captive conditions from May to September. Fertilized eggs were bright green in color and oval in shape. Average fecundity was found to be 49.26 ± 15.76 eggs/g body weight. The incubation period was 25-32 days at 27-30°C temperature. Berried females released the larvae in two batches at an interval of 18-22 h; the average production was 28 ± 13.45 larvae/female (average length of female, 55±6.1 mm; average weight, 1.7±0.04 g). The average size of larvae was 6.05 ± 0.1 mm. This initial success in the breeding of *M. dayanum* would be a baseline for further research for the development of mass-scale breeding and polyculture technology of this small freshwater indigenous prawn to address the problem of hunger and malnutrition among the poor community.

Keywords: Breeding, captivity, *Macrobrachium dayanum*, malnutrition, small freshwater prawn

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Biofloc technology (BFT) based maturation and breeding of Indian white shrimp, *Penaeus indicus* along with eyestalk ablation in captive conditions

Akshay Panigrahi*, Rashmi R. Das, Saravanan, A. and Balasubramanian, C. P.

ICAR-Central Institute of Brackishwater Aquaculture, 75, Santhome high road, R. A. Puram, Chennai, 600 028

*apanigrahi2k@gmail.com

A study of biofloc based maturation along with eye stalk ablation (ESA) trial was carried out to know the maturity status, breeding performance, immune status of Indian white shrimp, *Penaeus indicus*. The biofloc was maintained in two different ratios (C:N 10 and C:N 15) by adding different carbon sources along with CIBA-floc (bacterial consortia). The female maturity was recorded in terms of the stage of ovary and the male maturity was recorded in terms of the sperm viability after biofloc rearing. The experiment designed separately both for males and females were, T1: Control, T2: BFT(10) and T3: BFT(15) for males, similarly for females, T1: Control, T2:ESA only, T2: BFT(10) and ESA, T3: BFT (15) and ESA respectively. The maturation was observed after 6-7 days of eye stalk ablation in ESA+BFT group, but the control and the only ESA group showed slightly higher latency period of 10-12 days, the peak maturation was observed during 12-15 days in all treatments, the ESA+BFT showed higher percentage of maturation in both C:N 10 (53.33 ± 5.77) and C:N 15 (56.66 ± 5.67) than control. ESA only showed a maturation percentage of 40 ± 10. Similarly, the male maturity in terms of sperm viability also showed higher survival in both the BFT system than control. The initial sperm viability taken in all treatments and after 45 days of rearing; the spermatophore was then subjected to cryopreservation upto 45 days. After 45 days the sperm viability was checked in both the biofloc and control animals. The spermatophore from biofloc reared animals showed significantly higher viability of sperm than control animals. Average fecundity and nauplii production was also observed higher in biofloc reared broodstock than control; it also showed significantly higher fecundity and nauplii production. The hatching rate (%) observed was almost similar (85.93 ± 5.03 to 92.40 ± 2.41%), but slightly higher in biofloc group. The average length of protozoea larvae was also taken after metamorphosis. The protozoea from biofloc reared animals showed a higher ABL (average body length, 1601.15 ± 192.01 mm) than protozoea from control (1312.51 ± 325.61 mm). The average fecundity, hatching rate was significantly higher ($p<0.05$) in ESA+BFT group than control. The immune parameters were also analysed to see the health status of the brooders. The total plasma and serum protein increased in ESA+ BFT group in both C:N 10 and C:N 15 brood stock.

Keywords: Bacterial consortium, biofloc technology, carbon sources, eyestalk ablation, maturation,

Commercial scale seed production of pearlspot (*Etroplus suratensis):* A Farmer Participatory approach

Vikas P. A.* and Shinoj Subramanian

ICAR- Krishi Vigyan Kendra (Ernakulam), Central Marine Fisheries Research Institute, Narakkal, Kochi-682 505, Kerala, India

*vikaspattath@gmail.com

Pearlspot (*Etroplus suratensis*) is an indigenous fish endemic to India and Sri Lanka. It is the state fish of Kerala and is very popular in the Kerala cuisine. Fishermen catch pearlspot mainly from brackishwater creeks and canals for domestic consumption. However, several environmental and ecological problems have led to a significant reduction of pearlspot in these natural water bodies. Promotion of pearlspot farming is the only sustainable solution for this crisis. One of the main issues in pearlspot farming is lack of quality fish seeds in sufficient quantities. Massive seed production on a commercial scale is the only way to meet the ever-increasing demand for pearlspot seed. Several attempts to produce pearlspot seeds on a commercial scale under hatchery conditions have proven un-economical due to peculiar breeding behavior of this fish. The objective of this study is to test the technical and commercial viability of a method of large scale pearlspot seed production in farmer's fields through a participatory approach. Existing natural brackishwater ponds were utilized for this purpose. Farmers were selected from Karumalloor, Nayrambalam, Kumbalangi, Edakochi, and Vypin in Ernakulam district, Kerala and trained in pond preparation, breeding and rearing the seeds in natural ponds. The basic principle of this method is to provide favourable natural environment for breeding, protecting the eggs and seeds from predators and providing precise nursery care to ensure maximum survival percentage. It is observed that the fish finds its pair within seven days of releasing broodfish, and the eggs hatch within four days. The free-swimming larvae comes to the pond surface after three days for feeding. An average number of fry hatched from a single batch of eggs was 900 to 950. The average hatching percentage was 82. The cost of production was estimated to be Rs.5.0/- per fingerling and cost-benefit-cost ratio was 2.2. The skill of farmer in broodfish collection, transportation, stocking, pond preparation, seed collection, nursery rearing and seed packing is the key factor for success in this method of seed production.

Keywords: Commercial seed production, *Etroplus suratensis,* hatching percentage, pearlspot, survival

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Breeding and seed production of *Oryzias setnai* (Kulkarni, 1940) in marine captive conditions

Ambarish P. Gop*, Ratheesh Kumar, R., Anuraj, A., Rahul, R., Nanda Kishore, Muhammed Anzeer, F., Aneesh, K. S., Surya, S., Santhosh, B., Boby Ignatius and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*gopidas.ambarish@gmail.com

Oryzias setnai (Kulkarni, 1940), also called Malabar ricefish, comes under the family Adrianichthyidae. Small size, sexual dimorphism, relatively large and clear eggs, prolonged growth, ease of maintenance in captive conditions, easy availability and affordable price are characteristics of the medaka that encouraged its usage in experimental vertebrate biology. To establish the Malabar ricefish (*O. setnai*) as a model fish for scientific studies, we describe here the development of the broodstock and the seed production of this fish. Adult specimens of *O. setnai* (average total length (ATL), 22 mm) were collected from Cochin backwaters (salinity, 24 ppt) and transported to marine fish hatchery of Vizhinjam Regional Centre of ICAR-CMFRI. The fish were kept in FRP tanks of 300-litre capacity with a water volume of 250 l. Fish were given a mixture of rotifers, including *Brachionus plicatilis, B. rotundiformis,* and *Artemia* nauplii, at densities of 10–12 nos. ml^{-1} and 0.5–1 nos. ml^{-1}, respectively. The females laid sticky demersal fertilised eggs, which were found adhered to the sponge filter in the broodstock tank or to the walls of tanks; eggs were dull white in colour. Fertilised eggs size varied from 1055 to 1079 µm. Fertilised eggs had tough exteriors and hairy protrusions that helped them adhere to various surfaces. The hatching period was 15-17 days at salinity 28‰ and water temperature, 29 ± 0.9 . The hatched-out larvae had an average size of 4708 µm. During larval development, the hatchlings were fed a mixture of rotifers (10–15 nos. ml^{-1}). The larvae achieved an ATL of 5012 µm on the fifth day after hatching, 7557 µm on the tenth day after hatching and underwent metamorphosis between 17 and 20 days after hatching at a TL of 10,000–11,000 µm. The estimated regeneration period for the first batch was 51–54 days, and the developed F1 individuals ranged in size from 18–20 mm TL. The results indicate that *O. setnai* is a useful model organism for laboratory-based investigations due to its simplicity in feed requirements, ease of care, and ease of reproduction.

Keywords: Breeding, *Oryzias setnai,* malabar ricefish, model fish, seed production

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Optimisation of seed production of fanged seabream, *Sparidentex jamalensis* Amir, Siddiqui & Masroor, 2014 in captivity

Suresh Babu, P. P*., Anuraj, A., Shilta, M. T., Santhosh, B., Aneesh, K. S., Praveen N. D., Sonali, S. M., Mahendra Pal, Anjulakshmi, Prathibha Rohit, Suresh, V. R and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sbabu78@yahoo.com

Seed production of the newly described sparid, *Sparidentex jamalensis* in captivity was achieved successfully for the first time in the world. Males with oozing milt (without inducement) and female with oocytes measuring 420 to 470 µm (treated with cholesterol pellets of LHRH-a) kept (female: male, 1:1) for breeding in rectangular FRP tanks (3000 L) with sufficient aeration spawned after 42 h. The daily fecundity of the multiple spawner ranged from 1.79 to 11.23 lakhs. The fertilisation rate was 82 to 88% and hatching percentage was between 76 to 84%. Out of the 18 attempts, 88% of successful spawning was obtained with successful larval rearing only during the pre-summer season. Yolk sac larvae emerged after 17.22 h. The final pre-flexion stage (13 day post-hatch (dph), 4.2 mm) was characterised by straight notochord, absence of pigmentation and fin formation. Notochord flexion was initiated on 15 dph (8.45 mm) with marked development in dorsal, anal and caudal finformation. On the 40 dph (28.46 mm) miniature adult with fully formed silvery scales and lateral line featured in the juveniles. During the larval rearing period, three critical phases were observed; mouth opening (3 to 5 dph), weaning period (25 to 30 dph) and metamorphosis (35 to 40 dph). Initial swim bladder inflation was observed before 13 dph. Co-feeding of copepod nauplii and rotifer (3 numbers ml^{-1} each) was identified as the ideal initial feeding strategy. An average larval survival of 4.2 to 6.5% was obtained at the end of the metamorphosis on 40 dph. Natural light with a lux varying 1000 to 4000 lux daily yielded better initial larval survival for *S. jamalensis* larvae.

Keywords: Critical period, hatchery, LHRH-a, larvae, Sparidae

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Captive induced spawning and larval rearing of goldlined seabream *Rhabdosargus sarba*

Senthil Murugan, T*., Ezhil, P., Dani Thomas, Aritra Bera., Thiagarajan, G., Kailasam, M. and Lal, K. K.
ICAR- Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, Chennai – 600028, Tamil Nadu, India
*senthil.murugan@icar.gov.in

The goldlined seabream (*Rhabdosargus sarba*) is an important commercial fish species, supporting artisanal and small-scale fisheries in many parts of its range and is known for its unique coloration and distinct gold stripes along its body. It is a cosmopolitan species that undergoes a wide distribution pattern and is, found in subtropical and tropical waters throughout the Indo-West Pacific including the Red Sea, East Africa, Madagascar, Australia, East China Sea, Japan, Korea, Ryukyu, and Taiwan, in depths of 50 m. Few records are only there regarding captive maturation, induced breeding with different sex ratios, hormones and seed production. Given the growing demand of fish driven by rapid population growth, the introduction of a commercially valuable species like *R. Sarba* raises a lot of hope for aquaculture with ecological and socioeconomic significance on the Indian coast. Thus, the seed production technology would benefit the majority of fish hatcheries as well as small scale farmers. In this regard, the current study included collection of sub-adults from the wild, maturing them under captivity, conducting breeding trials for knowing their individual spawning performance with respect to different spawning induction and standardising the larval rearing protocol for seed production technology of *R. sarba*. The larvae hatched out after 25 ± 1 h, the mean size of the larvae of 0-day post hatch (dph) was found out to be 1.98±0.07 mm, body depth was found to be 926 ± 42 µm and oil globule length and breadth were both 244 ± 0 µm. Balloon-structured yolk was found at the anterior part, starting from the tip of the head to the anal potion. At 30 dph, the post-larvae exhibited a total length of 10.17±0.62 mm. The fins, with the exception of the pectoral fin, were fused with membranes, while rays started to develop in the dorsal, anal and tail regions. Notably, the anus was positioned at 48.8% proximity to the centre of the body. Larvae metamorphosed at 37 dph.

Keywords: Induced captive breeding, goldlined seabream, larval rearing, *Rhabdosargus sarba*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Production of hybrids of clown fishes and observations of the F1 progeny

Anikuttan, K. K.*, Rema Madhu, Madhu, K., Ramesh Kumar, P., Tamilmani, G., Sakthivel, M., Sankar, M., Bavithra, R., Tinto Thomas, Krishnaveni, K., Johnson, B., Vinod, K. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*dranikuttan@gmail.com

Clown fishes (Family: Pomacentridae) are the most commonly bred marine ornamental fishes that are predominantly available in the marine aquarium fish trade. They are sequential protrandrous hermaphrodites that forms monogamous pairs for breeding. Normally pair formation and breeding occur between members of the same species. The present study was carried out to explore the possibility of achieving pair formation and breeding between two different species of clown fishes, *viz. Amphiprion percula* (Percula clown fish) and *A. ocellaris* (Black ocellaris clown fish). Successful pair formation between female *A. percula* and male *A. ocellaris* was achieved under captive conditions. These brooders were maintained in glass tanks of 150 L capacity, connected to a mini-RAS (Recirculatory aquaculture system) that was also provided with photo-thermal regulations. Special broodstock diets comprising of clam meat and shrimp meat was given *ad libitum* to the brooders. The pairs started laying eggs after 3 months of conditioning. The larval rearing and nursery rearing were carried out following standardised protocols already developed for clown fish. The phenotypic traits of the F1 progeny were noted for more than 2 years, and thereafter, these animals were raised to be mature brooders for mating. The progeny was initially showing similar morphotype of percula clown fish, but later a small percentage of the juvenile acquired the colour pattern of false percula. After about one-year, yellow colour started to slowly fade out giving room for black colour to spread to those areas, leaving a little yellow colour at certain areas such as head, fins etc. The hybrids also showed significantly higher growth rate and faster rate of band formation than the normal percula clownfish probably due to hybrid vigour. Molecular studies on the F1 progeny were also carried out. The partial COI sequences of F1 progeny was submitted to NCBI GenBank with the accession numbers MT947233 which had maximum similarity to sequences of *Amphiprion percula* already deposited in NCBI, GenBank. The present study on production of hybrid clownfish is an effort to preserve the hobby through captive breeding, reduce reliance on nature for species collection, and also provide novel organisms with appealing designs for this emerging market.

Keywords: Black ocellaris clown fish, hybrid production, marine ornamental fishes, molecular studies, Percula Clown fish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Production of hybrid marine ornamental clownfish *Amphiprion occularis* through interspecific hybridization between female *Amphiprion ocellaris* and male *Amphiprion percula*

Madhu, K.*, Rema Madhu, Sandhya Sukumaran, Mohandas, M. P., Mrudhula Mohan, K., Harikrishna, N. H. and Gopalakrishnan, A.
ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
*kmadhu30@rediffmail.com

Research on interspecific hybridization was taken up to create designer clownfish with mixed colour pattern. For this, interspecific hybridization of female *Amphiprion ocellaris* (75 to 95 mm) and male *Amphiprion percula* (45 to 55 mm) was achieved from the juveniles produced at the marine hatchery of CMFRI, Kochi after 1.5 years of maturation; the pairs were raised in 500 l perspex aquaria. Hormonal administration, same tank parental separation method with intermittent pairing, forced parental care for shorter duration, foster/adoptive father and mother method, manipulation of nutritional parameters through provision of formulated moist feed and supply of enriched live feeds were used to achieve its pair formation. After 1.5 years of pairing, the pairs laid 75 to 1600 nos. of eggs per spawning at 10 to 12 days interval, and a consistent total of 185 spawning was obtained between 18.08.2017 to 18.08.2022 (60 months) with an average of 3 spawning/month. The spawning frequency obtained in this study is greater than the typical situation wherein only 2 spawning/month/pair was recorded. The spawning is influenced by lunar periodicity and the spawning usually took place 1 to 8 days after and before the full moon and new moon. The capsule-shaped eggs were initially light yellow and turned black on third to fifth day, and then to silvery on 6-7th day and the hatching took place at 168 h of incubation at 28.0 ± 0.5°C. F1 hybrid's egg production, fertilization, hatching, survival rates and morphometric differences were documented. The fertilized eggs were used to explore the maternal inheritance using 10 RAPD primers. Utilizing RAPD markers, genetic analysis of larvae and juveniles were carried out to verify hybrid vigor and also compared with that of juveniles produced from normal pairs of both parents. The study confirmed that the juveniles produced are the product of hybridization between *A. ocellaris* and *A. percula*. The progeny (hybrid) obtained through present study is named as *Amphiprion occularis*. This is the first attempt in the hybridization of clown fish under captivity in India in which parents originated from the hatchery-produced juveniles. Consistent breeding and production of hybrid clownfish over a five-year period of research is a significant achievement as clown fish are ground pillars and are well-liked attractions in marine aquarium industry. Creating hybrids and designer clowns through hybridization will provide a fresh, alternative of the species for the aquarium sector, and this will also decrease the reliance on wild specimens for aquarium industry.

Keywords: Aquarium industry, genetic analysis, hybrid clownfish, interspecific hybridization, marine ornamental fish

Embryonic development in induced-bred *Siganus vermiculatus* and effect of environmental conditions on fertilised eggs

Anuraj, A.*, Suresh Babu, P. P., Boby Ignatius, Mahendra Pal, Anjulekshmi, P., Praveen N. Dube, and Sonali, S. M.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*anurajarsicar@gmail.com

Rabbitfish, *Siganus vermiculatus* (vermiculated spinefoot) is an excellent candidate species for culture in marine and brackishwaters because of its herbivorous feeding habit, rapid growth, and economic value. In this study, we investigated the embryonic development in hormone induced bred *S. vermiculatus* and effect of environmental conditions *viz*., temperature and salinity on the incubation period and hatching success of fertilised eggs of *S. vermiculatus*. Broodstock development of *S. vermiculatus* was carried out in a 5 tonne recirculatory aquaculture system with diet consisting of formulated pellet with 40% crude protein supplemented along with squid meat. LHRH-a @ 20 µg kg^{-1} were injected intramuscularly below the dorsal fin, twice (at 24 h interval) to female brooder while the male brooder was administered hormonal injection only at the time of second injection of female. Demersal adhesive eggs were observed in tiles kept for egg attachment after 20 h 30 mins of last injection. Embryonic development was completed within 22 h 30 mins at 30^{o}C, 8.2 pH and 30 ppt. To determine the effect of environmental conditions on incubation, fertilised eggs were reared at a range of salinities (0–40 ppt) and temperatures (20–34°C) until hatching. Fertilised eggs were stocked for the trials @ 20 nos. l^{-1} in UV sterilised seawater. Best hatching success (90%) and slightly bigger size (1.89±0.04 mm) at hatch were observed at 25 ppt salinity whereas lowest incubation time was recorded at 35 ppt (22 h 15 mins). No hatching was observed below 10 ppt salinity and degenerated hatchling was observed above salinities of 35 ppt and temperature above 32^{o}C. Best hatching success (95%) along with the lowest time (21 h 30 mins) taken from fertilisation to hatching was found at higher temperature (32^{o}C). The incubation time was found to decrease with temperature and recorded highest at low temperature (20^{o}C) and, at temperatures above 28^{o}C, slightly bigger size at hatch size was observed (>1.91±0.03 mm). The results of the experiment show that temperatures between 28^{o}C-32^{o}C and salinities between 25 ppt to 35 ppt is ideal for incubation of eggs. The data on embryonic development and effects of temperature and salinity on fertilised eggs will help in improving the seed production protocols of vermiculated spinefoot in controlled conditions.

Keywords: Embryogenesis, induced breeding, mariculture, rabbitfish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Embryonic and early larval development of brackishwater ornamental fish *Monodactylus argenteus* (Linnaeus, 1758)

Dani Thomas*, Raymond, J. A. , Aritra Bera, Ezhil, P. , Thiagarajan, G. , Subburaj, R. and Kailasam, M.

ICAR-Central Institute of Brackishwater Aquaculture, 75-Santhome High Road, R A Puram Chennai-600028, Tamil Nadu, India

*dani.thomas@icar.gov.in

Silver moony (*Monodactylus argenteus*) holds promise as an ornamental species in the brackishwater ornamental industry. In this study, we documented the various stages of embryonic and early larval development of the species, beginning from egg activation to the period of exogenous feeding and completion of larval metamorphosis, employing morphological and histological indicators. We obtained embryos from hormonally induced captive broodstock and closely monitored their subsequent development. The duration of embryonic development, spanning from fertilization to hatching, lasted approximately 18 to 20 hours. Upon hatching, the larvae exhibited unpigmented eyes and an undeveloped body structure, accompanied by a substantial yolk sac. At hatch, the mouth was sealed by the oropharyngeal membrane, but it gradually opened during the later phase of endogenous feeding. Notably, the larvae underwent significant transformations in craniofacial morphology, locomotion, and the development of the digestive tract during this period. The digestive tract differentiated into the buccopharynx, oesophagus and small intestine during the endogenous feeding phase. As the endo-exogenous feeding period commenced, the intestinal valve and numerous longitudinal folds in the posterior region of the intestine took shape. Notable milestones in retinogenesis occurred throughout the endogenous feeding phase. Once the larvae transitioned to exogenous feeding, their mouths became fully functional. Our comprehensive analysis of embryonic and early larval development in *M. argenteus* will help identify the exact feeding time in the hatchery system and improve larval rearing protocols.

Keywords: Brackishwater ornamental fish, embryogenesis, larval ontogeny, silver moony

Evaluation of ideal stocking density for rearing spawn to fry during nursery phase of *Labeo rohita* (Hamilton, 1822) in biofloc system

Das, P. C.*, Swain, H. S., Dharitri Barik, Das, T. K. and Abhijit Nayak

ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar 751002, Odisha, India

*pratapcdas@yahoo.com/Pratap.Das@icar.gov.in

High density rearing of carp spawn to fry stage under a more controlled condition, as in concrete nursery tanks, yields higher fry survival than the conventional earthen nursery system which is often marred with poor fry survival. The biofloc system that offers an in-situ environment management along with additional round the clock availability of bacterial floc protein as feed source is expected to support the seed performance at higher rearing density during the crucial nursery phase. In the present study, spawn of rohu *Labeo rohita* were stocked at four densities 4,000 m^{-3} (T1), 6,000 m^{-3} (T2), and 8,000 m^{-3} (T3) and 10,000 m^{-3} (T4) to evaluate the ideal one in the biofloc system, as assessed in terms of their survival and growth performance. Rohu spawn was reared in 20,000 l poly-lined circular biofloc tanks (5 m diameter) in triplicates for 28 days. Commercially available dust feed (36% CP, 4% fat) were fed to the seed @ 400 g $lakh^{-1}$ in two split meals with a 10% daily increment of the ration from the day of stocking. The floc was prepared with use of molasses as a carbon source in the tank and C/N ratio of 12:1 maintained which enabled maintenance of floc volume at 7-8 ml l^{-1}. High fry survivals of 79.7-86.8%, reducing proportionately with rearing densities from T4 to T1, were observed in the tanks, but there was no significant difference of survival across the rearing densities ($P > 0.05$). Earlier studies on high-density spawn rearing of rohu at 2000 m^{-3} in concrete nursery system have reported 55-62% survival with 16.8-17.8 mm total length after 21 days. However, the final fry length after 28 days of rearing in the present study were 20.13±1.7 mm, 17.8±1.6 mm, 15.6±1.5 mm and 13.0±1.3 mm in T1, T2, T3 and T4, respectively. Such fry growth performance, particularly in the three lower densities, are comparable to the result of the concrete tank rearing, but the higher survival even at 2–4 times higher densities in T1, T2 and T3, indicated the potential of the biofloc system to support spawn survival and growth during the crucial nursery phase. Whereas, T4 at 5 times rearing density though supported higher survival, the total length was relatively low, demanding extension of the rearing period. Therefore, the present study recommended rearing density up to 8000 m^{-3} for successful nursery phase of rohu in the biofloc system.

Keywords: Biofloc system, nursery phase, rearing density, rohu

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Larval rearing of striped murrel, *Channa striata* in different refuge systems

Raghvendra Singh*, Aditya Kumar, Monika Gupta, Santosh Kumar, Ajay, K. S., Irtiqa Hamdani, Chandrabhushan Nishad, and Sarkar, U. K.

ICAR-National Bureau of Fish Genetic Resources, canal ring road, PO Dilkusha, Lucknow-226 002, Uttar Pradesh, India

*shakya.raghav@gmail.com

Channa striata commonly known as striped murrel is a popular high-valued indigenous food fish of the Indian sub-continent with considerable medicinal values. Despite having high consumer preference and high potential for commercial aquaculture, consistent production of good quality seed is still a major problem. Although, the induced breeding technology of this species is available, still production of required quantum of seed is a major concern due to poor survival during fry rearing particularly due to heavy cannibalism. To address the issue an experiment having different refuge systems was conducted for period of 21 days for estimating the survival percentage of fry. In the experiment there were four treatment groups T_1 (Plastic tub with 12 litres of water having medium sized stones) T_2, (Plastic tub with 12 litres of water having medium sized stones with 2-inch sand bed) T_3, (Plastic tub with 12 litres of water having Eichhornia plant) and T_4, (Plastic tub with 12 litres of with combination of all *i.e.* stones, sand and Eichhornia plant). One hundred individuals of four days old larvae produced from induced breeding were introduced to all the treatment groups. All the treatments were arranged in triplicate. Larvae were fed with mixed zooplankton six times per day. Continuous aeration was given in all the treatments with 30 percent water exchange at every 3rd day to keep the water quality parameter under optimum level. The highest survival in the T_2 group (56%) was significantly higher than other treatments followed by T4 (32%), T1 (27%), and the lowest was observed in T3 (18%). The present findings suggest that a sand bed having medium sized stones may prove a better substratum and habitat for achieving higher survival of fry in *C. striata*.

Keywords: *Channa striata*, larvae, refuge systems, survival

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Effect of substrate on growth and survival of fry of *Clarias dussumieri* (Valenciennes, 1840), an endemic food fish from Peninsular India

Chandana, B. L.[1,2]*., Abhilash, C. P.[1], Sai Krishnan[1], Charan Ravi[1], and Basheer, V. S.[1]

[1]ICAR-National Bureau of Fish Genetic Resources, Centre for PAGR, CMFRI campus, Kochi-682018, Kerala
[2]Kerala University of Fisheries and Ocean Studies, Panangad, Kochi–682506

* chandanaswairam007@gmail.com

Clarias dussumieri commonly known by the name Valenciennes Clariid (locally known by *Nadan mushi / Naadan muzhi*) is a cultivable, highly revered food fish, endemic to the Western Ghats, which commands high price. Dependence on natural stock to support the surging market demand is ushering to overexploitation and ensued ecological damages. The fish being one of the most important delicacies in the many regions of Kerala, can be propagated as a potential species for aquaculture. Clarias seeds were produced in the hatchery facility through induced breeding. Young ones with a mean initial length and weight of 2.02 ± 0.16 cm and 0.07 ± 0.02 g respectively were used for the experimental study which was conducted for a period of 30 days. The animals were stocked at a density of 2 no./ liter in various treatments containing bio-balls and metal chips as substrate. The growth and survival of young ones reared with bio-ball substrate was found to be superior to the ones reared with metal chips. The growth was found to be higher in the treatments in comparison to the control with no substrate ($P<0.05$). However, the survival of fry when reared with metal chips as substrate was lower than that of the treatment with bio-ball and that of control. The study indicates that *C. dussumieri* showed better growth performance and survival, especially in sheltered conditions which could be recommended for the successive production of this highly priced fish.

Keywords: Aquaculture, hatchery, overexploitation, sheltered, survival

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Growth performance of *Labeo rohita* (Hamilton, 1822) juveniles reared at varying salinity levels using inland saline groundwater

Patel, R. K., Verma, A. K.*, Krishnani, K. K., Sreedharan Krishnan, Chandrakant, M. H. and Singh, A. L.

ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

* akverma@cife.edu.in

An experiment was carried out to investigate the effect of different inland saline groundwater salinities for 120 days on growth, nutrient utilization, physiological, and haemato-biochemical responses of juveniles of *Labeo rohita*. The experimental setup comprised 24 circular tanks of each of 400 L capacity with 250 L water volume and stocked with juveniles of *L. rohita* (2.04 ± 0.01 g; n=25). The experimental tanks were categorized as seven treatments with different salinity levels *viz.,* T1 (2‰), T2 (4‰), T3 (6‰), T4 (8‰), T5 (10‰), T6 (12‰), and T7 (14‰); and control (C) with 0‰ salinity in triplicates. No significant difference ($p > 0.05$) in growth performance was observed with increasing salinity in C, T1, and T2, but the growth rate was found to be suppressed significantly ($p < 0.05$) from T3 to T7. The highest survival was recorded in the control (100%) followed by T1 and T2 (100%), T3 (88%), T4 (84%), T5 (76%), T6 (72%), and the lowest survival was recorded in T7 (0%). Increasing salinity above T2 (4‰) significantly retarded the growth and reduced physiological activities. The study suggests that a salinity level in the range of 0-4‰ is ideal for the culture of *L. rohita* and it is concluded that a survival of 72 to 88 % could be obtained in inland saline groundwater having salinity up to 12‰.

Keywords: Haemato-biochemical responses, inland saline groundwater, *Labeo rohita*, physiological salinity

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

A study on off season fish fingerling production in Nayagarh district of Odisha

Anil Kumar, S.* and Suchismita, D.
Krishi Vigyan Kendra, OUAT, Nayagarh-752070, Odisha, India
*anilkumarswainouat@gmail.com

The present study was specifically perceived on offseason fish fingerling production for rural farm youth in their seasonal ponds under Attracting and Retaining youth in Agriculture (ARYA) project of Krishi Vigyan Kendra, Nayagarh. The findings of the study revealed that the extent of impact of climate variable like high temperature in the district has the detrimental effect on the pond ecosystem. Therefore, the trained farm youths were motivated to adopt the offseason fingerling production technology for round the year income generation with a sustainable livelihood option. In this case, the present study was focussed on fixing of Sprinkler system as one of the options for aeration system in the pond that can help to reduce water temperature, proper oxygenation, improve dissolved oxygen level in the pond and also restrict to predatory birds. Simultaneously sprinkling of water can have a scenic beauty and revitalize a peaceful rural environment and facilitates for vegetable cultivation on the pond dyke. Observations on survival rate (%), dissolved oxygen level (mg l^{-1}), income generation and farmers' reaction were recorded. The average survival rate, DO level and net income was found to be 85.25%, 4.5 mg l^{-1} and Rs.88,120/- per ha respectively. Reflections of farmers towards the technology were positive. Thus, it is expected that this technology in the pond for fingerlings production can be adopted as an additional income generation activity to strengthen the livelihood of rural farm youths.

Keywords: DO level, net income, sprinkler system, survival rate, water temperature

Effect of stocking density during nursery rearing on the growth, survival, and compensatory growth of speckled shrimp, *Metapenaeus monoceros*

Vidhu Rajan, R.*, Shyne Anand, P. S., Balasubramanian, C. P., Aravind, R., Biju Francis, Rajamanickam, S. and Lal, K. K.

ICAR-Central Institute of Brackishwater Aquaculture, Santhome High Road, MRC Nagar, Chennai- 600028, Tamil Nadu, India

*Vidhurajan5721@gmail.com

Metapenaeus monoceros, one of the native penaeid shrimps in India, exhibits promising cultural potential and meets domestic demand. To enhance compensatory growth and production performance in the grow-out phase, a two-phase culture approach is suggested for *M. monoceros*. The primary objective of this experiment was to optimize stocking densities during the nursery-rearing phase of this shrimp. The study consisted of a forty-day nursery-rearing phase, followed by a thirty-day grow-out culture phase within a mixotrophic rearing system. Three different stocking densities were evaluated: 1000 PL m^{-3} (T1), 2500 PL m^{-3} (T2), and 5000 PL m^{-3} (T3). Further, in order to investigate the compensatory growth potential, shrimps raised in the nursery phase under each treatment were subsequently transferred to a grow-out system with a consistent stocking density of 150 PL m^{-3} for 30 days. A stocking density-dependent inverse relation in growth and survival was found during the nursery phase. The highest final body weight (ABW) of 0.384 ± 0.05 g and survival rate of 74.6 ± 2.2% were recorded at the lowest stocking density (T1), followed by T2 (ABW: 0.226 ± 0.01 g; survival: 68.3 ± 2.03%.). At the end of the 30-day grow-out trial, however, no significant differences ($p > 0.05$) were observed in weight gain and final ABW between T1 (85.9 ± 5.4%, 1.84 ± 0.12 g) and T2 (90.6 ± 3.2%, 1.72 ± 0.16 g), nor between T2 and T3 (98.17 ± 0.05%, 1.44 ± 0.04 g). Conversely, a comparatively better weight gain was observed in T3 treatment compared to T1 without a significant difference ($p > 0.05$) in average body weight (1.44 ± 0.04 g). During the nursery-rearing trial, the Feed Conversion Ratio (FCR) was better in the T2 treatment (1.18 ± 0.03), followed by T1 (2.19 ± 0.25). Better FCR was observed in shrimp nursery-reared in the T3 treatment (0.68 ± 0.02), followed by T2 (0.85 ± 0.08) and T1 (0.98 ± 0.07) in the grow-out culture. This study suggests that speckled shrimp could be nursery-reared at higher stocking densities before transferring to grow-out culture, resulting in improved growth performance, better feed management, and more efficient utilization of the culture area.

Keywords: Average body weight, Feed Conversion Ratio (FCR), nursery, Specific Growth Rate (SGR), weight gain (%)

Effect of varied salinities on breeding performance and larval development of orange chromide, *Etroplus maculatus*

Prem Kumar*, Senthil Murgan, T., Babita, M. and Biswas, G.

ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Andheri (W), Mumbai- 400061.

*Prem.kumar1@icar.gov.in

Orange chromide, *E. maculatus* is a euryhaline fish endemic to brackishwater streams, estuaries, and the lower reaches of rivers in peninsular India and Sri Lanka. Due to euryhaline nature, this fish can mature and breed in wide range of salinities. The current study was conducted to find out the optimal salinity for breeding and larval development of *E. maculatus*. To evaluate the breeding performance and larval development, mature male and female (Weight: 8-12 g and total length: 78-86 mm) in a sex ratio of 3:1 (male : female) were distributed in three different salinities (0, 5 and 10 ppt) in triplicates (n=3) and reared for three months. Fish were fed with boiled smashed chicken egg. After hatching, larvae were reared in same salinities and their development was recorded. Result of the study showed that the average spawning interval was 10, 17 and 22 days at 0, 5 and 10 ppt, respectively. Average incubation period was 75.66, 75 and 66.66 h at 0, 5 and 10 ppt salinities, respectively. Fertilization and hatching rate were 84.23, 83.98 and 37.56%; 60.33, 59.31 and 51.36% at 0, 5 and 10 ppt salinities, respectively. Total length of newly hatched larvae was 3.417±15mm, 3.239.22±18mm, 2.612.20±5mm at 0, 5 and 10 ppt salinities, respectively. Mouth of the newly hatched larvae opened on 4-5th days post hatching (dph). Mouth gap ranged between 295-300 µm. Average yolk sac volume of newly hatched larvae were 0.781, 0.759 and 0.331 mm^3 at respective salinities of 0, 5 and 10 ppt. Yolk sac absorbed earlier (6 dph) in 10 ppt salinity than the lower salinities of 0 and 5 ppt. Larval survival was 45.9, 60.82 and 36.94% at respective salinities of 0, 5 and 10 ppt. This study concludes that 0-5 ppt is an ideal salinity for breeding and larval rearing of *E. maculatus*.

Keywords: Breeding, Chromide, development, larvae, salinity

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Standardized larval rearing protocol of vermiculated spinefoot, *Siganus vermiculatus* for mass scale seed production.

Tanveer Hussain*, Suresh Babu, P. P., Prathibha Rohit, Boby Ignatius, Ambarish, P. Gop, Suresh, V. V. R., Anju Lekshmi, P., Mahendra Pal, Sonali, M. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*tanveer716@gmail.com

Vermiculated spinefoot, *Siganus vermiculatus*, the fastest growing siganid species, fetches high market price and export value. Even though, breeding of *S. vermicualtus* has been standardized in captivity, poor survival of larvae at the initial larval rearing period hampers the mass scale production of quality fry. Background color of the rearing unit, light intensity, algal density and first feeding strategy are some of the important factors which affects growth and survival of the larvae. In the present work, *S. vermiculatus* male (TL 23.30 cm & 235.0 g) and female (TL 25.02 cm and 309 g) were induced to spawn and fertilized eggs were stocked in 500 l FRP tanks (seawater 34 ppt) with 3 different tank background colors. The eggs were stocked into six treatment groups in triplicates, C (white), T1 (yellow), T2 (blue) tanks were placed in semi-outdoor facility with solar illumination whereas treatment groups T3 (yellow), T4 (blue) and T5 (white) tanks placed in indoor facility with artificial light illumination. The experiment was carried out for a period of 40 days. Larval density of *S. vermiculatus* (TL 2.35 ± 0.04 cm & 1.00 ±0.00 mg) were maintained @ 25 nos. l^{-1} in each tank. On 0 dph, *Isochrysis galbana* added to the tanks @ 10^4nos. ml^{-1} maintained up to 25 days. Copepod, *Parvocalanus crassirostris* nauplii and enriched rotifer, *Brachionus rotundiformis* (S-type) were provided as first feed @ 6–8 nos. ml^{-1} on 2 dph onwards. Enriched rotifers (2 – 20 dph), copepod nauplii (2 – 10 dph), copepodites (10 – 20 dph), Artemia nauplii (17 – 30 dph), artificial larval feed (22 – 40 dph) were used during larval rearing phase of *S. vermiculatus*. At the end of 40 days, results revealed that highest survival (12.09 ± 0.21%) were recorded in yellow tanks (T1) placed in semi–outdoor facility with solar illumination ($p<0.05$). Light intensity ranged from (700 – 2500 lux) in solar illuminated semi-outdoor tanks. Mean total length and body weight (21.26±0.44 mm & 221.4±5.94 mg), SGR (13.49±0.06 % day^{-1}) was highest in T1 as compared to other treatments ($p<0.05$). Metamorphosis started on 28 dph onwards and completed by 38 dph. From the overall results, it has concluded that mass scale seed production of S. *vermiculatus* can be achieved in rearing in yellow tanks placed in semi-outdoor facility with solar illumination.

Keywords: Copepods, rotifers, *Siganus vermiculatus*, solar illumination, yellow colour

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Early inroads into larviculture and standardization of feeding in John's snapper, *Lutjanus johnii* (Bloch, 1792)–a promising mariculture species for India

Ritesh Ranjan[1]*, Sekar Megarajan[1], Biji Xavier[1], Loka Jayasree[1], Shubhadeep Ghosh[2] and Gopalakrishnan, A.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Division of Fisheries, ICAR, Krishi Anusandhan Bhawan–II, New Delhi–110 012, India

*rranjanfishco@gmail.com

John's snapper, *Lutjanus johnii* is a suitable species for mariculture with high commercial value due to its fast growth rate, easy adaptability to culture conditions and wide tolerance, good meat quality and high consumer preference. However, the fish culture is constrained due to non-availability of seed. The hatchery at the Visakhapatnam Regional Centre of ICAR CMFRI has developed the techniques for the breeding and larval rearing of the species and the present study discusses the critical issues in larval rearing and has developed the methods for improved survival and production of quality seed consistently. The initial experiments identified the optimum feed at first feeding, suitable to the mouth gape size (123.11±0.64 µm); and subsequently trials on feeding with copepod nauplii was standardized for the early larval stage; and extended trials for the 6-20th DPH in larval rearing with combinations and densities of copepod nauplii, rotifers and *Artemia* nauplii. Eventually, an experiment was conducted to complete the larval rearing process with weaning on the artificial feed till metamorphosis. Different study resulted that, the nauplii of *Parvocalanus crassirostris* (F. Dahl, 1894) *var. cochinensis* was found to be suitable for first feed at 4 copepod nauplii per mL during the early stages of larval rearing (up to 5th DPH). Addition of rotifers with copepods from 6th DPH onwards had significantly increased higher larval survival. The results of this study are discussed in the paper and this can facilitate mass scale seed production of John's snapper in captivity, which is likely to emerge as a promising mariculture candidate species in India.

Keywords: Copepod, John's snapper, larval rearing, rotifer, survival

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Nursery rearing of vermiculated spinefoot, *Siganus vermiculatus* in indoor *FRP* tanks

Anju Lekshmi, P.*, Tanveer Hussain, Suresh Babu, P. P., Mahendra Pal, Prathibha Rohit, Boby Ignatius, Sonali, M. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*anjulekshmi0121@gmail.com

Siganus vermiculatus, commonly known as vermiculated spinefoot, is a commercially valuable species in south-east Asian countries. However, farming of this species has been hampered due to non – availability of quality fingerlings for stocking in grow out systems. Therefore, the present study aimed to establish an optimal protocol for the nursery rearing of *Siganus vermiculatus* in indoor FRP tank. Hatchery produced *S. vermiculatus* fry 40 day old (2.6 ± 0.176 cm and 0.4021 ± 0.075g) were stocked @ 250 nos. m^{-3} in 1 ton capacity FRP tanks filled with seawater (32 ppt) in triplicates. The experiment was carried out for a period of 40 days. The fry were fed *ad libitum* with artificial pellet feed (500-800 µm) containing 62% crude protein and 14% fat in three rations. Management measures like daily 50% water exchange with fresh filtered seawater. Uneaten feed and waste were siphoned daily. The temperature (26-30^{o}C), pH (8.3- 8.4), dissolved oxygen (5.5mg l^{-1}) and total ammonia (0.1 ppm) were within the favorable range in the rearing tanks. At the end of 40 days, *S. vermiculatus* attained fingerling size with mean total length (5.82 ± 0.144 cm) and body weight (4.68±0.322 g) with a survival rate of 88%. The present study provides protocols for nursery rearing of *S. vermiculatus* in FRP tanks for production of quality fingerlings

Keywords: Ammonia, salinity, *Siganus vermiculatus*, stocking Density, temperature

Studies on growth responses of black clam, *Villorita cyprinoides*, (Gray, 1825) in different environments

Vidya, R.*, Athira Binduraj and Laxmilatha, P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* vidya.panicker@gmail.com

Clams are the most widely distributed and abundant resource among the exploited bivalve resources of India. The black clam, *Villorita cyprinoides* (Gray,1825), is the most important clam species landed in India. The state of Kerala leads India in the production of clams with estimated annual landings of 62615 tonnes in 2017-2018 with Vembanad Lake, the largest estuary on the west coast of India, contributing 88.2% to the fishery. Being a rich and cheap protein source, clams are regularly fished from Vembanad Lake and the meat is sold for local consumption and as a feed in shrimp farming. This fishery provides livelihood to over 5000 clam fishers. In the present study, an attempt was made to compare the growth of black clam in the natural bed of and under controlled conditions in the hatchery with microalgal feeding and to know the effectiveness of live feeds in the growth and survival of black clam. Live feeds given in the rearing conditions were *Isochrysis galbana* and *Nanochlorospsis salina*. Growth measurements of black clam were recorded in three replicates in rearing conditions fed with *I. galbana* and *N. salina* and in the natural bed. Analysis of growth measurements indicated that the growth of black clam was higher in the natural bed compared to rearing conditions fed with microalgae. Higher growth rates in the natural bed may be due to the influence of sediment characteristics. In the rearing conditions, survival rates were highest in environments fed with *Isochrysis galbana* and lowest in natural bed. The abrupt changes in physio-chemical characteristics such as salinity, temperature, pH *etc*. of the water might be the reason for lower survival rates in natural bed.

Keywords: Bivalve, black clam, feeding, growth rate, microalgae

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Feasibility and growth studies of hatchery produced *Crassostrea madrasensis* (Preston, 1916) spat in Palghar district of Maharashtra

Santosh N. Bhendekar*, Thakurdas, Ashish Chaturvedi, Sunil Ail, Ajay D. Nakhawa and Venkatesan, V.

Mumbai Regional Station of ICAR-Central Marine Fisheries Research Institute, Mumbai-4000 61, Maharashtra, India

* santucofs@gmail.com

Despite hatchery produced oyster seed being costlier than wild collected ones, globally the major source of seed is changing from natural to hatchery-produced ones. Usually, natural spat fall of edible oyster (*Crassostrea madrasensis*) is unpredictable and low in quantity. Hence, ff the oyster seed is produced in hatchery, the availability of desirable stage in the required quantity and quality throughout the year can be ascertained. Consequently, this study was undertaken to study the feasibility of transporting and rearing hatchery produced oyster spat. The hatchery produced spat of *Crassostrea madrasensis* attached to cultch (oyster shell) were transported from Vizhinjam Regional Centre of ICAR-CMFRI, Kerala to Asangao village, Palghar district of Maharashtra. The total transport duration of oyster seed was 7 hours and all seeds were alive and in good condition. The spat were acclimatized to creek salinities. The oyster shells (6 nos.) were fastened with nylon ropes (3 mm dia) with a gap of 15 to 20 cm. Each cultch had 2-4 attached spat and each cultch was tied with nylon ropes (rens) to bamboo raft for carrying out the culture experiment. The mean shell length of the attached spats was 7 mm. After one year it reached to 92 mm. Growth rates, in terms of shell length, showed positive correlation with salinity. The present study confirms that hatchery breed oyster seed has great potential for oyster farming in areas where failure or unpredictable spat fall occurs.

Keywords: Growth, oyster culture, oyster spat, Maharashtra, seed transport

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

High density nursery and grow-out farming of *Penaeus vannamei* using copefloc technology

Aravind, R.*, Shyne Anand, P. S., Balasubramanian, C. P., Bhuvaneswari, T., Panigrahi, A., Vidhu Rajan, R. and Rajamanickam, S.

ICAR-Central Institute of Brackishwater Aquaculture, Santhome High Road, MRC Nagar, Chennai- 600028, Tamil Nadu, India

*aravind.pillai@icar.gov.in

A field demonstration was conducted at Pattipulam village pond to introduce and disseminate the copefloc based shrimp farming technology. The primary objective was to provide livelihood support and generate income for five families, comprising a total of 15 individuals, as part of the Scheduled Caste Sub Plan. The demonstration began with the nursery rearing of *Penaeus vannamei* shrimp, which was carried out in Fiberglass Reinforced Plastic (FRP) tanks at MES, ICAR-CIBA for 21 days. The copefloc was generated using a pure stock of three copepod species, namely *Dioithona rigida*, *Pseudodiaptomus annandelei*, and *Evansula pygmea*. To this mix, molasses, yeast, and finely powdered rice bran (sieved through a 100 µ scoop net) were added after a fermentation process. Once the copepod density exceeded 1000 individuals per litre, postlarvae (PL12) of *P. vannamei* were stocked at a rate of 10,000 individuals m^{-3}. The juveniles grew to sizes ranging from 0.312 to 0.552 g, with an average growth rate and survival rate falling within the range of 0.424 g and 94 to 100%, respectively. Subsequently, nursery reared *P. vannamei* were stocked once the density of copepods above 500 nos. l^{-1} in an earthen pond of 6000 m^2 area at a density of 40 nos. m^{-3} for a period of 75 days. Water quality parameters were consistently monitored on weekly basis, and the shrimp were fed five times a day. The total biomass harvested amounted to 4.2 tons of *P. vannamei* shrimp, achieving a Feed Conversion Ratio (FCR) of 1.42. The average weight of the shrimp reached 21.1 g, and sold at a price of ₹300 per kilogram. The shrimp exhibited an average survival rate of 85%, resulting in a production yield of 7 tons per hectare. In total, this technology generated an income of ₹12.5 lakhs, benefiting five families by providing essential livelihood support. This study highlights the immense potential of copefloc-based high-density nursery and grow-out farming. It not only shortens the culture period but also facilitates compensatory growth during the grow-out phase, all the while keeping the feed conversion ratio low. These combined benefits lead to the maximization of profits for all stakeholders involved.Top of Form

Keywords: Copefloc, high density, livelihood support, Pacific white shrimp

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Grow out production systems for mud crab, *Scylla serrata*

Balasubramanian, C. P*., Shyne Anand, P. S. Aravind, R. Christina, L. Jose Antony, Balamurgan, J., Biju, I. F., Vidhu Rajan, R., Vijayan, K. K. and Lal K. K.

ICAR-Central Institute of Brackishwater Aquaculture, Santhome High Road, MRC Nagar, Chennai- 600028, Tamil Nadu, India

*cpbalasubramanian@yahoo.com

Mud crab, *Scylla serrata*, has been the focus of diversification of brackishwater/coastal aquaculture in India, and many south east Asian countries. Long culture period for reaching the export market size is the major constraint for wide spread adaptation of mud crab farming. In order to circumvent this challenge, several models for grow out of mud crab has been suggested. The objective of this study was to evaluate the production and economic performance of these grow out systems. This study includes three different production systems: 1) three phased culture system, 2) poly culture system and 3) mono-sex *vs*. mixed culture system. The three phased modular system comprised a three months nursery rearing, four months of mid grow-out and three months of final grow-out system. Forty six percent of juveniles survived after three months of rearing with an average body weight of 84.8 g and 280 kg ha^{-1} production. In the mid grow-out phase, nursery reared juveniles were reared at a stocking density 0.1 crabs m^{-2} and reared for three months. The harvest weight was 270 g with a production of 1110 kg ha^{-1}. The final grow-out was for three months with a very low stocking density (0.01 crabs m^{-2}), and 80% survival and with a production of 1168 kg ha^{-1}. In the polyculture system, 75 days nursed, seed crab (45.1 g ± 3 g) were reared along with fingerlings of *Mugil Cephalus* (38 ± 6 g; rearing density 0.2 fingerlings m^{-2}) and *Penaeus monodon* (2 PL m^{-2}). After 150 days of culture, a total production of 1185. 3 kg ha^{-1} was obtained with 647 kg ha^{-1} of mud crabs, 343.3 kg ha^{-1} of mullet and 195 kg ha^{-1} of tiger shrimp. In the mono sex and mixed culture system, an experimental culture was carried out with following combinations: mixed sex [(1:1)-1 male and 1 female], mixed sex [(2:1)–2 male &1 female], mono sex female and mono sex male. Hatchery-reared *S. serrata* with an initial weight of 60.87 ± 6.89 g male and 54.57 ± 4.87 g female were stocked at 0.5 crab m^{-2}. A final body weight of 237.5±11.21, 199.60±13.26, 157.39±9.30 and 147.47±9.98 g was achieved in each combination respectively. Highest survival was obtained in mono sex female population (57.33%) and lowest in mono sex male (38.0%) culture. All the culture systems were found to be economically feasible.

Keywords: Mono sex culture, mud crab, polyculture, species diversification, three-phased-culture-system

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Optimal dosing of human chorionic gonadotropin (hCG) via sustainable-release hormonal implants improves gonad maturation, reproductive performance, and larval vitality of striped murrel, *Channa striata* reared under indoor condition

Aparajita Priyadarshani[1,2], Rajesh Kumar[2]*, Gokulakrishnan, M.[2], Jitendra Kumar Sundaray[2], Satya Narayan Sahoo[2], Saumyendra Nanda[1] and Dharitri Choudhary[1]

[1]College of Fisheries (OUAT), Rangailunda, Berhampur-760007 Odisha, India

[2]ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar–751002, Odisha, India

*rajeshfishco@yahoo.co.uk

A study was carried out to optimize the dosage of sustained-release hCG pellets to hasten the gonadal maturation and spawning performance of striped murrel (*Channa striata*) in indoor rearing conditions. Overall, sixty-four striped murrel broodfish of size 500-700 g were randomly distributed in duplicates in eight experimental tanks, following a completely randomized design. Each tank contained eight numbers of brood fish with 1:1 sex ratio. Brooders were implanted with graded doses of hCG hormone via sustained-release cholesterol pellets as follows, 500 IU kg^{-1} (G500), 750 IU kg^{-1} (G750), 1000 IU kg^{-1} (G1000) and the control group received implants without hCG (G0). The implanted brooders were reared in indoor conditions for five weeks and induced for spawning. After five weeks, levels of estradiol and testosterone in serum and the gonadosomatic indices of both male and female striped murrel brooders had significantly increased in all treatment groups irrespective of dosage than the control fish ($p<0.05$). The spawning performances such as total egg output and egg diameter had also significantly increased in all treatment groups than the control. The fertilization rates were found highest in G750 ($p< 0.05$) followed by G500 and G1000. The control group showed the lowest fertilization rates ($p< 0.05$) with none of the fertilized eggs hatching out. The hatching rates did not differ significantly among all the treatment groups ($p>0.05$). After 21 days of larval rearing, the growth performances including final body weight, percentage weight gain and specific growth rate (SGR) were significantly higher in larvae produced from 750 IU kg^{-1} of hCG implanted striped murrel brooders compared to other dose levels ($p< 0.05$); however, the survival rates of larvae remained unchanged among all groups ($p>0.05$). The results of the present study indicated that hCG @ 750 IU kg^{-1} body weight of fish via sustained release implants is ideal for better maturation and spawning performance of *C. striata* fish under indoor condition.

Keywords: Hormonal implantation, hormone pellets, indoor maturation, murrel culture, reproductive hormones

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Effect of different dietary n-3/n-6 polyunsaturated fatty acid levels on the captive maturation of *Anabas testudenius* reared in biofloc culture system

Sushree Sangeeta Dey, Babitha Rani, A. M.*, Shamna, N., Upasana Sahoo, Gauranga Biswas and Layana, P.

ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*babitarani@cife.edu.in

Biofloc embody nutritionally active compounds such as protein, fatty acids, vitamin E, ascorbic acids, and carotenoids that influence various reproductive-related processes such as gonadal maturation, gamete quality, and spawning performances. The study was conducted to evaluate the effect of different n-3:n-6 polyunsaturated fatty acid (PUFA) ratio in the diet on the captive maturation of *Anabas testudineus* while rearing in biofloc culture system. Three isolipidic and isonitrogenous diets were formulated with n-3:n-6 polyunsaturated fatty acid levels at 20:80, 25:75 and 15:85 ratios. All diet treatments were triplicated with 25 juvenile fishes stocked in 400 l of biofloc unit as a replicate. Each of the three formulated diets were fed to the fishes for a period of 90 days, and then induced bred with synthetic hormone to determine the breeding performances such as egg quality, fecundity, hatching rate and larval survivability. Intermediate fish sampling was done for histology and to determine gonado-somatic index, hepato-somatic index, and reproductive hormones such as testosterone, 17-a, 20-b dihydroxyprogesterone, 11-keto testosterone, 17-b estradiol, vitellogenin, follicule stimulating hormone and luteinizing hormone. The results showed that there was no significant difference between the treatments in terms of breeding performances, however the histology pattern and reproductive hormones exhibited that the diet with 20:80 n-3:n-6 PUFA helped the fishes to mature significantly faster than other two diets. Thus, it can be concluded that 20:80 n-3:n-6 PUFA in the diet is the optimum level although biofloc has specifically contributed in captive maturation of *A. testudineus* in all the treatments.

Keywords: Biofloc, breeding performance, hormones, maturation, polyunsaturated fatty acid

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Biochar enhances the growth parameters, haematological parameters and enzymatic activities of Genetically Improved Farm Tilapia (GIFT) reared in inland saline water

Tao Kara*, Chalungal Amal Thampi, Arun Konduri and Vidya Shree Bharti

ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*taokara.aempb106@cife.edu.in

The demand for affordable protein sources increases as the global population expands. Fish is one of the cheapest forms of animal protein, and demand for economical protein sources is on the rise. Natural resources are on the verge of extinction due to overexploitation to meet this growing demand. Due to overexploitation, natural resources including many fish species are on the verge of extinction. To address this challenge, there is a need for an alternative system that can increase aquaculture production while minimizing environmental impacts through adopting a circular economy approach. In this regard, we attempted to study the efficacy of biochar prepared from agricultural by-products, *i.e.*, sugarcane bagasse and paddy straw biochar as feed additive. An experiment was conducted using triplicate 500 l capacity FRP tanks, each containing two treatment groups and one control group. These tanks were filled with inland saline soil to maintain a 25 cm soil bed, and the water had a salinity level of 12 ppt. In each tank, 22 fish (genetically improved farm tilapia) with an average length of 5.14 ± 0.07 cm and a weight of 4.8 ± 0.05 g were stocked. The fish were fed to apparent satiation twice daily for a duration of 45 days. The results indicated that crucial growth parameters, including specific growth rate (SGR%), weight gain (WG%), and feed conversion ratio (FCR), exhibited significant improvements ($p<0.05$) compared to the control group. Furthermore, the incorporation of biochar into the feed led to significant enhancements in haematological parameters, including red blood cell (RBC) count, white blood cell (WBC) count, haemoglobin (Hb) concentration, haematocrit percentage (HCT), mean cell haemoglobin concentration (MCH), and mean cell volume (MCV) within the treatment groups when compared to the control group. Additionally, the inclusion of biochar as a feed additive was associated with a decrease in catalase (CAT) activity and an increase in amylase and lipase activities within the treatment groups compared to the control ($p<0.05$). In conclusion, using biochar as a feed additive improved the growth and overall health of the fish and demonstrated the potential to enhance fish production. Top of Form

Keywords: Biochar, circular economy GIFT, growth parameters, haematological parameters

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Exploring the impact of fish waste hydrolysate on growth enhancement in *Penaeus vannamei* during nursery phase

Sandeep, K. P*., Debasis De, Sivaramakrishnan, T., Sudhin, S., Raymond, J. A., Mahalakshmi, P., and Ambasankar, K.

ICAR-Central Institute of Brackishwater Aquaculture (CIBA), 75 Santhome High Road, Chennai, India 60002.

* sandkp@gmail.com

Achieving higher survival and growth in nursery rearing is a challenge in shrimp aquaculture. Fish waste hydrolysate (FWH) is a nutrient-dense liquid prepared from fish trimmings. To evaluate the effect of FWH on the growth and survival of *Penaeus vannamei*, as well as to understand the effect of FWH at different stocking densities, three outdoor experiments were conducted for 30 days each. Post larvae (PL) 18 of *P. vannamei* were used in three different stocking densities (1000, 2000 and 4000 individuals m^{-3}) and supplemented with different doses of FWH (0, 10, 20, 40, 80, and 160 ppm). The results of the experiment with high stocking density (4000 individuals m^{-3}) showed that the growth parameters, such as weight gain percentage (WGP), specific growth rate (SGR), average daily gain (ADG), and average final body weight (AFBW), were significantly higher ($p<0.01$) in treatments supplemented with 80 and 160 ppm FWH compared to the control without FWH. The survival of treatments with FWH supplementation of 80 ppm and above was significantly higher ($p<0.01$) than the control. The results of the second experiment with medium stocking density (2000 individuals m^{-3}) showed a similar trend in growth parameters to that of higher stocking density. WGP, SGR, ADG, AFBW, and survival were significantly higher ($p<0.01$) in treatments supplemented with 80 ppm FWH compared to other treatments. The results of the third experiment with low stocking density (1000 individuals m^{-3}) also showed a similar trend in growth parameters to that of higher stocking density. WGP, SGR, ADG, AFBW, and survival were significantly higher ($p<0.01$) in treatments supplemented with 80 ppm FWH compared to other treatments. Irrespective of the stocking densities, higher FWH supplementation supported the formation of flocs in the system, and floc density increased with the increase in FWH supplementation. The abundance of phytoplankton and zooplankton showed a significant increase in treatments supplemented with FWH. From the results, it is clear that all growth parameters were significantly higher at higher doses of FWH (80 ppm and 160 ppm), irrespective of the stocking densities. Survival increased by 12-19%, and average body weight increased by 25-35% in tanks supplemented with 160 ppm FWH compared to the control. Enhanced plankton and floc densities were observed in the FWH-supplemented tanks, which might have positively contributed to shrimp larval nutrition. Hence, the present study can be the baseline data to utilize FWH in shrimp nursery rearing to enhance growth and survival.

Keywords: Fish waste, growth enhancement, nursery rearing, plankton abundance

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Frozen Tubifex – an effective way of feeding ornamental fishes

Guntapalli Sravani* and Paramita Banerjee Sawant

ICAR- Central Institute of Fisheries Education, Versova, Mumbai-400061, Maharashtra, India

* sravani.aqcmb103@cife.edu.in

Tubifex tubifex has been identified as an excellent natural food source for fish and prawns owing to its optimal size and well-balanced nutritional composition that aligns with the dietary requirements of cultured fish. Live tubifex worms pose a higher risk of transmitting parasitic infections. Hence, care has to be taken before feeding them to fishes. Furthermore, live tubifex has a relatively limited shelf life of 2-5 days. In situations where live tubifex worms are unavailable, freezing them is an alternative solution. Utilizing frozen tubifex as a food source offers numerous advantages, including convenience, prolonged shelf life, commendable nutritional profile, dietary diversification, and appetite stimulation. Hence, a study was conducted to evaluate the shelf life of frozen tubifex (stored at -20^{o}C) for a period of 12 weeks (84 days) and impact on the nutritional profile during and after the entire storage period. Analysis of the nutritional profile was carried out at an interval of seven days, wherein, no significant variation was observed in crude protein till the 29th day, crude fat up to the 36th day and ash content up to the 15th day as compared to the first day of storage. Based on the results obtained, it can be concluded that frozen tubifex stored for up to 29 days at a temperature below -20°C, can be safely utilized as a potent feed for rearing ornamental and food fish, whenever access to live tubifex worms is limited. This study therefore, presents a comprehensive overview of the fundamental aspects concerning the nutritional value of frozen tubifex as a potent alternative dietary option for fish.

Keywords: Dietary diversification, freezing, nutritional profile, shelf life, Tubifex

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Feeding techniques in the nursery rearing of bigfin reef squid, *Sepioteuthis lessoniana*

Kavitha, M.*, Geetha Sasikumar, Linga Prabu, D. and Kalidas, C.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* kavifish@gmail.com

The bigfin reef squid, *Sepioteuthis lessoniana* is a fast-growing cephalopod, active swimmer, and top predator. The aquaculture of *S. lessoniana* has been achieved with variable degrees of success in different parts of the world. The species shows rapid growth with a high feeding rate and thus requires a massive supply of live feed organisms during the nursery phase of its culture. The aim of this study was to evaluate the feeding techniques in the nursery rearing of *S. lessoniana*. On the day of post-hatch (DPH-1), the hatchlings were fed with a mixed variety of live feeds of different sizes collected from the wild, mainly paste shrimp, *Acetes japonicus* (4-10 mm), mysid, *Mesopodopsis* sp. or the post-larvae of penaeid shrimp (*Penaeus merguiensis, P. indicus, P. semisulcatus* (5–10 mm)). The live feeds were fed to the squid paralarvae *ad libitum* at a frequency of 3 times per day. The study revealed that live feed with a size range of 4-10 mm was more appropriate for feeding the hatchlings of squid during the early phase. In the absence of small-size mysids and shrimp post-larvae, hatchlings were fed with sub-adults of *Artemia* sp. (4-8 mm) and results showed that hatchlings were not attracted towards them but consumed them in meagre quantity for their survival. After 30 days of post-hatch, the live feed consisted primarily of *A. japonicus* (10-20 mm), juveniles of penaeid shrimps (10-40 mm) and fish species including guppy, molly, mullet, *Mugil cephalus* (10-45 mm). The squids were fed with live larger shrimp and fish until 60 days. The *S. lessoniana* was trained to feed on flesh (forage fish and shrimp) after 60 days of post-hatch during the late nursing phase due to the requirement of higher quantity of live feeds and to reduce the production costs. The feeding percentage of *S. lessoniana* was calculated and it was found to consume live food organisms at the rate of 20-30% of its body weight per day. Further, observations showed that cannibalism prevailed with inadequate live feed availability and the individuals of various sizes of young *S. lessoniana* were attacking the same prey. In addition to the live feeds, the young *S. lessoniana* were fed with formulated wet-pellet feed which were not accepted. The non-acceptance of formulated feed is a bottleneck during the nursery rearing of *S. lessoniana* that warrants substantial quantity of live feed for the successful culture of the squid.

Keywords: *Acetes* sp., cephalopod, live feed, mysids, squid

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Use of copepods as live feed for marine ornamental fish larval rearing

Santhosh, B.*, Ambarish P. Gop, Anil, M. K., Muhammed Anzeer, F., Aneesh, K. S., Darsana, S., Ritty Maria Thomas, Mijo V. Abraham, Krishna, S., Rathi Bhuvaneswari, Anuraj, A., Jose Kingsley, H., Leslie, V. A., Akhil, A., Madhu, K., Boby Ignatius, Suresh, V. V. R. and Gopalakrishnan, A.

ICAR Central Marine Fisheries Research Institute, Ernakulam North P.O., Kochi, 682 018, Kerala, India

* santhoshars@gmail.com

Copepods are the most abundant organisms in marine plankton and form an important feed for many marine fishes and invertebrates and their larval forms. Many newly hatched marine ornamental fish larvae have a mouth size of approximately 100µm and since the naupliar stages of many marine copepods are in the size range of 20-50 µm, they form an ideal live feed for these fish larvae. Copepods and their larval form are nutritionally rich and form ideal prey for fish larvae. As a result of intensive research for the past decade, 12 species of marine copepods were isolated and identified and pure line stock cultures were developed by ICAR-CMFRI for using as live feed for marine fish larval rearing. These are *Acartia bilobata, A. southwelli, A. tropica, Bestiolina similis, B. coreana, Parvocalanus crassirostris, Pseudodiaptomus annandalei, P. serricaudatus* and *Temora turbinata* (Calanoida) *Dioithona oculata* and *Oithona brevicornis* (Cyclopoida) and *Euterpina acutifrons* (Harpacticoida). Ideal feed, environmental and culture conditions of all these species were delineated and stock and mass cultures of these copepods are being carried out in ICAR-CMFRI hatchery. Mostly a combination of microalgae is needed as ideal feed for the optimum culture of all these species. These copepods are being widely used as larval live feed for many marine ornamental fishes at Vizhinjam Regional Centre for ICAR-CMFRI. Apart from using these copepods in the seed production of many species of clown and damsel fishes, successful seed production has been achieved for nine species of marine ornamental fishes as a breakthrough research. These are Maldives damselfish (*Amblyglyphidodon indicus*), Cloudy damsel (*Dascyllus carneus*) Azure damsel (*Chrysiptera hemicyanea*) Black- bar chromis (*Pycnochromis retrofasciatus*), Two-tone chromis (*Pycnochromis fieldi*) Dottyback (*Pseudochromis* sp.) Marcias anthias (*Pseudanthias marcia*), Sea goldie (*Pseudanthias squamipinnis*) and Shrimp goby (*Amblyeleotris* sp.). Larval feeding protocols were standardized for each of these fish species, either using copepods alone or in combination with other live feeds like rotifers and artemia. Using copepods increased the health and survival of most of the marine ornamental fish larvae. No additional enrichment was used in any of these cases. In most of these copepods, PUFA content, especially the combination EPA and DHA is in the ideal situation required for marine fish larvae. Copepod culture and the larval rearing protocols developed are much simpler compared to the previous reports, and dissemination of these technologies will support the development of hatchery production of marine ornamental fish in India.

Keywords: Copepods, larval rearing, live feeds, marine ornamental fishes, seed production

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Marine microalgae, *Isochrysis galbana* culture in Photobioreactor: Effect of CO_2 supply on enhanced growth and productivity

Biji Xavier[1]*, Ritesh Ranjan[1], Sekar Megarajan[1], Jayasree Loka[1], Vamsi Balla[1] and Shubhadeep Ghosh[2]

[1]ICAR-Central Marine Fisheries Research Institute, Visakhapatnam Regional Centre,Ocean view Layout, Pandurangapuram, Visakhapatnam -530 003, Andhra Pradesh, India
[2]Division of Fisheries, ICAR, Krishi Anusandhan Bhawan–II, New Delhi–110 012, India

*bijicmfri@gmail.com

Microalgae, are primary producers in the marine food chain, where they form prime feed for zooplankton like rotifers and copepods, which in turn are the main feed for larval forms of marine finfishes. *Isochrysis galbana* is a small marine microalga (4-6 µm in diameter) utilized in the aquaculture industry due to its high division rate and moderate lipid accumulation, resulting in high lipid productivity. Due to its high content of omega-3 fatty acids especially DHA, *I. galbana* has been incorporated in different marine finfish larval diets. Since the requirement for microalgae is huge for its application, the mass culture of microalgae is inevitable. In recent years, the trend of mass cultivation of microalgae has shifted from a conventional open system to a closed photobioreactor (PBR) system, in order to reduce contamination and achieve higher cell density. In this context, an experiment on the cultivation of *I. galbana* was conducted in a photobioreactor with the objective to enhance cell count and productivity. For the experimental trial, the reactors were inoculated with *Isochrysis* culture with a cell count of $4x10^6$ cells ml^{-1} as inoculum (20% V V^{-1}) with the standard dose of culture medium to maintain same initial cell density of 1.5 x 10^6 cells ml^{-1} in all reactors. The culture was maintained for 5 days in the growth phase at a temperature of 18-21^oC, pH of 7.8-8.4, salinity of 23-25 ppt, and light intensity of 2000 lux. From, the third day of inoculation, the culture was given different treatments, namely, R1: second dose of culture medium; R2: dose of carbon dioxide (CO_2), R3: a combination of a second dose of culture medium and CO_2 and R4: maintained as control. In all the treatments the culture progressed well with initial log phase for short duration and long exponential phase. At the end of the experiment, treatment R2 performed better with maximum cell density (10.0 $\times 10^6$ cell ml^{-1}), high specific growth rate, µ (0.474 day^{-1}) and division rate, k (0.684 day^{-1}). The minimum duplication time, tg of 1.461 day^{-1} for the same treatment resulted in the highest volumetric productivity, Px of 4.742 cell L^{-1} h^{-1}. It was concluded from the study that the application of CO_2 in the photobioreactor can enhance cell density and productivity for mass-scale production of *I. galbana*.

Keywords: Carbon dioxide, *Isochrysis galbana*, photobioreactor, productivity, specific growth rate

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Commercial scale cultivation of marine microalgae in open raceway ponds for algae meal production– Technical evaluation

Kalidas, C.*, Linga Prabu, D., Ranjith, L., Kavitha, M. and Asha, P. S.

ICAR- Tuticorin Regional Station of CMFRI, Tuticorin-628001, Tamil Nadu, India

* kalidas.c@icar.gov.in

The study aims to investigate the technical efficiency of production pond, harvest and drying unit to optimize the marine microalgae meal production in commercial scale. The system consists of six twin-cement, oval shaped open pond recirculation units (OPRe) (49.5 m^3) coated with food grade liners and provided with paddle wheel (16 rpm) connected to 2.5 m shaft length consists of four stainless steel blades for the mass production of selected marine microalgae *Nannochloropsis gaditana* and *Isochrysis galbana*. The result of the production ponds shows that the maximum biomass production recorded (212.67 million cells ml^{-1}) at a water depth of 0.21 m and 190.85 million cells ml^{-1} at 0.25 m and 150.34 million cells ml^{-1} at 0.18 m depth. The average water qualities recorded were salinity (50±3.0 ppt), temperature (31±2.0^oC), pH 9.3±0.5 and dissolved oxygen 5.6±0.4 mg l^{-1}. The harvest efficiency of the tubular bowl centrifuge is 1000 l h^{-1} with a bowl capacity of 6 kg operated at the speed of 16000 rpm. The centrifuge operated for 2 cycles of each 5 hours per day and recorded the algal paste yield of 5.0±0.3 kg per cycle. The cell concentration in the harvested microalgal paste (n=3) was 60±2.0 billion cells g^{-1}. The estimated microalgae algae biomass production was 1.05±0.09 g m^{-2} day^{-1}. The filtered culture water was re-circulated back to the OPR for continuous production for a period of 120 days. The harvested wet biomass was dried under the poly-house drier unit (45-48^oC) fitted with dehumidifier for a duration of 48±2.0 h. This drying method resulted in the reduction of wet to dry biomass production at the ratio of 1: 0.28. The dried algal strings were ground using commercial pulverizer at the speed of 16000 rpm for 2-3 min to produce fine microalgae meal and used as an aqua-feed ingredient. In conclusion, technically the tubular bowl centrifuge is more suitable in mass harvesting of marine microalgae (10 µ size). The OPRe used for the commercial production of marine microalgae in a water depth of 0.21 m is ideal for significant enhancing the cell concentration for microalgae biomass production.

Keywords: Biomass, *Isochrysis* spp., *Nannochloropsis* spp., recirculation, tubular bowl centrifuge

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Biochemical effect Of microplastic ingestion on tilapia *(Oreochromis niloticus)*

Shylaja, G.[1]*, Kripa, V.[2], Kajal Chakraborty[1], Sanal Ebeneezar[1], Chandrasekar, S.[1], Krupesh Sharma[1], Sayooj. P.[1] and Sajeela, K. A.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Coastal Aquaculture Authority, Chennai, India

*g.shylajacmfri@gmail.com

Aquatic systems worldwide are being severely altered or destroyed at a rate faster than they are being restored. Among anthropogenic interventions, the deleterious impact of plastic litter has evolved as an emerging contaminant of concern today impacting aquatic biota. The aim of this study was to investigate the potential toxicological effects of microplastics on biota with special reference to biochemical changes by exposing them to microplastic incorporated feed. Diets were prepared utilizing a basal diet formulated with 36% protein and 7% lipid which was in compliance with the nutritional requirement of tilapia. The control diet contained 0% plastic while the treatment diets had an inclusion of plastic polymers, namely, T1- Polyvinyl chloride resin (PVC-r), T2-Polyvinyl chloride compound (PVC-c) andT3- Polyethylene resin (PE-r) at 1% (w w^{-1}). Uniform sized (6-8 cm) fingerlings of tilapia (*Oreochromis niloticus*) were stocked in triplicate tanks for each treatment as well as for control and feeding was done for a 12-week trial period. Four consecutive sampling at Zero day (D-0), day 30(D-30), day 60(D-60) and day 90(D-90) were done to evaluate the growth parameters. Proximate analysis of the feed and the fish samples were done at the commencement of the experiment and on the termination of the feed trial (D-90). Fatty acid profiling of the whole body of the samples were carried out at D-90. The results of the study revealed that there was a significant variation in the mean weight gain, between the control and treatments at D-90($p<0.05$). The lowest weight gain (246.06±4.22g) obtained was for the treatment T2 with PVC compound, a mixture of PVC resin with chemical additives. The other three growth parameters namely, Percentage weight gain, Specific growth rate (SGR%) and Feed conversion ratio (FCR%) also exhibited a statistically significant variation between the control and the treatment ($p<0.05$). The fatty acid profiling showed high concentration of saturated fatty acids for fishes of all treatments compared to the control condition, depicting the impact of microplastic ingestion in biota. Among the three experimental treatments, T2 could elicit more negative impact on the fatty acid concentration as the process of leaching of chemicals would have initiated in the body tissue. However, prolonged exposure might lead to adverse effects, and therefore, evaluation of the potential long-term impact of these particles is warranted.

Keywords: Biochemical, fatty acid, impact, microplastics, proximate

Assessment of Condition Factor in *Pangasianodon hypophthalmus* reared under different Aquaculture Systems

Madhulika[1]*, Sujata Sahoo[2], Jebarson Solomon[1] and Patekar Prakash[1]

[1]ICAR-Central Institute of Fisheries Education, Mumbai – 400061, Maharashtra, India
[2]ICAR-Central Institute of Fisheries Education, Kolkata – 700091, West Bengal. India

*madhulika.fpbpb202@cife.edu.in

The condition factor (K) serves as a widely adopted metric for evaluating the overall well-being of fish including nutrition. It provides insights into both the physical and biological aspects of fish, capturing variations resulting from a complex interplay of factors including feeding conditions, parasitic infections, and physiological dynamics. Understanding the condition factor is crucial in the management of aquaculture systems as it offers valuable information about the environmental conditions in which organisms are being cultivated. The study aimed to evaluate the condition factors of *Pangasianodon hypophthalmus* from extensive, semi-intensive and intensive aquaculture systems. The study was conducted in Kolkata, West Bengal during May to June, 2022. A total of 30 fish samples ranging from 50.1 g- 429 g were collected from each culture system. The the stocking density ranged from 10-15 fish m^{-3}, 60-80 fish m^{-3} and 100-150 fish m^{-3} in extensive, semi-intensive and intensive culture ponds respectively. To minimize stress, fish were anesthetized using clove oil. The length and weight of each fish was measured and Fulton's condition factor was computed for each fish employing the Htun-Han equation. Furthermore, a comprehensive health assessment was conducted, examining the fish's skin, fins, eyes, and gills. In this study, the findings revealed a statistically significant difference ($p<0.05$) in condition factor, with the highest values observed in the intensive culture system, followed by the semi-intensive and extensive culture system. Culture systems and environmental factors have substantial influence on fish health. The environment is a crucial determinant of fish growth and development. The assessment of the condition factor in *Pangasianodon hypophthalmus* in different culture systems revealed that the fish were in good health, without any significant nutritional concerns. The study also shows that condition factor can be calculated in a very non-invasive way and the findings of this study can serve as a valuable point of reference for future health assessments and studies.

Keywords: Health, length- weight relationship, *Pangasius*, stocking density

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

An investigation on the behavioral responses of spiny lobster, *Panulirus homarus* (Linnaeus, 1758) to salinity shifts with perspectives for coastal aquaculture practices

Ratheesh Kumar, R*., Sumithra, T. G., Reshma, K. J., Rahul, R., Sreenath, K. R. and Zacharia, P. U.

ICAR-Central Marine Fisheries Research Institute, Post Box No. 1603, Ernakulam North P.O., Kochi, 682 018, India

*rkcmfri@gmail.com

Scientific information on the influences of salinity shifts on the behavioral attributes of marine animals is essential in understanding animals' welfare status, thus to select potential coastal aquaculture candidates and suitable commercial cultivation sites and to devise conservation strategies in the context of climate change. This study establishes the data on the changes in easily monitorable three visual behavioral attributes, *viz.* rate of antennule flicking per minute (AFM), the feed response time (FRT), feed residue% (FR) following gradual and abrupt shifts (within ± 25‰) from the control (35‰) for a high-value coastal aquaculture candidate, *Panilurus homarus.. Results showed that* the behavioral attributes of *P. homarus were significantly (p<0.05) influenced by b*oth higher and lower salinity regimes from the control. The abrupt rise in AFM was the initial visible response to the salinity shifts. Further, beyond 17 to 47‰ and 26 to 41‰, AFM was permanently decreased in gradual and abrupt changes, respectively. A significantly increased FR% (beyond 17 to 41‰ and beyond 32 to 41‰, respectively) and decreased FRT (beyond 29 to 38‰ and beyond 32 to 38‰, respectively) on gradual and abrupt salinity shifts were observed. The animals became completely anorectic beyond 44‰ to 14‰, and beyond 44‰ to 23‰ respectively, on gradual and abrupt salinity transitions. A better coping mechanism and a more comprehensive range of salinity tolerance were observed for gradual shifts in the behavioral responses rather than abrupt shifts. The study forms first-hand data on behavioral attributes of *P. homarus* upon salinity shifts and the established ranges and values can form foundational reference data for future research. Altogether, *P. homarus* demonstrated a greater tolerance to a wider salinity range, allowing them to thrive in the coastal environment and making it suitable for coastal aquaculture.

Keywords: Antennule flicking, coping mechanism, feed residue, feed response, , salinity tolerance

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Effect of thermal acclimation on the tolerance of silver pompano, *Trachinotus blochii*: A species for climate-resilient mariculture

Divu, D*., Suresh Kumar Mojjada, Abdul Azeez, P., Swathi Lekshmi, P. S., Anil, M. K., Ambarish P. Gop, Ratheesh Kumar, R., Mayur S. Tade, Aarsha Subramanian, Suresh, V. R. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*divudamodar@gmail.com

As global temperatures continue to rise due to climate change, deciphering the thermal tolerance of marine organisms takes on heightened significance in the context of sustainable and diversified mariculture. In this light, the evaluation of the heat tolerance in fish species becomes not only an academic pursuit but also a practical necessity to ensure the resilience and viability of aquaculture systems. The ppresent study delved into the Critical Thermal Maxima (CT_{max}) and Critical Thermal Minima (CT_{min}) of silver pompano *(Trachinotus blochii)* across six distinct acclimation temperatures (T_{acc}) ranging from 18 to 36°C. The water temperature was gradually elevated at a controlled rate of 0.3°C per minute, enabling the calculation of CT_{max} and CT_{min} through the application of the Critical Thermal Methodology. The findings unveiled the CT_{max} and CT_{min} of *T. blochii* as 41.1±0.0478°C and 12.0±0.0748°C, respectively. Notably, the Thermal Tolerance Polygon was computed as 357.02°C encompassing the specified temperature range. The results of the investigation illuminated that silver pompano acclimated to higher temperatures exhibited enhanced thermal tolerance and *vice versa*. Furthermore, the study showcased the capacity to augment their thermal tolerance through a tailored acclimation regimen, thereby enhancing their adaptability to variable environmental temperatures. Leveraging the robust attributes of *T.blochii* as a preferred candidate species for existing mariculture production, their temperature plasticity can be seamlessly integrated into climate-smart marine aquaculture systems, offering a viable strategy to alleviate the adversities wrought by climate change.

Keywords: Acclimation temperature, climate change, mariculture, silver pompano, sustainable farming

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Does the lunar periodicity affect the spawning rhythm in captivebred marine ornamental fishes under controlled environment?

Sakthivel, M.*, Tamilmani, G., Anikuttan, K. K., Rameshkumar, P., Sankar, M., Johnson, B., Madhu, K., Rema Madhu, Krishnaveni, N., Ishwarya, R., Rao, G. H. and Jayasingh, M.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sakthicares@gmail.com

Success in captive breeding of marine ornamental fishes mainly depends on the development of quality broodstock for consistent spawning by mastering their reproductive biology to enable continuous larval production. Synchronization of spawning with lunar periodicity is a common phenomenon in many marine teleosts in the tropics. In natural habitats, this rhythm usually coincides with lunar-associated tidal cycles which synchronize the release of gametes and favour subsequent development survival, and dispersal of eggs and larvae. In the present study, we hypothesized that the rhythm of spawning of hatcheryproduced and captiveraised ornamental fish is not influenced by the lunar periodicity at a controlled environment under captivity in recirculating aquaculture system (RAS) system. Detailed spawning characteristics of nine varieties of clown anemone fishes namely, Percula, Fire clown, False Percula, Nose-stripe clown, Picasso, Platinum, Black ocellaris, Maroon clown and the crossbred of Black ocellaris with Percula were studied in relation to lunar periodicity for a period of four years (June 2016 to June 2020) at the Mandapam Regional Centre of ICAR-Central Marine Fisheries Research Institute. The fishes were maintained under captivity in RAS maintained in a closed room where the natural environmental cues were physically deprived but a controlled environment including temperature and light intensity (12 h light and 12 h darkness) was provided. Water quality parameters including temperature and duration and intensity of light were maintained consistently. The data on spawning and hatching were recorded; the dates of spawning were assigned codes and fitted into the four quarters of a lunar calendar to assess the influence of lunar cycle on captive spawning. The statistical analyses of data on spawning (n=1179) revealed that the lunar periodicity did not show any significant ($p>0.05$) influence on the spawning rhythm in any of the nine varieties of clownfish under the RAS rearing system. During the study, successful spawning and larval production was achieved in all the four phases of lunar cycle. This indicates that the spawning in these clown species is highly influenced by the rearing conditions rather than lunar periodicity. Though the adaptive significance of such a spawning behaviour is unclear, the information generated may be useful for obtaining continuous year-round spawning and subsequent larval production of these commercially lucrative fish. The consistent spawning obtained irrespective of lunar periodicity could be attributed to the conducive environment in the RAS in conjunction with constant food supply and less aggressive behaviour brought on by pair bonding.

Keywords: Clownfish, lunar periodicity, marine ornamental fish, RAS, spawning rhythm

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Innovative approaches on procurement, transportation and development of captive broodstock of Asian seabass *Lates calcarifer* (Bloch)

Subburaj, R.*, Kailasam, M., Makesh, M., Jayakumar, R., Thiagarajan, G., Aritra Bera and Dani Thomas

ICAR Central Institute of Brackishwater Aquaculture, 75 Santhome High Road, R.A. Puram, Chennai, Tamil Nadu, India

*subburaj.r@icar.gov.in

Asian seabass *Lates calcarifer* is one of the important candidate food fishes and most sought-after alternative species for aquaculture in India. The global marketing surveys indicate that seabass trade will grow @5% CAGR in next decade and India is expected to produce a significant quantity of this high valued fish. To augment this, Asian seabass hatchery with adequate quantity and quality seed production is essential and in this line establishment of considerable number of private hatcheries in the coming years is needed. At present, existing seabass hatcheries are encountering problems like sourcing good quality brooders, transportation and timely maturation and maintaining correct male female ratio, regular and offseason breeding *etc*. To address all these issues for sustainable seed production, broodstock development and management is essential at the hatchery level. In these broodstock selection, transportation, quarantine, prophylactic treatments, feed and health managements are playing a crucial role. ICAR–Central Institute of Brackishwater Aquaculture which pioneered in seabass hatchery seed production in India has standardized the techniques, protocols and procedures for procurement, transportation, quarantine, development and management of seabass. The proven technology developed for seabass has helped the development of captive seed production for many other species of salt water fishes. In this paper, selection of good source of brooders, criteria for selection of brooders, brooder handling, procedures for good survival, quarantine procedures, prophylactic treatment methods, PIT tagging and vaccination for viral diseases are discussed in detail. Broodstock management aspects such as different holding systems for captive land-based maturation in open tank, flow through and RAS systems, optimal biomass for holding in different systems to induce maturation and captive breeding, and optimizing the health and feeding regime are also discussed All these aspects of seabass broodstock development will help in production of quality seed and extended period of breeding for sustainable seed production and farming.

Keywords: Barramundi, culture protocols, hatchery, seed production

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Degradation kinetics of potassium permanganate in tropical aquaculture environments

Rajesh, R*., Saraswathy, R**., Satheesha Avunje and Patil, P. K.

ICAR- Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R A Puram, Chennai – 600 028, Tamil Nadu, India

*Presenting author

** R.Saraswathy@icar.gov.in

Aquaculture is a key contributor in ensuring global food security, with seafood being one of the most important and valuable commodities to meet protein-rich nutritious food demand. India plays a vital role in the production and export of seafood with 17,35,286 MT shipments estimated at USD 8.09 billion (Rs 63,969 crore) in FY 2022-23. Safeguarding against potential diseases is key to successful aquaculture. Potassium permanganate ($KMnO_4$) is used as a disinfectant and broad-spectrum oxidant to control and prevent diseases in fish and other aquatic organisms. It has been found to effectively treat bacterial, fungal, and parasitic infections particularly external parasites. This study investigates the degradation kinetics of $KMnO_4$ in aquaculture ponds under exposure to sunlight and aims to evaluate its degradation. The experiment comprised 3 concentrations (2, 50 and 150 ppm) of $KMnO_4$, three different salinities (2, 15 and 25 ppt) with varying pH (5, 7 and 9). The experiment was conducted in glass bottles kept in sunlight and the samples were collected and analyzed at periodical intervals. During the experiment, the average light intensity was 53,785 lux and the average temperature and photoperiod were 33^{o}C and 12 hours 46 mins respectively. The results revealed that potassium permanganate undergoes photodegradation under sunlight exposure. The rate of degradation depends on initial $KMnO_4$ concentration, temperature, pH, salinity and sunlight intensity. At 2 ppm concentration, the reaction of degradation was very rapid, whereas under 50 ppm and 150 ppm, the half-life was much longer at 32.5 and 63.61 hours. Faster degradation was observed in pH 5 as compared to pH 7 and pH 9, with a half-life of 44.1, 47.65 and 52.43 hours in pH 5, 9 and 7 respectively. Low salinity showed faster degradation in all pH and concentration with a half-life of 45.95, 48.22 and 50.10 hours under 2, 15 and 25 ppt respectively. The degradation kinetics followed first-order reaction kinetics. The findings provide valuable insights into the environmental fate of $KMnO_4$ in sunlight-exposed aquatic systems and offer essential information for managing its use sustainably. The efficacy of recommended dosage of 2 ppm degrades rapidly and therefore dosage can be increased in order to maintain 2 ppm concentration for a short term.

Keywords: Aquaculture, degradation, disinfectant, potassium permanganate

Water budgeting and cutback approach in coastal shrimp culture

Rajeeb K. Mohanty* and Arjamadutta Sarangi

ICAR-Indian Institute of Water Management, Bhubaneswar 751023, Odisha, India

* rajeebm@yahoo.com

Studies on hydrological water balance to determine density-dependent water use is a major requirement in improving aquaculture performance. Rearing densities of pacific white shrimp, *Litopenaeus vannamei* under three densities with three replicate treatments [T_1: 0.4 million post-larvae (PL) ha^{-1}, T_2: 0.5 million PL ha^{-1}, T_3: 0.6 million PL ha^{-1}] besides water cutback approach was investigated. The water use efficiency, water productivity, water footprint, sediment load, and production performance were evaluated. Conditional water exchange was carried out based on water quality parameters. Water quality suitability index was observed to be very good (7.5–9.0) up to 13^{th}, 10^{th} and 5^{th} week of culture in T_1, T_2 and T_3, respectively, which was attributed to rearing density, smaller-sized shrimp and minimum feed inputduring initial phase of rearing. Optimum rearing density of 50 PL m^{-2} (T_2) led to total water use of $3.25\times 10^4 m^3$. This intervention was observed to improve shrimp productivity (10.58 t ha^{-1} 120 d^{-1}), consumptive water use index (1.72m^3 kg^{-1} biomass), total water footprint (1,229 m^3 t^{-1} biomass) and net consumptive water productivity (USD 1.28 m^{-3}). *L. vannamei* culture with low to moderate water exchange as in T_2, assisted to uphold water quality suitable for shrimp growth, improved water use efficiency (0.58 kg biomass m^{-3} water), minimized sediment load (45.3 m^3 t^{-1} biomass), effluent outputs (0.63×10^4 m^3), pumping cost (USD 30.1 t^{-1} biomass produced), and ratio of output value to the cost of cultivation (1.97). Although sea water availability was plenty and its saving was not a major concern, its budgeting in coastal aquaculture helped in (1) water saving up to 30-33%, (2) energy/ fuel saving US $ 310-320 per ha/ crop, (3) manpower saving USD 72-80 per ha/ crop, (4) input saving (lime/ dolomite) US$ 88-90 per ha/ crop, (5) reduced sediment load by 12-16%, (6) lessening water exchange probability, less effluent discharge (reduced by 30%) and (7) minimal adverse impact on flora, fauna and benthic population structure of effluent induced water body. Findings of this study would assist in expanding shrimp rearing operations, and the water management measures indicated here can minimize waste of water and deterioration of pond water quality while enhancing shrimp yield and water use efficiency.

Keywords: Effluents, Pacific white shrimp, shrimp farming, water conservation

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparison of total carbon budgets for *Penaeus vannamei* in earthen and polyethylene lined culture systems

Aravind Revi*, Nagavel, A., Kumararaja, P., Saraswathy, R., Gopinath, D., Neeraj Kumar and Muralidhar, M.

ICAR-Central Institute of Brackishwater Aquaculture, 75 Santhome High Road, RA Puram, Chennai-600 028, Tamil Nadu, India

*revimini1969@gmail.com

Total carbon budgeting studies in shrimp aquaculture systems are limited. Therefore, the current study was aimed at developing the methodology for total carbon budgeting and comparing it in earthen and polyethylene-lined *Penaeus vannamei* culture systems in triplicate with an average stocking density of 50 nos. m^{-2} in both systems. All the previous carbon budget studies from aquaculture were focused on organic carbon fraction. The current study has taken the total carbon content including the inorganic carbon for carbon budgeting. The carbon budgeting was developed based on the mass balance method by accounting for the carbon content for different input components like stocked shrimp, water at the time of stocking, initial soil and added feed, fermented filtrate and other inputs into the pond, and output components like harvested shrimp, water at the time of harvest, soil after harvest (earthen ponds), and sludge accumulated (periodic removal and collected on the day of harvest from lined ponds). Water and soil samples were collected fortnightly from both systems for the analysis of basic physicochemical parameters. For the total carbon input, soil accounted for the highest in earthen systems (avg. 47.7%) and water in polyethylene lined systems (avg. 64.8%) followed by feed (44.6% in earthen; 34.2% in lined), and contribution of others as inputs was less than 10% in both the systems. For the total carbon output, the soil accounted for the highest share of 67.5% in earthen systems, and water with a share of 37.8% in polyethylene-lined systems. The unaccounted carbon outputs were lower in earthen culture systems (avg. 13.57%) compared to polyethylene-lined systems (avg. 20.7%). The retention of carbon by shrimp was found to be higher in polyethylene-lined systems (avg. 19.7%) when compared to earthen systems (avg. 11.9%) owing to higher survival. The findings of the present study recommend minimising waste generation by improving feed management and following better management practices. Our findings can also provide scientific guidance to mitigate greenhouse gas emissions.

Keywords: Carbon inputs and outputs, earthen Pond, lined Pond, *Penaeus vannamei*

Sustainable development of open sea cage farming in Indian mariculture: Insights from water quality analysis using Generalized Additive Modeling (GAM)

Mayur Shivdas Tade[1,2]*, Divu D.[1], Suresh Kumar Mojjada[1], Abdul Azeez, P.[1], Swathi Lekshmi Perumal Sundaram[1], Aarsha Subramanian[1] and Jai Shree[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Kerala University of Fisheries and Ocean Studies, Panangad Road, Madavana, Junction, Kochi, Ernakulam- 682506, Kerala, India

*mayur.tade@gmail.com

The mariculture sector contributes around 18% to global fisheries and aquaculture production, playing a significant role. However, it is still in its early phase of development in India. The technological breakthrough came in 2008 when ICAR-CMFRI introduced open sea cage farming technology, revolutionizing the Indian mariculture sector by cultivating valuable marine finfish and shellfish. Despite its advantages, concerns exist about open sea cage farming's impact on water quality and eutrophication, affecting overall ecosystem sustainability. To address these apprehensions, a strategic effort has been undertaken. Employing a framework of Generalized Additive Modeling (GAM), a preliminary investigation was undertaken in Veraval, Gujarat, focusing on the interplay between water quality parameters/nutrients and seasonal phytoplankton diversity. The employment of the Generalized Additive Modeling (GAM) technique demonstrates significant efficacy in ecological analyses, particularly in the context of fisheries and ecological variables. This investigation was carried out at both the cage culture site and a designated reference site. The selection of the Shannon diversity index for phytoplankton serves as a pertinent indicator, facilitating the thorough analysis of coastal water quality dynamics. The results of this study reveal that the computed seasonal Shannon diversity indices at the cage culture site were 3.30, 3.19, and 3.34 during the pre-culture, culture, and post-culture phases, respectively. In contrast, a value of 3.45 was observed at the reference site. Evidently, the reference site showcased a higher degree of phytoplankton diversity. The most dominant class phytoplankton was Bacillariophyceae, followed by Dinophyceae/Dinoflagellates. Shannon diversity index could explain 72.9% of the deviance in Total Suspended Solids (TSS), 30.5% in Ammonia, 28.5 in temperature, 28% in dissolved oxygen, 23.5% in pH, 15.9% in phosphate, and 6.3% in nitrate, all with a significance level of $p<0.05$. The strategic modeling approach offers valuable insights, aiding informed decisions making for sustainable utilization of coastal water resource. Furthermore, the methodology allows for the estimation of carrying capacity to support potential open sea cage farming endeavours in India's mariculture sector.

Keywords: Generalized Additive Modeling (GAM), mariculture, phytoplankton, sea Cage Farming, sustainability

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Impact of extremely heavy rainfall on water quality in shrimp aquaculture areas of Godavari river basin of Andhra Pradesh

Gopinath, D*., Nagavel, A., Aravind Revi, Sravanthi Oduru, Kumar, C. and Muralidhar, M.

ICAR-Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, Chennai – 600 028, Tamil Nadu, India

*Presenting Author-

**Corresponding Author- Muralichinitu.M@icar.gov.in

Climate change-induced changes particularly in environmental parameters play a vital role in the success of aquaculture. The water quality of source waters (SWs) and shrimp culture ponds (CPs) and productivity are affected by seasonal variations and extremely heavy rainfall. In the present study, the effect of heavy rainfall followed by a flood on the quality of SWs and CPs was assessed in the shrimp culture areas of Sivakodu Palam, Yuva Lanka, Gudimula, Gondi, Malikipuram, and Antravedi Karai Villages in Narsapur Mandal of West Godavari District, Andhra Pradesh. The study area received on average high rainfall of about 73 mm per day during 2nd week of July 2022 amounting to about 480 mm which is 35% excess compared to normal rainfall, resulting in flood in the Godavari River. The water samples were collected once a week from the fixed sampling stations on SWs (5 nos.) and CPs (5 nos.) from each village in July during the period of heavy rainfall and after flood in August, and analysed for physicochemical parameters, nutrients and mineral profile. The decrease in pH and salinity was more in SWs compared to CPs conversely, the decrease in alkalinity values was more in CPs. Though a decrease in metabolites (total ammonia-N and nitrite-N) and nutrients (nitrate and phosphate) concentration was observed, the values of the metabolites were low and nutrients were high in CPs compared to SWs after the flood. A drastic decrease in the minerals profile (Ca, Mg, K, Na) was observed during the flood. The values of all the parameters reached normal within 4-5 weeks after the flood. The changes in the water parameters during extreme weather events indicated the need for the implementation of better management practices to bring back the optimum water quality in culture ponds at the earliest, to avoid stress to animals.

Keywords: Pond, rainfall, shrimp aquaculture, source water, water quality

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Biodiversity and social impact of shrimp farming in coastal regions of Andhra Pradesh

Rajasekar, D[1]. and Yogalakshmi, J.[2]*

[1]Forest Conservation Official, Punjab and Expert Consultant, GRGS
[2]Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

*assessments@greenranks.com

Sustainable Development Goals have listed Aquaculture under Goal 14, "Life below water" and is one of the 17 Sustainable Development Goals established by the United Nations in 2015. Andhra Pradesh (A. P.) is the leading shrimp producer, accounting for more than 50% of the total output of India. The state of A. P. is having economic interventions and major activity of aquaculture farms in and around the coastal areas of A. P. The state has favorable climatic conditions and ample water resources, besides a long coastline of 974 km for aquaculture. Around 1.38 lakh farmers are involved in aquaculture in 2.12 lakh hectares in A. P. Shrimp farming presents both opportunities and constraints for biodiversity conservation; opportunities include habitat creation, alternative livelihoods, awareness and education, technological innovation and constraints include habitat destruction, pollution, disease transmission, overuse of resources, fluctuating market demand *etc*. While shrimp farming can provide opportunities for biodiversity conservation, it is important to carefully manage these activities to minimize their negative impacts on the environment and promote sustainable practices that benefit both people and the planet. There are several methods of shrimp farming, but the most common method is semi-intensive farming using earthen ponds. The farms are typically in earthen ponds with adequate space in between. Shrimp ponds are constructed in areas with access to creek or canal water, bore water, drain canals, having borewell water resources with saline water suitable for shrimp farming and infrastructure such as road connectivity, electricity *etc*. is available. Pond construction, stocking, feeding, water quality management, disease management, harvesting, post-harvest processing, restoration and conservation of natural habitats are discussed in this paper. The paper also describes and discusses the identified ecological constrains of the aquaculture farms such as possible conversion, alteration, habitat destruction and alteration, water quality impacts, biodiversity loss, disease transmission *etc*. The Biodiversity Inclusive Screening Criteria *viz*. location or siting, habitat preservation, water quality management, biodiversity management, social and economic impacts is also discussed. The participatory social impact assessment due to the aqua farms and impact assessment in terms of biodiversity, social and other environmental parameters along with recommendations and mitigation measures are also described and attempted in the paper. Overall, the coastal zone of Andhra Pradesh has huge potential for aquaculture but the practices of sustainability and best management practices are recommended for long term sustainability.

Keywords: Andhra Pradesh, aquaculture, environment impact assessment, social Impact, sustainability

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

A metabolomic snapshot through NMR revealed differences in phase transition during induction of reproduction in *Ulva ohnoi* (Chlorophyta)

Payal A. Bodar*, Rajendra Singh Thakur, Jasmine Rajai, Satej Bhushan and Vaibhav A. Mantri

CSIR- Central Salt & Marine Chemicals Research Institute, Gijubhai Badheka Road, Bhavnagar-364002, Gujarat, India

*Payalbodar55@gmail.com

Reproduction is central in any biological system, wherein an organism gives rise progeny through asexual or sexual means. Green seaweed *Ulva* represents a simple thalloid system and is a model organism which has been used for studying induction of reproduction in multicellular Protista. The present investigation deals with the metabolomic status of *Ulva* cells undergoing phase transition (vegetative, determination and differentiation) when exposed to different abiotic conditions which was deciphered using a combination of microscopy and NMR techniques. *Ulva* thalli were grown in different salinity (20-35psu), temperature (20-35^{o}C), photoperiod (18:6, 12:12 and 6:18 D/N), light intensity (220, 350 and 500 µmol photons $m^{-2}. s^{-1}$), nitrate (0.05-0.2 g l^{-1}) and phosphate (0.05-0.2 g l^{-1}). The induction of reproduction was followed by microscopic observations after 24h (determination phase) and 48h (differentiation phase). Microscopic observation suggested significant percentage of cells undergoing transition in both phases under all abiotic conditions except salinity and phosphate. ^{1}H NMR analysis revealed that difference was more pronounced when cells undergo transition from vegetative to determination phase. Total 30 metabolites were identified in category of sugar, amino acid and aromatic compounds. Threonine, lactate (bin value 1.27-1.37 ppm) decreased (6.39-2.37) in average whereas creatinine (bin value 2.88 -2.98 ppm) increased (12.58-22.97) in average from vegetative to differentiation. PCA analysis revealed maximum metabolite variation in differentiation phase. Spearman correlation showed highest metabolite variation among temperature and phosphate during differentiation phase. Present study will aid in understanding the mechanisms underlying cell differentiation during reproduction. The result may serve as an important reference point for future studies, besides helping in control over seedling preparation for commercial farming as well as management of rapid green tide formation. Further molecular analysis can help to understand the transition of one phase to another in the reproduction of *Ulva*.

Keywords: Metabolome, microscopy, NMR, phase transition, reproduction

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Effective temperature shock and photoperiod for seed production of edible green seaweed *Ulva lactuca*

Bavithra, R*, Anikuttan, K. K., Tamilmani, G., Johnson, B., Sakthivel, M. and Rameskumar, P.

Mandapam Regional Centre of ICAR-CMFRI, Marine Fisheries Post, Mandapam Camp, Ramanathapuram district, Tamil Nadu – 623 520, India

* bavithra.r@icar.gov.in

The native edible green seaweed *Ulva lactuca* has high nutritional and medicinal value. *U. lactuca* or sea lettuce is the second ideal seaweed for mariculture because it a fast growth rate and it can sustain a wide range of environments. To promote *Ulva* farming and to reduce the wild collection from natural stocks, seed production and supply of seedlings for year-round sea farming is the need of the hour. The present study initiated a method for seed production of edible green seaweed *U. lactuca* with effective temperature shock and photoperiod. The initial step was to collect seaweeds from natural stock and wash with UV sterilized water. Later, the vegetative portion (thalli) of *Ulva* was cut into small pieces. Then it was subjected to temperature shock (0°C,4°C,7°C,11°C) and subsequently placed into autoclaved filtered seawater along with the medium under a 24h light:0h dark and 16h light:8h dark photoperiod at 20°C. The cell division initiated after 48 h and huge numbers of seeds were produced. The best and quick results were attained through the temperature shock at 0°C followed by 4°C temperature shock with the photoperiod of 24h light: 0h dark. The desired results could not be obtained through temperature shock of (7°C and 11°C) under the 24h light:0h dark as well as 16h light:8h dark photoperiod at 20°C. So, the study proved that seed production edible green seaweed of *U. lactuca* was achieved with effective temperature shock at 0°C under the photopheriod of 24h light:0h dark. This method of seed production of *U. lactuca* is very simple and cost effective.

Keywords: Photoperiod, seaweed, temperature shock, thalli

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

High-Density Polyethylene (HDPE) raft-based tube-net farming: a novel seaweed culture technique in open sea

Sekar Megarajan*, Ritesh Ranjan, Biji Xavier, Shubhadeep Ghosh, Suresh, R. D., Raju, S. S., Imelda Joseph, Boby Ignatius and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* sekarrajaqua@gmail.com

Seaweed cultivation continues to expand with variety of culture methods developed. However, commercial level seaweed production in tropical seas with turbulent state has failed due to the absence of appropriate culture methods. A novel integrated High-Density Polyethylene (HDPE) floating raft-based tube-net method with multipoint mooring was developed for use in deeper and rough sea conditions in different coastal regions. The design prototype was evaluated for its structural stability, culture and economic feasibility by culturing Kappaphycus *alvarezii* off Visakhapatnam coast, along north-western Bay of Bengal. Square-shaped HDPE raft of 3 × 3 m, was tied with ten tube-nets of each 3 m length and 0.32 m dia, made of HDPE net material. A cluster of 25 rafts were deployed as a single unit and the entire system was stabilised by multipoint mooring. The raft structure with seaweed, along with anchoring system endured the high waves and wind without any adversity and supported the optimum seaweed growth at the study location. Four different initial seeding biomasses (3.0, 5.0, 7.5 and 10.0 kg per tube-net) was assessed for growth in different climatic seasons. A total of six cycles were carried out for a culture duration of 45 days per cycle in different seasons. Growth parameters were observed to be significantly higher than initial seed biomass of 5.0 kg, as evident in maximum growth rate (3.52%) and net biomass (191.11 kg raft^{-1} crop^{-1}) for all seasons except during summer season, April to July. The novel method showed economic returns of INR 1, 52,431 per cluster unit, with a profit margin of 31.35%, indicating the profitability of the developed culture system. The novel method of seaweed farming will ensure year-round farming and can be tried in other coastal states of India with similar climatic conditions. However, the development of this type of culture method faces many challenges, including high initial investment, labor involvement, and inclement weather that hampers estimated biomass projection. Despite these challenges, the present method of seaweed farming in deep waters up to 10 meters depth and rough sea was found suitable and can be adopted in seas with similar dynamics for further promotion of seaweed farming. The paper discusses on the pros and cons of the techniques and the lessons learnt in the process during the trials in the coast.

Keywords: Deep and rough sea, growth, HDPE raft, *Kappaphycus alvarezii*, tube-net

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Feasibility studies on floating raft culture of *Gracilaria edulis* from coastal waters of Vellapatti, southeast coast of India

Ranjith, L. *, Johnson, B., Tamilmani, B., Vinothini Vaz, M., Michael Anandaraj, S., Kalidas, C., Lingaprabu, D., Kavitha M. and Asha, P. S

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*ranjith.l@icar.gov.in

The agarophyte red algae *Gracilaria edulis* (=*Hydropuntia edulis*) is harvested naturally from the southern coast of India for its agar content. In view of the growing demand for high-agar-yielding seaweed and reducing the pressure on wild *G. edulis* resources, a pilot-scale experimental culture was conducted to assess the viability of seaweed culture (floating raft method) in the coastal waters of Vellapatti, Thoothukudi. The improved floating raft method (3 m x 3 m; 135 nos.) was employed to withstand adverse weather conditions and improve floating efficiency. Three clusters (15 rafts in each cluster) were parallel placed and moored with iron anchors in three locations (45 rafts in each) along the Vellapatti coast. Growing *G. edulis* vegetative fragments (30±5 g fresh wet weight) were inserted between the rope twists at, on average, 500±45 g per rope (7.8±0.2 kg per raft) with a fish exclusion net below. The two harvests were completed in a pilot-scale experiment after 45 days of culture, and on average, a 7.4 to 8.5-fold increase in growth was observed. The observed crop yield in the improved floating raft method ranged between 57.0 and 68.1 kg of fresh wet weight per raft, with a specific growth rate of 4.85% in a 45-day crop cycle. The improved floating raft structures had stabilized the raft's position and reduced drift in adverse weather conditions. Epibiont infestation and grazing were observed; however, impact during the cultivation period was found to a lesser extent only. In addition, environmental suitability and the nutritional composition of the wild *vs.* cultured *G. edulis* assessed have been discussed in the paper. This pilot-scale experimental culture of food-grade agar-yielding *G. edulis* along the region's scenario revealed baseline information for farmers, entrepreneurs, and policymakers to perform large-scale commercial farming.

Keywords: Environmental suitability *Gracilaria edulis*, nutrition profile, pilot-scale experimental culture, raft culture

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Success story on species, site and method suitability of seaweed farming in Ratnagiri coast, Maharashtra

Ramkumar, S*., Rane, U. H., Vaibhav, D. M., Punam, A. K., Baikar, K., Ranjith, L. and Venkatesan, V.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* ramfrm@gmail.com

Seaweed farming in Maharashtra has huge scope with the state having a vast coastline of 720 km. Potential seaweed sites were estimated at 2724 ha based on the 11 criteria accessed by ICAR-CMFRI for the coastal waters of Maharashtra. To assess the species, site and method suitability for seaweed farming, we identified five coastal village: Wayangani, Golap, Peth Killa, Kalbadevi, and Bhandar Pule, of Ratnagiri district. *Kappaphycus alvarezii* seaweed seedlings were installed in the bamboo raft and tube net on these coasts at a depth of 1.5 to 3 m. Bamboo raft seaweed cultivation is a floating culture method. In the case of tube nets, seeded nets were suspended in the water column at 1 meter from the surface water. Women's self-help groups on these coasts were trained and engaged in this seaweed farming activity to promote and create awareness about the potential of seaweed mariculture. After 35 to 40 days of culture, it was observed that *K. alvarezii* species growth tripled in the bamboo raft culture technique and 2.5 times in the tube net culture technique. Water quality parameters observed at the culture sites were: atmospheric temperature 29–32.5°C; surface water temperature 26–28°C; dissolved oxygen 5–5.5 ppm; pH 7.3–8.2; and salinity 30.4–32.5 ppt. Results revealed that these selected sites, species, and culture techniques were suited for successful seaweed farming in Ratnagiri district. This study suggests that the same experimental model for farming indigenous seaweed species can also be adapted and promoted in the future to assess their farming viability along coastal areas. If seaweed mariculture is encouraged for commercial farming, it will undoubtedly offer an alternate source of income for women SHG groups.

Keywords: *Kappaphycus alvarezii*, Ratnagiri , seaweed farming, site suitability

Good Management Practices in seaweed farming

Johnson, B.*, Tamilmani, G., Divu, D., Suresh Kumar Mojjada, Sekar Megarajan, Shubhadeep Ghosh, Mohammed Koya, Muktha, M., Boby Ignatius, Vinod, K., and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*jsfaith@gmail.com

Seaweeds are valued commercially for their cell wall polysaccharides such as agar, algin, carrageenan *etc*., and for bioactive metabolites, manure and fodder. They have a variety of commercial applications in food, pharmaceutical, cosmetic and mining industries. Some seaweeds are also gaining importance as healthy food for human consumption apart from their use as raw materials in extraction of bioactive compounds and marine chemicals. India has a seaweed production potential of 9.88 million tonnes wet weight per year while the current production stands at merely 52,107 tonnes wet weight per year. Seaweed farming has the potential to provide revenue up to Rs. 13.28 lakhs per year in dry weight basis. It is estimated that average production cost excluding seed cost is Rs. 26.30 per kg, farmgate price is Rs. 95 per kg and net gain is Rs. 68.70 per kg. The expansion of seaweed farming in the country will improve the socio-economic status of fishers and will also be helpful in mitigating the negative effects of climate change. This paper narrates step-by-step procedure of what one should and one should not do in seaweed farming. It elaborates the Do's and Don'ts in seaweed farming techniques like bamboo raft, monoline and tube net methods. The paper also explains about maintenance, management of disease, epiphytism and natural calamities, harvest and post-harvest handling. Other aspects like potential area for seaweed farming, farming techniques for native seaweed species, economics of seaweed farming, IMTA and raft-based tube net farming method are also included. The adoption of Good Management Practices will be helpful in reducing the input cost and increase production levels. Seaweed culture supplements marine production and provides sustainable income to coastal fishers.

Keywords: Farming, Good Management Practices, seaweed

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Aquaponics: Reshaping bio-integration based circular economy as a sustainable strategy for income diversification and climate resilience in agri-aquaculture food system

Ajit Kumar Verma*, Venisza Cathy John and Chandrakant Mallikarjun Hittinahalli

ICAR- Central Institute of Fisheries Education, Versova, Mumbai, Maharashtra, India

* akverma@cife.edu.in

Aquaponics, an interdisciplinary agri-aquaculture climate-resilient agricultural approach, is a ground breaking solution that has substantially strengthened and reshaped the agricultural food sector by increasing productivity and income by integrating aquaculture (fish) and hydroponics (plant production without soil). The current trajectories of global challenges, *viz*., population growth, urbanization, and depleting resources, signifies the importance of a circular-based economy that addresses the food-energy-water nexus of United Nations Sustainable Development Goals (SDG) by improved resource utilization (land, water and fertilizer) and minimal waste discharge. In this context, aquaponics as a bio-integrated model emphasizes the SDGs (SDG 1: zero poverty, SDG 2: zero hunger; SDG 12: responsible consumption and production; SDG 14: life under water) through higher production efficiency of value-added products (vegetables and protein-rich food) *via* wastewater and nutrient recycling with efficient land, water (90-95% reuse), and fertilizer (from fish waste rather than non-renewable source) use; and thus, minimizing the environmental cost of production. This eminent social enterprise witnessed a growing endorsement in rural and urban settings (rooftops, abandoned buildings, food deserts, *etc*.) as a prospective livelihood strategy to secure food and diversify income streams for landless and poor households. A broadened community-based aquaponics enterprise can serve as a beneficial model that significantly improves household income to eradicate poverty and is an invaluable tool for women's emancipation and empowerment in developing countries fostering sustainable socio-economic growth.

Keywords: Aquaponics, circular economy, diversification, climate resilience

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Design and Development of 'Aquaculture Automation Technology' for Sustainable Shrimp Farming

Vishnu V. Das*, Anish Sathyan, Jerry Daniel, J. and Chellapandi, P.

C-DAC– Center for Development of Advanced Computing, Nandavanam, Vellayambalam, Thiruvananthapuram, Kerala 695033, India

*vishnu.v@cdac.in

Shrimp farming is one of the most profitable and fastest-growing sectors in the aquaculture industry. India has a long coastline and a scope for extensive exploitation of marine wealth. In India, an estimated brackish water area suitable for shrimp culture is 11.91 lakh ha, of which around 1.356 lakh ha area is currently under shrimp farming. The sustainability of shrimp culture in the Biofloc system is very successful in practice. However, increased energy costs, advanced technical skills, constant monitoring, and further research are necessary to acclimatise Biofloc production. Various viral, bacterial, and fungal diseases are also significant challenges that Biofloc shrimp production faces worldwide. There are no proper top-dressing automation methods for continuously monitoring and evaluating shrimp growth and pond conditions. In this perspective, new top-dressing automation technology is suggested to reduce the labour and production costs required to reduce bacterial and organic loads for sustainable shrimp aquaculture in India. Aquafarm automation allows farmers to maintain optimum water parameters by continuously monitoring and applying corrective measures at the right time, place, and amount. The Aquaculture Automation system (AcAS) can intelligently operate pumps/valves based on the data collected from the field and the pre-configured algorithms available in the controller. The Aquaculture Automation System is a fully autonomous monitoring and controlling system for various parameters in the aquaculture ecosystem. The AcAS achieves different controlling prospects by sensing data from multiple sensors. The AcAS suits the pond environment and other fields in most aquaculture sectors. The aquaculture automation trial was carried out for the grow-out culture of *Penaeus vannamei* shrimp in a Biofloc system under low salinity conditions or non-natural environments. Top-dressing agents are used for the prevention and control of shrimp diseases and to improve the growth yield in Biofloc systems. The cost of probiotics and pond optimisers restricts the financial and environmental viability of shrimp aquaculture. Automation in aquaculture reduces labour and production costs in Biofloc systems. Continuous monitoring of pond water parameters and microbial activity will reduce the labour and production costs for shrimp farming. With automation trials, high levels of shrimp growth performance and better water quality in Biofloc systems can be achieved. The sustainable utilisation of automatic aquaculture systems can thus lead to enormous social and economic benefits for the country's coastal regions.

Keywords: AcAS–Aquaculture Automation system, automation, biofloc, *P.vannamei*, top-dressing

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Development of super intensive marine finfish RAS

Anil, M. K., Gomathi, P.*, Raju, B., Jose Kingsley, Shalini, O., Krishnapriya, P. M., and Anand, V.
Vizhinjam Regional Centre of CMFRI, Thiruvananthapuram 69552, Kerala, India.
*gomathimfsc@gmail.com

Around the world, the majority of finfish mariculture production occurs within net cages. However, coastal net cage farming presents several significant drawbacks. More than 70% of the nitrogen provided as feed in these cages is lost into the open water, leading to environmental pollution. The widespread adoption of cage culture in coastal waters, particularly in backwaters and bays, inevitably results in substantial self-pollution. Cage farming also faces challenges related to parasitic and viral diseases, in addition to its vulnerability to natural disasters like high waves, strong winds, and floods, resulting in substantial crop losses. Globally, land-based Recirculating Aquaculture Systems (RAS) are gaining importance as an alternative method of mariculture, particularly for high-value finfish production. Land-based RAS offers numerous advantages, including the precise control of critical water quality parameters, efficient land and water utilisation, and maximised production. This production method is sustainable, environmentally friendly, and biosecure. It provides flexibility in site selection and species cultivation, facilitates easy and complete harvesting, and allows year-round production planning. However, it is important to note that the high capital cost is a major obstacle to the widespread adoption of land-based RAS, which can only be overcome through intensive farming practices. To address this challenge and develop land-based super-intensive farming technology, Vizhinjam RC of CMFRI has established a dedicated facility. This system comprises a 30-ton dual-drain tank, a balancing tank, a drum filter, a foam fractionator, a biological filter, a degassing unit, a cartridge filter, a UV filter, an oxygen concentrator and Speece cones. The dual-drain system serves to remove concentrated waste through the central drain, while the side drain eliminates surface film and a portion of the circulating water. The balancing tank regulates the water flow through these drains. The drum filter effectively removes particles larger than 60µ from the circulating water, and the foam fractionator targets dissolved and colloidal organic matter as well as particles smaller than 60µ. The oxygen concentrator-Speece cone assembly maximizes the dissolution of pure oxygen into the system water, sustaining high stocking densities. This system will be instrumental in developing and fine-tuning the super-intensive mode of production, with the results of the first trial being presented and discussed.

Keywords: Land based, mariculture, marine finfish, super intensive RAS

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Modified pen design for fish farming: A new venture for aquaculture in shallow coastal waters

Rema Madhu*, Madhu, K., Abhilash, K. S., Immanuel Issac, Mohandas, M. P., Harikrishna, N. H., Mrudhula Mohan, K. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

* rema.madhu@rediffmail.com

The introduction of GI and HDPE cages starting in 2009 made it possible to cultivate fish in coastal and brackish water locations, and many farmers accepted the CMFRI technology of cage fish farming as a substitute for traditional farming methods and a source of employment. However, cage fish farming became impracticable in some regions due to declining depth consequent upon flood, sand deposition, and associated phenomenon occurring in Kerala beginning in 2018. As an alternative to cage farming and to protect the interests of fish farmers, a modified pen was designed for shallow areas having depth less than 2.5 m. To test the modified pen structure, we identified a site at Chathamma ward and SC beneficiaries of "Anugraha" SHG were provided with a modified pen unit measuring 6x3x3meter on 16th March 2021, under SCSP (Scheduled Caste Sub Plan). Outer and inner frame of pen was made of 1.5 inch G.I pipes with pole supports (4 m) and both the frames were kept apart (gap of 30 cm) with clamps. The pen was stocked with 2000 numbers of pearl spot *Etroplus suratensis* seeds (size 4-5cm) and fed with 1.8mm pellet feed three times per day at 10% of their body weight for initial four months. After 2.5mm size was reached, the fish were fed at 5% of their body weight. After 11 months of culture, the fishes reached a total length of 20 to 22 cm with weight ranging from 350 to 400 g and the beneficiaries earned INR 2.65 lakhs from this single unit. The study revealed that growth of fishes in the modified pen was at par with that in cages. Thus the new innovation of modified pen structure was found suitable for culture of fishes in shallow areas of coastal waters, where water depth is not conducive for cage farming and this method enabled the effective utilization of shallow coastal water bodies for fish production by farmers. As the fishes were grown inside net cages, this method made the fish harvest easy on need basis as in the case of cage farming. As the design is widely accepted by farmers, pens with 6x6x6, 7x7x7 and 12x12x12 m were launched successfully at farmers field for augmenting aquaculture production and as a livelihood option for farmers.

Keywords: Fish culture, modified pen, Pearl spot, shallow coastal water

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Technology for coastal pond farming of Indian Pompano (*Trichinous mookalee Cuvier, 1832)* – new options in coastal aquaculture

Sekar Megarajan*, Ritesh Ranjan, Biji Xavier, Shubhadeep Ghosh and Shiva Ponnaganti

Jayasree Loka, Boby Ignatius, and Gopalakrishnan Achamveetil
[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Division of Fisheries, ICAR, Krishi Anusandhan Bhawan–II, New Delhi–110 012, India

*sekarrajaqua@gmail.com

Coastal pond farming is an important farming system that contributes to food security and livelihood development. Indian pompano (*Trachinotus mookalee*) is a recently domesticated marine fish, considered to be one of the good candidate species for coastal farming. Coastal pond farming technology was developed by optimizing several parameters to deliver a sustainable and viable culture method. Three different grow-out culture experiments were conducted in each one-acre water-spread pond area, using hatchery-produced Indian pompano fingerlings of 10.0 ± 3.0 g in size. In the first approach, grow-out culture was studied by direct stocking of fingerlings (10.0 ± 3.0 g) and stocking of pre-grow-out reared fish of 100 ± 18.0 g. In the second experiment, different stocking densities with 0.75, 1.0 and 1.5 number of fish m^{-2} and in the third approach, feeds of different nutrient compositions–40% crude protein (CP) and 10% crude fat (CF), 36% CP and 10% CF were evaluated. The farming trials showed that, grow-out culture of the species with nursery reared individuals at stocking density of 1.0 number m^{-2} using feed of 40% CP and 10% CF grew well and gave better economic returns. Fish reared in pre-grow-out system for four months and then cultured in grow-out system for the period of seven months and thus a total culture period of 11 months, grew to an average size of 985.5 ± 18.5 g, with a survival of 97.4%. The absolute and specific growth rate obtained were 2.93 g day^{-1} and 1.33% day^{-1}, respectively with an FCR of 1:1.79. Stress indicators such as serum glucose (46.40 ± 2.14 mg dl^{-1}), cortisol (38.72 ± 11.19 ng ml^{-1}) and HSP-60 (17.5 ± 0.99 ng ml^{-1}) concentrations were at optimum. Muscle nutritional composition was balanced with 19.5% CP and 4.87% CF, with an optimum ratio of essential fatty acids. Optimised culture method showed high economic profitability with net profit (INR 2.95 lakhs), high operating ratio (0.75) and the cost of production was INR ~265 kg^{-1} of fish. Optimised farming method showed that coastal pond farming of Indian pompano is technically feasible, and can be a new profitable venture in coastal mariculture, adding one more species to the fish farming basket.

Keywords: Candidate species, coastal pond, Indian pompano, species diversification

Unleashing prosperity: Cage culture empowers SC communities in Ernakulam district

Sary, P. S.*, Athira, P. V., Ambrose, T. V., Binitha, K. V., Smitha, R. X., Nimisha, B., Reshma Gills and Vipinkumar, V. P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sarysivam@gmail.com

Cage culture systems hold immense potential to significantly enhance the livelihood of fisherfolk by boosting the production of high-value fish species. Low-cost cages and extensive cage farming practices in coastal areas have attained considerable attention recently. In Kerala, cage farming was initiated in 2007 with the implementation of sea cages at Munambam in Ernakulam District by the ICAR-Central Marine Fisheries Research Institute (CMFRI). With the escalating local demand for high-value fish, the adoption of brackish water cage culture systems has now expanded to encompass nearly all coastal districts of the state. This growth holds the potential to further improve the livelihood of inland fisherfolk. The key benefits of cages compared to traditional land-based systems include affordable initial expenses and easy maintenance. The present study aimed to analyze the economic viability of cage culture techniques and its management policies that would benefit the socioeconomic development of the Scheduled Cast beneficiaries. As part of the Department of Science and Technology (DST) funded project, "Science Technology and Innovation Hub in Fisheries Sector, Kochi corporation, Ernakulam District, Kerala State" granted to CMFRI, four cage culture units were established in the selected areas of Ernakulam district; two units (dimension 4x4 and 2x2) in Veerampuzha backwaters near Kambithazham in Edavanakkad and other two units (6x4 and 6x4) in Valiyavattom kayal of Manjanakkad in Njarakkal. These two units were undertaken by four SHGs containing 24 direct SC beneficiaries. To ensure gender equality, three men and three women stakeholders were included in each SHG. Pearlspot (*Etroplus suratensis*) and seabass (*Lates calcarifer*) were the two species selected for farming. The two cages of Veerampuzha backwaters were stocked with 3500 pearlspot seeds (@ 50 nos) and 3000 pearlspot seeds (@ 50 nos m^{-3}) respectively, while two cages of Valiyavattom kayal were stocked with 900 seabass seeds (@ 30nos/m^3) and 3000 pearlspot @ 50 nos m^{-3} respectively. These fishes were fed with high protein-rich pellets and trash fish twice a day. Among the cultured species, pearlspot showed 75-76% survival with an average Benefit Cost (BC) ratio of 2.1 and seabass showed 75% survival with a BC ratio of 1.8. The Pay Back Period (PBP) of pearlspot culture was 8 months while seabass was 4 months. The cage culture holds enormous potential in catapulting fish production to new heights and igniting a surge of job opportunities, which in turn, would propel the socioeconomic status of the target groups towards progress and prosperity.

Keywords: BC Ratio, PBP, pearlspot, seabass, socio economics

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Coastal resource management and economic performance of mud spiny lobster mariculture in tropical sea cages, north-eastern Arabian sea, India: An empirical study

Aarsha Subramanian*, Divu, D., Suresh Kumar Mojjada, Swathi Lekshmi P. S. and Mayur S. Tade

Indian Council of Agricultural Research-Central Marine Fisheries Research Institute (ICAR-CMFRI), Veraval Regional Station, Matsya Bhavan, Bhidia plot, Veraval, 362 269, Gujarat, India

*aarshasubramanian@gmail.com

Lobsters have stirred curiosity in mariculture as a strategic approach to satiating the burgeoning appetite. With the projected growth, the expanding global lobster market is valued at USD 6.3 billion in 2021. With the intent of bridging the void between viability insights and the stakeholders of capture-based mariculture (CBM), we investigated the economic performance and profitability of *Panulirus polyphagus*, the mud spiny lobster, within open-sea farming systems, particularly focusing on sea cages. The study delves into the economic sustainability of lobster farming and obstacles such as seed availability endure, scientific progress has the potential to amplify resource efficiency. The outcomes propose broader applicability extending beyond the realm of lobster farming, potentially yielding advantages for various sectors within aquaculture. The analysis reveals an annual revenue of $3,605.04, an internal rate of return (IRR) of 33%, and a net present value (NPV) of $1,226.17, indicating profitability. The research contributes valuable insights for building enterprises, enhancing food security, and supporting traditional community-centric lobster farming in India and potentially other nations involved in lobster farming. This endeavor will offer stakeholders and policymakers a comprehensive grasp of these valuable marine assets and the dynamics of the farming system, empowering them to decipher economic trajectories and strategize more effectively for the times ahead.

Keywords: Aquaculture economics, Capture-based mariculture (CBM), lobster, sea cage farming, sustainability

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Brackishwater cage farming of Asian seabass *Lates calcarifer* as an additional income generation activity by fisher women SHG's

Jayakumar, R.*, Kailasam, M., Bhuvaneswari, T., Geetha, R., Subburaj, R., Thiagarajan, G. and Dhavaselvam, A.

Central Institute of Brackishwater Aquaculture (CIBA), Indian Council of Agricultural Research (ICAR), 75, Santhome High Road, Chennai – 600 028, Tamil Nadu, India

* jeyakumar.r@icar.gov.in

Asian Seabass *Lates calcarifer*, is an economically important food fish in India and being reared in brackishwater ponds and cages installed in brackishwater and open sea. Three fisherwomen Self Help Groups (SHGs) belonging to Kottaikadu village (12°15'07.4"N 79°59'15.4"E), Cheyyur Taluk, Chengalpattu District, Tamil Nadu are involved in collecting oyster meat and selling as their major income generating activity and it is sufficient to support their livelihood. These fisherwomen self help groups were provided Galvonized iron (GI) cages (4 Nos.) of 4m x 3m x 2m size, each with a cultivable area of 24m^3. GI cages were installed in the backwaters adjacent to Buckingham canal in their village. Seabass fingerlings of 12.50 cm average length and 23.50 grams weight were stocked @700 numbers /cage. The fishes were fed @5-8% of their body weight rationed twice a day with formulated floating pellet feed containing crude protein 48% and crude fat 10%. The GI cages consist of one outer net and an inner net. Based on the level of fouling of barnacles and algal growth, these nets were changed once in 45-60 days. Grading of fishes was done in all four cages at 30-45 days interval to maintain uniform size fishes in all the cages to minimize cannibalism and to maximize the growth. After rearing about 213 days, the fishes attained 450-1200 g size with an average weight of 658.0 g and were harvested from the cages. An average production of 268.50 kgs/cage of seabass was achieved and fish were sold @Rs.350/kg. This small-volume cage farming with formulated feed has helped to get an additional income to improve the livelihood of these SHGs.

Keywords: Asian Seabass, brackishwater cage rearing, *Lates calcarifer*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

The significance of small-scale cage farming in the livelihood transformation of coastal Karnataka's fishers

Sujitha Thomas, Rajesh, K. M.*, Dineshbabu, A. P., Geetha Sasikumar and Prathibha Rohit

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* rajeshmkm3@rediffmail.com

Karnataka's 300 km coastline, encompassing an expanse of 8000 hectares of brackish water, has been grappling with a steady decline in fish production, subsequently impacting the livelihoods of the fishermen who depend on these waters. Responding to these challenges, a transformative initiative began in 2009, cultivating species like red snapper, seabass, and pearl spot in customized cages along the coast. Starting with 5 cages, it yielded about 1.8 tons of fish in a 10-month cycle, strategically timed for the lean fishing season. This not only supplemented income but also invigorated local fishing communities, offering an alternative to estuarine fishing. Presently, the coastal region has an installation of over 800 cages, indicating the widespread adoption of this innovative practice. Adaptations and refinements to cage design and operational techniques remained a constant pursuit throughout the years. This contributed to a remarkable escalation in cage-based fish production. Notably, this evolution is evident in the quantitative shift from an initial yield of 1.8 tons in 2009-10 to a substantial 800 tons in the progressive period spanning 2022-23 and contributing Rs 40 Crores to fish production in the state. The successful dissemination of this technology has been achieved through a comprehensive approach, incorporating participatory methodologies, focused group discussions, expert-led training sessions, and hands-on technical guidance. Over the past fourteen years, the small-scale cage farming initiative has yielded substantial returns, marked by a noteworthy surge in fish production and a concurrent enhancement in the socio-economic well-being of the fishing communities. The tangible outcomes of this endeavour are clearly evident: the adoption of advanced techniques, amplified production rates through strategic farming, and the empowerment of fisherfolk. The viability of this technology has been consistently upheld, fostering a dynamic environment that has encouraged continuous refinement and diversification of the species being cultured (e.g., Pompano culture). In summation, the sustained efforts of the cage farming initiative, spearheaded by CMFRI, have not only offered alternative avenues for livelihoods but also facilitated a meaningful diversification of livelihood options for coastal fishers in the state. These efforts concurrently address the pressing concerns of nutritional and financial security among the coastal fishing communities.

Keywords: Coastal aquaculture, coastal community, economic security, finfishes, sustenance

Nurturing pearlspot seed production technology: A thriving enterprise in the fisheries sector

Athira, P. V.*, Sary, P. S., Ambrose, T. V., Binitha, K. V., Smitha, R. X., Nimisha, B., Shoji Joseph, Reshma Gills and Vipinkumar, V. P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*athiravidhya91@gmail.com

Pearlspot (*Etroplus suratensis)*, Kerala's state fish, has a high consumer demand which guarantees a steady market price for fish growers. This study investigates the extent of pearlspot seed production in an earthen pond as a viable example for the welfare of fisherfolk and a possible supply of fish seed for aquaculture. As a part of the Department of Science and Technology (DST) funded project, 'Science Technology and Innovation Hub in Fisheries Sector, Kochi corporation, Ernakulam District, Kerala State', granted to ICAR-Central Marine Fisheries Research Institute (CMFRI), three pearlspot seed production units were established in the selected locations at Karumaloor, Vallarpadam, and Njarakkal of Ernakulam district. The economic indicators projecting the Benefit Cost Ratio (BCR) and Pay Back Period (PBP) were explored in the units operated. Pearlspot seed production unit had a PBP of 0.16 years, BCR 4 and a break-even point of 11500 numbers. A gross revenue of ₹ 9 lakhs was generated from a total annual operating cost of ₹ 2,01,200/- with a net income of ₹ 6,98,800/-. A comprehensive study of the extent of empowerment among the members was done and the first of the eight components of empowerment was economic empowerment, followed by confidence-building. Farmers' major constraints were assessed using Garrett ranking technique and was found that the most important constraint was the difficulty in collecting seeds, followed by marketing challenges, high feed cost, cost of brooder fishes, difficulty in water quality maintenance and cost of packing and transportation. The study pointed out that farmers and seed producers were facing a major challenge due to the entry of intermediaries into the seed distribution market, which led to instances of supplying inferior-quality seeds at lower prices, resulting in substantial financial losses. With government accreditation as trustworthy seed producers, trained entrepreneurs can consistently supply farmers with high-quality seeds. As per the study's findings, the pearlspot seed production unit nestled within the earthen pond emerged as a prime contender for one of the most promising fishery-based micro-enterprises, offering a whole lot of opportunities for self-employment and vital support to fish farmers.

Keywords: BC Ratio, constraints, empowerment, PBP, socio economics

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Fisher-women of Chilika empowered through mud crab fattening in HDPE boxes: An alternative livelihood support intervention under SCSP

Rajesh Kumar Pradhan[1]*, Gyanaranjan Dash[1], Swatipriyanka Sen Dash[1], Shubhadeep Ghosh[2] and Madhu, K.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P. O., Kochi -682018, Kerala, India
[2]Division of Fisheries, ICAR, Krishi Anusandhan Bhawan–II, New Delhi–110 012, India

*rajeshfrm220@gmail.com, 8767364829

Chilika, the largest lagoon in India extends through Puri, Khorda and Ganjam districts of Odisha. The livelihood of the fishing communities adjacent to the lagoon and its island villages is mostly based on the small-scale fisheries from the lagoon. Natural calamities, in combination with climate change often result in a great degree of loss to the primary livelihoods of the marginal fisher folks in this region. Therefore, a livelihood support intervention for the socio-economic upliftment of the marginal and weaker section of the society was attempted by the Puri Field Centre of ICAR-CMFRI. A SHG consisting of 20 women from Scheduled caste fisherman families were selected for livelihood support through the SCSP program from Alupatna village of Odisha. The group was supported with all the necessary inputs and region specific sustainable mud crab (*Scylla serrata*) culture technique due to its high market demands, superior meat quality and nutritional value. As cannibalism and aggression during moulting are the major behavioural constraints that adversely affect the output in captive rearing of mud crab, 1000 nos. of HDPE boxes for individual crabs along with necessary accessories were provided for the culture operation. The water quality and salinity of the culture site were maintained by recirculating water from the lagoon. Locally collected wild seeds of mud crab (weight: 50-100 g) were stocked individually in each box and fed with fresh trash fish @ 10% of their body weight once daily. The crabs were harvested in a phased manner according to their meat content and market demand. The harvestable size was 400 to 600 g body weight. That was sold at a price range from 600 to 850 INR to local vendors. A total of Rs. 1,30,000.00 was earned from the culture operation that was distributed to the members of SHG. The successful demonstration of this culture technique would increase the technical skill of the women for self-dependence, ensuring better livelihood support for their social upliftment.

Keywords: Captive rearing, livelihood, moulting, mud crab

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Participatory approach in marine ornamental aquaculture for livelihood and conservation

Rekha, M. U., Dhayanidhi, N. B., Rejani Chandran, Bharathi, S., Akash, S., Haslamathi, T., Shilpa, P. N., Ajith Kumar, T. T.*and Sarkar U. K.

[1]ICAR–National Bureau of Fish Genetic Resources, Lucknow–226 002, Uttar Pradesh, India

*ttajith87@gmail.com

The contemporary surge of interest in marine ornamentals is projected to be a pivotal driver in the remarkable growth of marine aquarium trade. The forecasts indicate that the global reef aquarium market will reach a valuation of USD 11 billion by 2028, propelled by an anticipated compound annual growth rate (CAGR) of 10.7%. This burgeoning demand, however, raises the concerns about over-harvesting from natural sources, imperilling targeted and non-targeted species within the reef systems. To address this, ICAR-NBFGR has standardized and expanded marine ornamental aquaculture techniques to the coastal districts of Maharashtra and Lakshadweep islands, aligning livelihood with conservation. In partnership with the Mangrove Foundation, Government of Maharashtra, ICAR-NBFGR has established a premier marine ornamental fish breeding facility at the Coastal and Marine Biodiversity Centre in Airoli, Maharashtra. Streamlined protocols facilitate regular mass-scale seed production for five clownfish species; *Amphiprion ocellaris, A. percula, A. perideraion, A. frenatus* and *A. clarkii* to meet market demand. Eighteen hands-on training sessions have conducted for 550 beneficiaries from five coastal districts of Maharashtra between January 2019 and May 2023. Presently, 15 cluster mode rearing units are under operation in 12 villages across Sindhudurg, Ratnagiri and Palghar districts, managed by 102 trained beneficiaries with balanced gender ratio. Beneficiaries are receiving 1.5 to 2 months old clownfish seeds from the ICAR-NBFGR hatchery facility at free of cost. These seeds undergo further rearing for 2 to 2.5 months by the beneficiaries and following, they are being sold for revenue. In Lakshadweep, the islanders rely on live-bait-based tuna fishing, where, the unsustainable practices have led to decline of the live-bait populations and consequently, reduced tuna catches. Addressing this, ICAR-NBFGR has introduced a participatory approach to marine ornamental aquaculture, involving the women islanders. This initiative focusing with high-value marine shrimps; *Thor hainanensis* and *Ancylocaris brevicarpalis*. Breeding and seed production are being done at the ICAR-NBFGR & CMLRE Live germplasm centre for marine ornamentals at Agatti and resultant juveniles are being distributed to the beneficiaries for further rearing. Among the 82 trained islanders, 46 women are being actively engaged in marine ornamental aquaculture across four community aquaculture units. An agreement with the trader, facilitates the sale of ornamental shrimps cultivated by these women, contributing to income augmentation and the conservation of native aquatic genetic resources through local community involvement.

Keywords: Clown fish, conservation, livelihood, marine Ornamental aquaculture, participatory approach,

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Aquaculture of soft corals (Octocorallia:Alcyonacea) as a step towards their conservation in coral reef ecosystems

Vinod, K.*, Ramamoorthy, N., Rani Mary George, Gopakumar, G. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*vinod_kavungal@yahoo.co.in

Soft corals are one of the important communities in the coral reef ecosystem. These Cnidarians which belong to the Order Alcyonacea have a wide distribution in the tropical waters, mainly in the continental shelf and slope, although a few species are found in deeper waters. These are soft-bodied colonial forms, brightly coloured, appear in varied shapes and sizes and play a significant role in the coral reef ecology. Globally, studies have shown that the soft corals have pharmacological value since most of them are potential sources of bioactive compounds and possess anti-tumour, anti-bacterial, cytotoxic properties etc. The soft corals are also excellent candidates in the ornamental trade due to their bright colouration, beautiful appearance and dynamism in aquaria. The checklist of Octocorallia from the Indian coral reefs published by previous workers indicate 253 species belonging to 66 genera with an extremely rich diversity of 190 species in Andaman and Nicobar Islands, followed by 47 species in the Gulf of Mannar and 40 species in Lakshadweep Islands. The soft corals are however very sensitive to natural as well as anthropogenic perturbations and all species belonging to the families Acanthoaxiidae, Alcyoniidae, Briareidae, Chelidonisididae, Clavulariidae, Cornulariidae, Ellisellidae, Melithaeidae, Nephtheidae, Parasphaerascleridae, Pleaxauridae, Subergorgiidae and Xeniidae have been included in the recent Wildlife (Protection) Amendment Act, 2022 of the Indian Wildlife (Protection) Act, 1972. Propagation of soft corals in captivity and ranching of established colonies in degraded reef areas would be one of the viable options for their conservation. We have earlier demonstrated the artificial propagation of soft coral *Sinularia kavarattiensis* for the first time in India through different methods of fragging and reared them successfully both in the laboratory and open sea. The present paper illustrates the findings of the preliminary laboratory studies conducted on the propagation of soft corals *Lobophytum pauciflorum* (Family: Sarcophytidae) and *Cladiella laciniosa* (Family: Cladiellidae), detailing the different fragging methods employed, substrata identified, and survival and growth of new explants.

Keywords: Aquaculture, conservation, propagation, soft corals

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Growth and asexual propagation of magnificent tentacle anemone, *Heteractis* sp. and bubble tip anemone *Entamacea quadricolor* for promoting sea anemone aquaculture and its sustainable aquarium trade

Krishna Sukumaran*, Ambarish P. Gop, Archana Satheesh, D., Muhammed Anzeer, F., Aneesh K. S., Nisha, S., Jose Kingsley, H. Jose, Santhosh, B., Suresh, V. V. R. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*krishnasukumaran2022@gmail.com

Magnificent anemone, *Heteractis* sp. and bubble tip anemone *Entamacea quadricolor* are economically important host sea anemone species providing essential habitat for anemone fish; hence these are highly sought after in aquarium trade. There is limited scientific information on the captive rearing protocols for these species. Preliminary studies were undertaken to record the growth rate, daily feed consumption and behaviour in captivity. The study was also aimed at observing the response of these two anemone species to longitudinal cutting as a means for their captive propagation. The anemones (n=12 each) were collected at a water depth of 5-10 m from coastal waters of Tuticorin, Tamil Nadu and transported to Vizhinjam Regional Centre of ICAR-CMFRI. Stocking was done in semi-outdoor translucent plastic tanks (220 L) with aeration. Daily water exchange (10%) was provided. Feeding was done daily with fresh squid or shrimp to satiation @ 40-60 mg day^{-1} in the case of bubble tip anemone (body weight 30-120 g) and @ 80-150 mg day^{-1} in the case of magnificent anemone (body weight 130-270 g). Growth of the anemones were recorded by measuring the pedal disc diameter (n=12). The water quality parameters *viz*., temperature, salinity, pH, dissolved oxygen and total ammonia-N ranged from 27-29°C, 32-35 , 6.8-8, 5-7 and 0.3-0.7 mg L^{-1} respectively. The percentage growth was found to be 60.61±30.08 % and 52.5±20.4 % in magnificent anemone and bubble tip anemones respectively after 45 days of rearing. Parent anemone of both the species were bisected. In case of bubble tip anemone, the cut edges joined together in few seconds, feeding could be initiated within one week and the slightly off-centre fully formed mouth could be observed within 45 days of cutting. In case of tentacle anemone, mouth was off-centre after 60 days cutting. Natural splitting was also observed in bubble tip anemone (n=6). The study indicates longitudinal cutting as one potential method for artificial propagation of sea anemones for sustainable aquarium trade and to support conservation efforts of the species.

Keywords: Artificial propagation, bubble tip sea anemone, growth, ornamental fish trade,

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Indigenous ornamental fishes of the Western Ghats: Development of captive breeding for conservation

Charan Ravi, Abhilash, C. P., Sai Krishnan, K. R., Sarath Verghese, Neethu, Z., Basheer, V. S.* and Sarkar, U. K.
ICAR-National Bureau of Fish Genetic Resources, Centre for PAGR, ICAR-CMFRI Campus, Kochi-682 018, Kerala, India
*vsbasheer@gmail.com

Ornamental fishes are widely traded in the world and most of the time, many indigenous fishes are traded by collecting directly from their habitats. The Western Ghats in India harbours more than 300 species of freshwater fishes with more than 69% high endemism. More than 150 ornamental fish species are being traded from this region and almost all are collected from the wild. Barbs are the most sought species from the Western Ghats and seven out of top 10 barbs in the ornamental industry are from India. To develop breeding protocol of the ornamental fishes, we have taken six indigenous ornamental barbs; *Dawkinsia rubrotinctus, Dawkinsia arulius, Dawkinsia tambraparniei, Haludaria fasciata, Pethia setnai* and *Pethia nigripinna*, and developed a simple breeding protocol in captivity. Fishes were collected from natural water bodies, kept in the FRP tanks, acclimatised and reared with pellet feed. Prior to breeding, brood fishes were conditioned for two weeks using live feed and frozen artemia, as feed. For breeding, brood fishes (1m:2f) were introduced in 200L FRP tanks in groups of 4-6 fishes. A spawning setup; plastic tub, 15" dia and 6" deep, with ceramic rings upto a depth of 2" and with spawning mops, was placed in the tank. After 1-2 days, tub was removed from the tank and inspected for eggs and hatchlings. The eggs were small, translucent and adhesive and after a week, fry were siphoned out into rearing tanks. The average hatching was 60% in *D. rubrotinctus*, 55% in *D. arulius*, 70% in *D. tambraparniei*, 55% in *H. fasciata*, 65% in *P. setnai* and 70% in *P. nigripinna*. Temperature of water was in the range of 26-28^{0}C, pH in the range of 6.0-7.3 and dissolved oxygen 4.0-5.2 ppm. Free swimming spawn were fed with green algae, later with artemia nauplii initially for 10 days and later with moina. All six species were bred in almost similar conditions and nearly 1000 young ones of each species were produced. Larvae were reared in FRP tanks with live feed and pellet feed for about 8 weeks. Fishes attained marketable size (3-5 cm) in 12-16 weeks. The FI -stock of all the species was bred again and completed the cycle of these species in captivity. This simple technique of breeding will be useful for easing out the pressure from wild collection and marketing of these important species. The developed breeding protocol will be helpful for ornamental fish entrepreneurs and also for the conservation of these fishes in their habitat.

Keywords: Barbs, brood fishes, conservation, endemism, spawning mops

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Successful mass production of *Clarias dussumieri* a near-threatened endemic catfish of the Western Ghats through captive breeding

Charan Ravi*, Abhilash, C. P., Sai Krishnan, K. R., Chandana, B. L., Sarath Varghese, Neethu, Z. and Basheer, V. S.

ICAR-National Bureau of Fish Genetic Resources, Centre for PAGR, ICAR-CMFRI Campus, Kochi-682018, Kerala, India

* charan.fishcol@gmail.com

Malabar catfish, *Clarias dussumieri*, is the largest clarid catfish, endemic to the Western Ghats, commonly known as 'naadan mushi' in Kerala. In nature, this species can grow to a maximum size of over 3 kg, making it an excellent flagship species for aquaculture. The population of *C. dussumieri* has declined sharply across its entire range in recent years, prompting recommendations to revise its IUCN Red List status from near threatened to endangered. Compared with carps, hatchery technology in India has not advanced enough for mass-scale catfish seed production. A lack of brood care, inappropriate feed, inadequate rearing environment, insufficient ability to maintain optimum water quality parameters, and disease control cause huge mortality during larval rearing. A preliminary culture evaluation by the ICAR-NBFGR found *C. dussumieri* to be a potential species for aquaculture. In order to promote conservation aquaculture, ICAR-NBFGR has conducted a comprehensive study on breeding and larval rearing of *C. dussumieri* for mass-scale seed production. Standardisation of brood fish management that allows multiple and extended spawning, an optimal sex ratio for voluntary spawning, a well-designed hatching system, optimum stocking density of larvae, early feeding and weaning, and rearing conditions and feeding, water quality management, and disease control were achieved. ICAR-NBFGR has also initiated efforts to distribute seeds to the Department of Fisheries for culture and raising of broodstock, as well as to the farmers for evaluation of this species in their culture ponds and biofloc systems.

Keywords: Aquaculture, conservation, hatching system, multiple spawning, stocking density

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Captive breeding makes a way for the recovery of an endangered catfish *Horabagrus nigricollaris* endemic to River Chalakudy

Abhilash, C. P*., Sai Krishnan, K. R., Sarath Verghese, Neethu, Z., Chandana, B. L., Charan Ravi, Basheer, V. S. and Sarkar, U. K.

ICAR-National Bureau of Fish Genetic Resources, Centre for PAGR, ICAR-CMFRI Campus, Kochi-682018, Kerala, India

*abhilashtvn@gmail.com

Horabagrus nigricollaris, black collared yellow catfish, is an endangered endemic catfish to the River Chalakudy, and is one of the most sought-after ornamental fishes from Kerala. Due to its limited range and rarity, *H. nigricollaris* needs conservation strategies that will help improve its number and ensure its conservation. As a method for conserving endangered aquatic species, captive breeding has gained considerable attention recently and is often claimed to be an effective tool in conservation work, especially for populations at imminent risk of extinction. The present study focused on the broodstock development, induced breeding, and embryonic development of *H. nigricollaris*. Adult fish weighing between 36 to 156g were collected from the Vettilapara region of Chalakudy River in several batches between 2021 and 2022 by local fishermen using gill nets and traps. Broodstock development were carried out in cages in earthen pond (4x4x1m) and fed with commercial floating pellets (Growel, India) comprising of 40% crude protein. A total of 10 breeding trials were conducted between December 2022 and March 2023 with sex ratio of 1m:1f. Ovulation and spermiation was induced by intra-peritoneal injection using WOVA-FH hormone at 1.0 µl g^{-1} body weight of fish. Absolute fecundity ranged from 1,500 to 2,100 with fertilization rate of 60-75% and hatching rate of 60-70%. The fertilized eggs were adhesive, golden pale yellow in colour with diameter 2.0 to 2.20 mm. As the embryo develops, we observed various stages *viz*., zygote, blastula, gastrula, and segmentation until hatching. Hatching took place between 27-30 hours at water temperature 26-28°C. Newly emerged hatchlings had a well-defined yolk sac, and a short tail. The yolk was fully absorbed in 60-66 hours, and the mouth was fully formed This report serves to summarize our successful efforts to condition broodstock of *H. nigricollaris* in captivity, spawn them with hormonal stimulation and rear the young.

Keywords: Broodstock, conservation, fertilization, hatching, induced, ornamental fish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Prioritization of Watersheds for Fisheries Development in North-western Himalayas

Muruganandam, M.*, Saswat Kumar Kar and Sadikul Islam
ICAR-Indian Institute of Soil and Water Conservation (ICAR-IISWC), Dehradun, India
*mail2mmm20@gmail.com

Prioritization of Fisheries Sensitive Watersheds (FSW) or Fisheries Potential Watersheds (FPW) was carried out based on the Recovery Potential Index (RPI) of US-EPA using critical ecological, stressor, and social attributes and indices. While the principles of watershed management promote a top-down treatment approach and protection of upstream-headwater reaches, the prioritization depends on existing differences in ecological, stressor, and social attributes between micro-watersheds. The RPI is the overall index and rank-ordered prioritization arrived from the individual and collective indices. The Aglar watershed (≈ 30000 ha; 35 micro-watersheds) in Tehri-Garhwal, Uttarakhand, India was the model study watershed. Data on various physical and morphometric attributes and complexities of micro-watersheds were used to specify ecological, aquatic connectivity, water quality, stressors, and social attributes including fishing population, and fishing frequency. Although the entire Aglar is upstream/headwater for the Yamuna River, its micro-watersheds in different reaches differed in many attributes studied, which the RPI captured for rank-ordered prioritization. The prioritization revealed that most of the downstream-reach micro-watersheds of the Aglar River ranked healthy as compared to upstream and middle-stream reaches indicating that upstream and middle-stream reach micro-watersheds need prioritized interventions to rehabilitate and promote sustainable fisheries resources and production. Upstream and middle-stream Aglar micro-watersheds being upstream to the river, harbor lesser fisheries resources and have a considerable extent of ecological limitations, and environmental stressors besides social restrictions as compared to downstream reaches as having been reflected in the RPI. This study using a customized assessment protocol, indices, weights, and scores for assessment and prioritization of FSW or FPW based on watershed sensitivity using RPS Tool was able to prioritize micro-watersheds of Aglar river, and created a databank on the watershed and its fisheries resources. The results of this study can be used as input required for appropriate policy guidelines to promote watershed management and fish production. The outcome of the study has relevance to similar regions in India and other countries as well.

Keywords: Aglar, Fisheries Sensitive Watersheds, Recovery Potential Index (RPI), watershed prioritisation

A review and projections on watershed management to improve fish production in Uttarakhand, India

Muruganandam, M.

ICAR-Indian Institute of Soil and Water Conservation (ICAR-IISWC), Dehradun India

* mail2mmm20@gmail.com

Considering the existing WHS, local constraints for fish farming due to higher altitude, cold temperature, limited inputs availability *etc*., only 10% of the total area and 10-50% of the production potential observed in the experimental farming are accounted for future projection on fish farming potential in WHS. About 52662 ha-m of rainwater can be harvested if 10% of the total catchment area and the tentative rate of 1 ha-m water yield from every 10 ha of catchment in Uttarakhand are considered, which would produce a total of 118490, 59245 and 23698 t additional fish per annum at 50%, 25% and 10% of the observed average fish production rate (4.5 t ha-m^{-1} based on average of foothill and mid-hill Himalayas) respectively. Considering the existing limited assured irrigation and land constraints, paddy-fish culture can be integrated in at least 5% (14,411 ha) of the total paddy fields (2,88,225 ha) in Uttarakhand, which would produce about 4,300 t of additional fish at 50% (300 kg ha^{-1}) of the production achieved in the experiment (600 kg ha^{-1}), for local consumption. The present highest production level of 6422 t in Uttarakhand is over 6 times lower than the demand of 50% of fish consumers in the state. The present fish production of 2534-6422 t year^{-1}, which amounts to 30,532-34420 t would not meet the tentatively estimated demand of 50,000 t for 50% of the population of total 1.01 crore. The existing or projected demand can be met by either increasing the area of production from 10% to 20% or by increasing the production potential to 20% of the observed production in research experiments. Fish production potential of Uttarakhand (44,000 t) can be achieved mainly by harnessing running water area for trout production and low-lying area in plains for carp production. Thus, the importance of fisheries in Integrated Watershed Management (IWM) requires no emphasis for its positive impact on food security, resource conservation and rural development. In fact, approaches and strategies to scale up hill fisheries and aquaculture require integration of fisheries into Integrated Watershed Development Plan (IWDP).

Keywords: Himalayas, paddy-fish culture, trout culture, watershed

Brackish water aquaculture sector post-tsunami and the utilization of submerged land for aquaculture in South Andaman Island

Kiruba-Sankar, R.*, Sirisha Adamala, Saravanan, K., Praveenraj, J., Chittaranjan Raul and Zamir Ahmed, S. K.

ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India

*rkiruba.sankar@icar.gov.in

The scenario of brackish water aquaculture in the tropical archipelago of Andaman and Nicobar is studied and reported through stakeholder surveys. The tsunami and earthquake of 2004 created a lot of submerged water bodies wherein seawater inundated low-lying paddy fields and other land areas. To reinstate land utilization, aquaculture was identified as one priority area. We conducted surveys in the Andaman archipelago (North, Middle, and South Andaman) to understand the existing scenario and the active farmers undertaking brackish water aquaculture. We could identify only ten farmers practicing aquaculture as well as ten farmers who have discontinued or with a plan to revive their farming activities in the archipelago. Our surveys across the Island revealed that South Andaman is an active hub for brackish water farming activities considering its proximity to air and seaport connectivity. Mud crab (*Scylla olivacea* and *S. tranquebarica*) fattening and trading is the most popular activity among the respondents followed by shrimp farming (*Penaeus vannamei*, *P. monodon*) and milkfish culture (*Chanos chanos*). Garrett ranking revealed land unavailability as a major constraint for undertaking aquaculture activities. A total of 566 ha of water spread area was available as NDWI spread area from locations in Manjeri, Mithakari, Sippighat, Wandoor, Chouldhari, Guptapara, Flat Bay, Ograbraj, and Dundus Point. The inundated water bodies in Dollygunj, Sippighat, Wandoor, and Ograbraj were found to have good potential to initiate brackish water aquaculture in the first phase of activities. Efforts were initiated in collaboration with the Andaman and Nicobar administration to identify the submerged areas using GIS/remote sensing tools and to prepare leasing policies to facilitate aquaculture activities in such inundated water bodies. The sector needs more attention towards empowering the stakeholders through sustainable utilization of these inundated water bodies and providing employment and economic development to the island stakeholders.

Keywords: Aquaculture, brackish water, leasing, policy, stakeholders

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Scope, opportunities and challenges in mariculture entrepreneurship development in Gujarat

Bhatt Bhargav, H.*, Divu, D., Swathi Lekshmi, P. S., Suresh Kumar Mojjada., Boby Ignatius and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*bhargav.bhatt@icar.gov.in

Mariculture entrepreneurship offers a promising avenue for coastal communities to diversify their income streams and promote sustainable aquaculture practices across the globe. In India, the state of Gujarat is endowed with the longest coastline and 33% of continental shelf is available to reap the potential of mariculture. However, the state is still lacking in unlocking the potential of mariculture enterprises. Thus, the current study attempted to analyze the scope of entrepreneurial development of integrated mariculture activities across the coastline. The study identified and revealed the scope, opportunities, weakness and threats of mariculture sector by analyzing technology transformation, resource conceptualization, entrepreneurial behavior studies (various socio-economics facts) and policy analysis across the state. The study also leverages its feasibility of deploying SHGs and co-operative model for the same practices across the state's coastline. The findings revealed that, fishers of Gujarat are ready to adopt new technologies and innovations and are driven towards self-investment and resource mobilization. The bottlenecks were non-availability of quality seeds in time, cost effective quality feed and other essential operational inputs. Focus, research and minor transformation must also be needed in policy implementation (*i.e.*, easy to get permit, financial and technical support) to motivate more entrepreneurs across the state for mariculture entrepreneurship. Importantly, nurturing the various issues in the development of sea-based cage farming across the state will not only provide better employment opportunities but also ensure sustainable, and environment friendly farming practices for contributing to food and nutritional security. To augment the development of such activities, both social integration, seasonal and resource (*i.e.*, timely availability of seed, feed and other resources for the said activity in synchronization) and policy integration must be taken on seriously for successful promotion of mariculture entrepreneurship along the Gujarat coast.

Keywords: Cage culture, entrepreneurship development, mariculture, policy and socio-economics

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Development of mariculture technology parks in India: A SWOT-based evaluation adds a new dimension to the mariculture sectorlandscape

Suresh Kumar Mojjada*, Divu, D., Swathi Lekshmi P. S., Mayur S. Tade, Aarsha Subramanian, Suresh, V. V. R. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sureshkumar.mjd@gmail.com

Mariculture in India has undergone substantial advancements, establishing its unique presence within the national context. The sector is poised to emerge as a pivotal driver of sustainable seafood production, socioeconomic growth, and employment opportunities. The conceptualization of Mariculture Technology Parks, rooted in the recommendations of the National Mariculture Policy (NMP), represents a holistic step forward, introducing a novel dimension to the Indian mariculture landscape. The scattered or unplanned expansion of sea farming certainly leads to disruption of ecosystem, user conflicts and other social issues. Thus, sustainable, conflict-less and ecosystem-based sea space governance will be a challenge in India in the emerging mariculture scenario in territorial waters. To address this, we employed SWOT, as a strategic tool, to facilitate and review the current state of the industry and assist in the tactical planning process. In the current study, we analysed the strengths, weaknesses, opportunities and threats of the open sea mariculture industry spread across the Indian peninsula. Ten most influential attributes, each under strengths, weakness, opportunities, and threats were enlisted, subjected to stakeholder, and expert ranking followed by the application of Rank Based Quotient (RBQ). The study demonstrated that the most crucial strategies that had to be considered for the growth of mariculture sector development are comprehensive sectoral planning, promotion of new production technologies, infrastructure development such as hatchery facilities and nurseries for stockable-sized seed availability, seasonal integration, improved entrepreneurship-based, pro-industry policy refinements and implementation of efficient marine spatial planning in conjunction with other maritime sectors. The results of this study will aid decision-makers in Indian fisheries and mariculture sectors in their efforts to improve and develop legislation and ocean accounting, thus achieving the intended socio, economic and ecological goals of the country through mariculture production.

Keywords: Blue economy, cage culture, mariculture, MSP, policy planning, SWOT

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Delineation of aquaculture development zones in coastal India using geospatial techniques

Ashok K. Nayak*, Mohanty, R. K., Rautaray, S. K., Jena, S. K., Das, M., Jena, R. K., Patra, P. K. and Sarangi, A.
ICAR-Indian Institute of Water Management, Bhubaneswar-751023, Odisha, India
*ashok.nayak@icar.gov.in

Coastal ecosystems have played a significant role for anthropogenic activities since time immemorial. However, major constraints are the lack of aquaculture and agriculture development in coastal region, including non-identified land suitable for developmental activity despite the availability of technologies and resources. An attempt was made in this study to identify suitable sites for aquaculture in the coastal region of eastern and western coasts of India. Land use and land cover maps of western coast *i.e.* Ernakulum and Thrissur districts of Kerala, and three coastal districts of Odisha, *i.e.* Puri, Jagatsinghpur, and Kendrapara in the eastern coast were prepared by using Sentinel-2 data. The georeferenced water samples were collected from these regions and water quality parameters *viz.* pH, CO_2, dissolved oxygen, TDS, transparency, alkalinity, and salinity were estimated. Further, soil, water, and infrastructure facilities were assessed by the analytical hierarchy process (AHP). Based on the point data of water quality parameters of different stations, the geo-statistical interpolation technique was undertaken to generate the spatio-temporal variability map in ArcGIS 10.3 platform. Raster maps thus generated were reclassified as per the suitability rating and thematic maps for these seven water quality parameters were prepared. Moreover, for soil quality analysis, different soil parameters were considered for mapping *viz.* soil pH, soil texture, organic carbon, soil depth (cm) and slope (%). The soil suitability map was prepared by assigning weightage to the parameters based on the published protocols and AHP model. For infrastructure facilities, the distance to water sources (km), distance to the hatchery (km), and distance to the market (km) were considered in the study. Sixteen thematic layers were prepared using ArcGIS. In this process, the region was categorized into different suitable locations for developing aquaculture activities in Jagatsinghpur district. The thematic maps were prepared after geospatial analysis tool (raster calculator) indicated the location and extent for the development of aquaculture in different suitability classes *viz.* most suitable (35%), moderately suitable (41%) and other not suitable and constraint areas (24%) out of the total land cover area of Jagatsinghpur district. The present study will assist in delineation of aquaculture development zone for enhancing production and income of stakeholders.

Keywords: ArcGIS, raster, site selection, thematic maps, zonation

Prospect and management of wetland fisheries: A case study of Kasaraiya Dhar Maun in Bihar

Vivekanand Bharti*, Tarkeshwar Kumar, Jaspreet Singh, Surendra Kumar Ahirwal, Kamal Sarma, Rohan Kumar Raman and Ujjwal Kumar

ICAR-Research Complex for Eastern Region, Patna, Bihar-800014

*vivekanandbharti15@gmail.com

The annual saga of extreme floods is a big challenge in the development of agricultural and allied ventures in Bihar. After the receding of floods, water is trapped inside a bowl-like depression commonly known as *chaur,* and *maun* in low lying area. Presently, the area of chuars and mauns in Bihar is approximately 9,41,000 ha and 9,000 ha, respectively which are not properly utilized and remain unproductive. Scientific technological interventions are the prominent way to convert these wastelands into moneymaking resources. With this point of view, a study was conducted at Kasaraiya Dhar *maun,* located in Khagaria District of Bihar at 25.492937^{0} N longitude and 86.619178^{0} E latitude formed by meandering of the Budhi Gandak River. The *maun* is sickle-shaped with an average depth of 10 m throughout the year and supports the livelihood of around ten villages. This *maun* is under the control of District fisheries department which has leased it out to the local fisheries co-operative society, where fish are caught only by the authorized fishermen. We analyzed the ichthyofaunal biodiversity and soil and water quality parameters of Kasariya *maun* in monsoon, pre-monsoon and post monsoon seasons during the year 2021-23. Results indicated that a total of 42 fishes species belong to 15 families of finfishes, prawn and molluscs were present in the *maun*. The physicochemical parameters like hardness, alkalinity, ammonia, nitrite, pH and dissolved oxygen of water and soil parameters like N, P, K EC, organic content and pH were found to be within the permissible rage for aquaculture. Hence, this wetland of Bihar may be utilized for enhancing fish production through pen and cage culture and culture-based fishery.

Keywords: Aquaculture, fisheries resources, Kasaraiya dhar *maun*, wetlands

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Fish and fishery of Idukki Reservoir, Kerala

Deepa Sudheesan*, Thankam Theresa Paul, Manoharan, S., Das, A. K. and Das, B. K.

ICAR-Central Inland Fisheries Research Institute, Kochi Research Station, CMFRI Campus, Ernakulam North P.O., Kochi-682018, Kerala, India

*deepasudheesan@gmail.com

Reservoirs of India have huge production potential of 500, 200 and 100 kg ha^{-1} $year^{-1}$ from small, medium and large reservoirs respectively. However, the actual yield is much lower and in order to bridge this gap, appropriate management tools and strategies needs to be implemented. The present study was carried out to know the status of the fish production from Idukki reservoir, the only reservoir in Kerala under the large category with a surface area of 6000 ha, and accordingly formulate suitable production enhancement strategies. Three dams, *viz*., the Cheruthoni dam, the Idukki arch dam and the Kulamavu dam form the reservoir. From the study, 23 fish species belonging to 9 families were recorded from the reservoir. Indigenous fish species of the reservoir include *Ompok bimaculatus, O. malabaricus, Channa marulius, Tor khudree*, *Mastacembelus armatus, Heteropneustes fossilis, Anabas testudineus*, *Barilius bakeri, Garra mullya, Pethia punctata, Mesonoemacheilus triangularis*, *Pseudetroplus maculatus etc*. *Cyprinus carpio*, *Ctenopharyngodon idella* and *Oreochromis mossambicus* were the exotic species recorded from the reservoir. *Cyprinus carpio* contributed maximum (15-30%) to the total annual catch from Idukki reservoir, followed by *Catla catla* (24-28%), *Channa marulius* (18-14%), *Labeo rohita* (11.5%) and *Ctenopharyngodon idella* (10.7). The maximum catch was recorded during July-September. From the study it is evident that the stocked non-native fishes are the major contributors to the catch from the reservoir while indigenous fish species like *Tor*, *Channa striata*, *Heteropneustes fossilis*, *Hypselobarbus kurali*, *etc*. have become rare in the catches. Therefore, stocking suitable indigenous fish species may be prioritized for fishery enhancement programmes as well as to promote its revival and conservation. Sustainable increase in fish production through enclosure culture as a fisheries development strategy can be adopted in the reservoir.

Keywords: Fishery status, large reservoir, production enhancement strategy

Fishery of black clam, *Villorita cyprinoides* (Gray, 1825) from Vembanad Lake

Vidya, R.*, Geetha Sasikumar, Laxmilatha, P., Jayasankar J., Eldho Varghese, Alloycious, P. S. Sajikumar, K. K. and Jestin Joy, K. M.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* vidya.panicker@gmail.com

The black clam, *Villorita cyprinoides*, is the most important clam species in India contributing more than three-quarters of the clam landings in the country. Kerala leads in clam production in India with Vembanad Lake, along the west coast, contributing 55.5% to the estimated clam production of India. The fishery for clams and finfish provide the major livelihood avenue for coastal communities around the lake. The black clam is harvested extensively from its natural habitats in the lake. More than 5,000 fishermen are involved in the fishery. Being an abundant and cheap protein source, clams are regularly fished from Vembanad Lake, and their meat is marketed locally and in export markets for consumption. The production of black clams declined from a peak of 75,592 t in 2006 to 52,611 in 2022. The average annual black clam production from Vembanad Lake was estimated at 44,832 tonnes The catch and catch rates from 2005-2022 of black clam were analysed for the present study. Both fishery samples and bottom bed samples were collected for the study. The mesh size of the gear which is locally known as "kolli" for collecting fishery samples is fixed at 20 mm. The size range in the fishery samples ranged from 8.57-49.48 mm while in the clam beds it ranged from 1.5- 49.4 mm. This paper attempts to delineate the stock status of *V. cyprinodes* from Vembanad Lake. This study presents the stock status of this resource assessed based on Surplus Production Model under a Bayesian framework and suggest management measures for sustainable exploitation of the resource.

Keywords: Black clam, livelihood, *Villorita cyprinodes,* stock status

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Ashtamudi clam fishery-catch trend and status

Venkatesan*, V., Laxmilatha, P., Geetha Sasikumar, Jenni, B., Alloycious, P. S., Sajikumar, K. K., Jestin Joy, K. M. and Sheela, P. P.
ICAR–Central Marine Fisheries Research Institute, Ernakulam North P. O., Kochi–682 018, Kerala, India
*venkatcmfri@yahoo.co.in

The Ashtamudi Lake is well-known for its many fishery resources which support the livelihood of thousands of traditional fishers. The most popular among these is the Ashtamudi short-neck clam, *Paphia malabarica* locally known as *kallikakka*, which has the global sustainability certificate. This certificate was awarded because this resource is harvested sustainably through several management measures including the 3-month closed season (December to February) during clam breeding period and a minimum legal size (MLS) limit that ensures protection of young clams. CMFRI regularly monitors the clam resource through surveys especially during the closed season or banned periods. Catch trend and catch rate of Ashtamudi short-neck was analyzed from 2002-2022. Catch of *P. malabarica* has been declining from 2018 onwards. Estimated catch of *P. malabarica* in 2017 was 11,215 tonnes which reduced to 5210 tonnes in 2018 (*i.e.* 53% reduction from the previous year). Catch in the subsequent years–2019 and 2020 further reduced to 3741 tonnes and 1781 tonnes respectively. Catch rate of *P. malabarica* has also reduced drastically from 255 to 124 kg during 2017–2020. Due to floods of 2018, the stock of *P. malabarica* was severely affected resulting in low stock biomass. Post flood environmental changes has also affected the stock which is currently below the LRP of 6000t. Combination of factors has created this ecological disaster including proliferation of seaweeds that had smothered most of the clam beds, change in water currents and hydrodynamics of the lake resulting in reduced flow, stagnation of water and erection of bunds during construction of the Dalawapuram Bridge. The water and soil analysis indicates that there is a significant change in the soil structure and most of the sites are now predominantly sandy. Ashtamudi Clam Governance Council (ACGC) has taken several measures to augment the biomass of this resource.

Keywords: Ashtamudi Estuary, catch trend, *P. malabarica*, southwest coast, status

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Status of blood clam fishery of Kakinada Bay, Bay of Bengal

Jasmin, F.*, Santosh N. Bhendekar, Geetha Sasikumar and Pattnaik, P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*jasmin.f.cmfri@gmail.com

In India, bivalves play a vital role in supporting small-scale fisheries, contributing to both the livelihood and nutrition of coastal communities. Kakinada Bay along the east coast of India is an important bivalve fishing area and holds significant importance for its cockle (blood clam) fishery. This blood clam fishery is supported by two species *Anadara* (*Tegillarca*) *granosa* and *A.* (*T.) rhombea*, under the class Bivalvia, family Arcidae and Subfamily Anadarinae. The monitoring of catch and effort is crucial for the sustainable management of fishery resources. In the present study, the fishery, catch trends, catch rates, biology and stock status, of blood clams were examined. The data pertaining to the fishery landings spanning a decade (2012 to 2022) was collected using standard methods. A detailed study on biology was carried out during 2016-2018 on maturity. The clams are hand-picked during the low tide and the major crafts employed in the fishery include the 'Shoe dhoni,' 'Nava,' and fiber 'teppas'. These crafts facilitate the storage of the clams in plastic/net baskets. In Andhra Pradesh, more than 60% of the blood clams are exported, while nearly 30% serve as a major ingredient in shrimp feed as well as in the shell industry. A small fraction of the landings goes for domestic consumption. The catch recorded a negative trend from 250 tonnes to 214 tonnes, with a peak of 335 tonnes in 2016. The landing data for 2020 to 2021 could not be included due to the COVID-19 lockdown. The average catch rate observed was about 21.177 kg unit^{-1}. The size distribution in the fishery ranged from 22 to 78 mm. The mean size of *Anadara* sp. in the fishery also recorded a decreasing trend from 42 (2016) to 40 mm (2018). This underscores the need for resource management of the stock and implementation of minimum legal size for the exploitation to protect juvenile overfishing.

Keywords: *Anadara*, clam fishery, cockles, stock

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Fishery and stock assessment of *Babylonia spirata* (Linnaeus, 1758) (Neogastropoda: Buccinidae) along south-west coast of India

Venkatesan, V., Vidya, R.*, Laxmilatha, P., Kavitha, M., Sajikumar, K. K., Alloycious, P. S. and Jestin Joy, K. M.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* vidya.panicker@gmail.com

Globally, gastropods have a documented commercial fishery. In India, gastropods have been mainly used for ornamental purposes. Two species of whelks *viz*., *Babylonia spirata* (Linnaeus, 1758) and *B. zeylanica* (Bruguière, 1789) belonging to the family Buccinidae are commercially fished from Kollam, south-west coast of India, since 1990s and are exported under the trade name "Baigai". *Babylonia spirata* or 'spiral babylon' has a wider distribution along east and west coasts of India and Andaman and Nicobar Islands. The species is present throughout the year in the fishing ground off Kollam, is caught as bycatch in shrimp trawlers and is also part of a targeted fishery during certain months (April-June) when more than 50% of the annual whelk catch is taken. Fishery and population characteristics of *B. spirata* were carried out from January 2017- December 2019. The shell length of *B. spirata* ranged from 19.6 to 57.3 mm in the samples. The asymptotic length (L_∞) and growth coefficient (K) were estimated at 60.9 mm and 0.82 y^{-1} respectively. The mortality parameters, the instantaneous total mortality rate (Z), fishing mortality (F) and natural mortality rates (M) were estimated at 4.83, 3.57 and 1.26 respectively. Exploitation rate (F/Z) was estimated at 0.74. The results of this study will serve as baseline information for formulating future management measures.

Keywords: *Babylonia spirata,* gastropods, mortality estimates, whelks

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Non-penaeid shrimp fishery along Maharashtra coast-catch trend and status

Sunil Kumar S. Ail*, Santosh N. Bhendekar Nagnath, Vaibhav, D., Mhatre, Ajay D. Nakhawa and Venkatesan, V.
Mumbai Regional Station of ICAR-Central Marine Fisheries Research Institute, Mumbai-4000 61, Maharashtra, India
* sunilsail86@gmail.com

Non-penaeid shrimps form an important fishery along north-west coast of India. Of the major gears operated along the Maharashtra coast, *dol* net contributed the maximum to total non-penaeid catch. The non-penaeid resources were mainly contributed by three species namely *Acetes sp*., *Nematopalaemon tenuipes* and *Exhippolysmata ensirotris*. The non-peaneid group contributed to 20% of total marine landings of the state and played an important role in the food chain for many fishes including Bombay duck, ribbonfishes, sciaenids *etc*. Catch trend of non-penaeid shrimp was analyzed from 2012-2019. During this period, the average landing of non-penaeid resource from the *dol* and trawl net was 42,600 mt and 2760 mt respectively. The group constitutes 45-60% of the *dol* net fishery and 2-3% of the trawl net landings. Among the total non-penaeid landings, nearly 92% of the catches was formed by *dol* nets. Peak landings were observed during November- December and March-April. During March-April, this resource is mainly targeted for dry fish market. The species contribution from the *dol* net were *Acetes* and *Nematopalaemon* forming 30-50% each and *Exhippolysmata ensirotris* formed 10%. Non-penaeids are consumed fresh as well as dried and also used for making paste for adding flavor to various dishes. The CMSY analysis showed that the group is exploited sustainably along the coast of Maharashtra.

Keywords: Catch trend, CMSY, non-penaeids, species composition

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Regime shift dynamics of oil sardine fishery in Kerala

Somy Kuriakose*, Mini, K. G. and Sindhu K. Augustine

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*somy.kriakose@icar.gov.in

The Indian oil sardine *Sardinella longiceps* forms the largest single species fishery in India and among the maritime states, Kerala contributes a significant share of the landings of this resource. Oil sardine fishery in Kerala is characterised by exceptionally wide fluctuations on a seasonal, annual and decadal scale. The state's oil sardine landings have varied between 1546 tonnes in 1994 to 3.99 lakh tones in 2012. After hitting an all-time high in 2012, the landings of this resource continued to show a declining trend till 2016, with an estimate of 45,958 tonnes. During 2017, the landings showed a marginal increase with an estimate of 1.33 lakh tonnes and further showed a decreasing trend till 2021. However, the species has regained the top most position with 110267 tonnes in 2022, from a meagre 3297 tonnes in the previous year, which is the lowest estimate in the past two decades. In order to identify sudden changes in patterns of the oil sardine landings in Kerala over the course of 38 years starting in 1985, a change-point analysis is carried out. Change points are abrupt shifts in time series data that represent transitions occurring between states. It determines the number of changes and estimates the time of each change. During the period, four abrupt changes in the oil sardine landings were identified using the Bayesian change point approach. Additionally, the posterior probabilities of changes at any given point of the time series were also estimated. The year 2014, when landings began to drop after reaching their highest peak in 2012, is the changepoint with the highest probability. In a similar way, the changepoint in 1993 preceded collapse of sardine fishery in 1994. The other two changepoints were identified in 1999 and 2010, which similarly correspond to fluctuations in the oil sardine landings. In order to identify the years of sudden changes, the binary segmentation algorithm was also employed. Both methods detected the same change point year. The fishing pressure, climatic and hydrographic factors in relation to spawning biology, and the trophic interactions in the ecosystem can all be attributed for the abrupt changes in oil sardine abundance.

Keywords: Change point analysis, Indian oil sardine, marine fish landings, regime shift

Status of marine fisheries of Odisha: An Overview

Gyanaranjan Dash[1*], Rajesh Kumar Pradhan[1], Swatipriyanka Sen Dash[1] and Shubhadeep Ghosh[2]

[1]Puri Field Centre of ICAR-Central Marine Fisheries Research Institute, Puri-752 002, Odisha, India
[2]Division of Fisheries, ICAR, Krishi Anusandhan Bha wan–II, New Delhi–110 012, India

* gyanranjandashcmfri@gmail.com

Odisha, with a landing of 1.33 lakh tonnes, contributed about 4% to the total marine landings of India in 2022. The total landing from marine capture fisheries in Odisha was at its highest in 2011 after which it showed an overall decreasing trend. The landings could be seen below the annual average landings of 1.76 lakh tonnes after 2012, except for 2020 and 2021, during which it has shown an increase in general trend. Nevertheless, the marine fish landings in 2022 decreased to 1.33 lakh tonnes, showing a 26% reduction compared to the previous year's landings. The resources were predominantly exploited by mechanized multiday trawlers (61%), followed by outboard ring seines (10%), outboard gill netters (18%), mechanized gill netters (6%) and other gears (5%). The maximum catch and catch rate were realized immediately after the seasonal fishing ban during the third quarter (from July to September), followed by the first quarter (from January to March). Pelagic resources contributed the most (49%) followed by demersal resources (31%), crustacean resources (15%) and molluscan resources (5%). Pelagic landings are mainly contributed by minor clupeids (16%), ribbonfishes (13%), *Sardinella* (11%), Indian mackerel (10%), *Thryssa* (8%), *Hilsa kelee* (6%), Bombay duck (5%), minor carangids (4%), tuna (4%), horse mackerel (4%), *Coilia* (4%) and others. Croakers were the most dominant group, contributing nearly 31% to the total demersal landings, followed by catfishes (17%), pomfrets (12%), minor perches (8%), soles (5%), eels (4%), rays (4%), goat fishes (3%), silverbellies (3%), sharks (2%), threadfin breams (2%), threadfins (2%) and others (8%). Prawns contributed the maximum (85%), followed by crabs (15%) to the crustacean landings in the state. The prawn landings were predominantly constituted by *Parapenaeopsis* spp. followed by *Penaeus* spp., *Metapenaeus* spp. and *Solenocera* spp. Among crabs, the major landings came from *Portunus sanguinolentus* followed by *Charybdis feriatus* and *P. pelagicus*. Lobsters, mainly *Panulirus polyphagus* contributed a very negligible quantity to the crustacean landings in the state. The cuttlefishes contributed the most (80%) followed by squids (20%) to the molluscan landings in the state. The selected important marine resources, when investigated for their stock status using biology-based stock assessment tools, were found to be optimally exploited and in a sustainable healthy state. The recent fluctuations in the landings appear to be more due to the loss of active fishing days due to frequent incidences of cyclonic weather conditions and also due to demand-driven alteration in exploitation strategies.

Keywords: Marine fishery, Odisha, stock status, sustainable

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Live bait resources of Lakshadweep–Imperative need for sustainable utilization and conservation

Rekha, M. U.*, Teena Jayakumar, T. K., Haslamathi, T., Bharathi, S., Akash, S., Ajith Kumar, T. T. and Sarkar, U. K.
ICAR–National Bureau of Fish Genetic Resources Lucknow–226 002, Uttar Pradesh, India
*rekhamfsc@gmail.com

Lakshadweep, India's solitary coral atoll, showcases unique geography with scattered islands, accommodating approximately 75,000 residents, whose livelihoods are intricately linked with reefs and encompassing ocean. Notably, 13% of the population comprises full-time fishermen specialized in live-bait-driven pole and line tuna fishing. This practice predominantly targets yellowfin and skipjack tunas. Boats ranging from 20-30 and 60-70 feet, equipped with pole and lines as well as live bait holding tanks (with capacities of 500l to 2000l). After identifying tuna schools, live baits are cast into the sea. Subsequently, the tuna is attracted, fed on the bait fish, and then captured using pole and line techniques. A significant portion of the captured tuna is allocated for masmin production, while the remaining portion is marketed for fresh consumption. The fishing season extends from mid-September to mid-May, during which the selection of live bait fish is adjusted in accordance with their prevailing abundance. Prominent live bait species for capturing the skipjack and yellowfin tunas encompass *Spratelloides delicatulus* (local name–Bondali), *S. gracilis* (Rahi), *Doboatherina duodecimalis* (Madam or Bampan challa), *Taeniamia fucata*, *Ostorhinchus apogonoides* (Bodhi), *Ostorhinchus fleurieu* (Bodhi), *Zoramia leptacantha* (Bodhi), *Rhabdamia gracilis* (Bodhi), *Verulux cypselurus* (Bodhi), *Gymnocaesio gymnopterus* (Mukram), *Dipterygonotus balteatus*, and *Chromis viridis* (Pachachalla). These species are captured using traditional 'Olavala' gear made from coconut leaves, encircling nets, and lift nets. Besides, other live bait species, such as *Pomacentrus pavo*, *Lutjanus kashmira* (Manja), and *Odonus niger* (Karatti), are being used for catching larger lagoon fishes like snappers and groupers. In recent times, squids, octopuses, and worms are also used as live baits, largely. Alarmingly, current exploitation rates surpass the maximum sustainable yield (MSY) for many live bait fish species, posing a threat to ecosystem balance and health. Monitoring and immediate intervention are crucial to maintain wild live-bait fish populations. Hence, a sustainable alternative requires captive propagation and supply to fishermen, thereby easing pressure on natural live-bait fish populations. Hence, adopting breeding and seed production of suitable live bait species, *C. viridis* and *P. pavo* offers the potential to enhance fisherfolk livelihoods, while bolstering wild populations through sea ranching initiative. ICAR-NBFGR spearheads the standardization and scaling up of the breeding technology for two species of damsel and one species of *Apogon*.

Keywords: Bait, coral reef, tuna, pole and line, sea ranching

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Characterization of low-valued bycatch in the bottom trawlers of Gujarat

Rajan Kumar*, Shikha Rahangdale, Vinaya Kumar Vase and Dineshbabu, A. P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*rajanfrmcife@gmail.com

Trawl sector forms the mainstay of marine capture fisheries of India. Bottom trawl operation is one of the major means of fish harvest from the continental shelf region of coastal Indian EEZ. The fish caught by multi-day bottom trawls has basically two components, the retained catch and discards. The retained catch can further be classified as high-valued catch (HVC) and low-valued bycatch (LVB). The catch rates of LVB from multi-day bottom trawlers were 16.03 and 18.32 kg h^{-1} for the year 2018 and 2019, respectively. The fishes (83.9%) are the most dominant component of LVB, followed by crabs (7.7%) and *Acetes* spp (7.1%). The catch rates of LVB for single day trawlers were 54.71 and 96.59 kg h^{-1} during 2018 and 2019, respectively. The study observed profound dominance of *Acetes* spp. (85.1%) in low-value bycatch. Stomatopods (5.32%) ranked 3rd among the LVB after *Thryssa* spp. (7.89%). Catch rates of the LVB are not static both in space and time. An attempt was made to quantify the spatial distribution of LVB across difference season along the north-west coast of India. The average catch rates during the period from January 2018 to December 2019 was 34.85 kg h^{-1}. But the actual catch rates showed a wide variation between 9.7 to 284.4 kg h^{-1}. The high catch rates are restricted to off Maharashtra coast in a depth range of 30-60 m. Such skewness in the distribution was due to the abnormally high abundance of *Odonus niger* off the west coast of India. The other hot spots for LVB were recognized off Porbandar and Kachchh region in shallower depths and off Madhavpur and Mangrol in deeper waters during the post monsoon. In winter, the hot spots are off north Gujarat in mid and high depth categories. The summer-monsoon season witnessed a sharp decline in the abundance of *O. niger* abundance and hence more uniform distribution in catch rates of bycatch were observed along the north-west coast of India.

Keywords: Bottom trawl, GIS, LVB, north-west coast, spatio-temporal

Sustained food security from unconventional fishery resources: market oriented lucrative fishery of pufferfishes in Tamil Nadu, India

Remya, L*., Rajkumar, M., Thirumaliselvan, S., Suresh, M. Joseph Jegan, S., Mahalingam, V., Midhun, M., Rajkumar, R., Ramesh, A., Manojkumar, M. and Shoba Joe Kizhakudan

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*lremya9@gmail.com

As oceans occupy vast areas of earth (71%), the attention naturally is focused on the oceans to satisfy the livelihood of the burgeoning population. Global scenario of marine fish landing indicates that 35.4% of fish is unsustainably fished, 57.3% is sustainable and 7.2% is underfished stocks. This results in a serious biomass reduction in the ocean as the years progress. Possible solutions/recommendations are reducing overcapacity, impose ban and regulate mesh size, declaration of protected areas, implementation of minimum legal size *etc*. One of the most practical solutions which has been addressed poorly in management measures is the search of abundant, underutilized, nutritious, highly fecund, less vulnerable and low value fishes. Though highly poisonous the skinned, gutted and beheaded (dressed) pufferfishes of coastal waters meet these criteria. Previously these fishes were either discarded at sea or discarded at shore owing to inedibility and difficulties in handling. Local dealers started collecting dressed brined puffers from small fish drying units in coastal areas of Gulf of Mannar and Palk Bay. Monthly samplings and personal enquires were conducted at various landing centre along Gulf of Mannar and Palk Bay and Coromandel Coast in Tamil Nadu during 2018-22. Unlike most of conventional fishes, puffers do not have intramuscular bone, makes them convenient to consume. In addition, this product is devoid of fishy odour, looks like broiler chicken with a white colour, thus popularly called as 'white chicken' among traders and hotels. The dressed meat is on an average 27-35% of raw fish weight depending upon the species. Some portion of this moves to dry fish market after brining and the weight loss in the final stage comes around 54-60%. Annual average pufferfish landing for a period of 2018-22 was estimated at 741.12t. Landings of puffers by different craft and gears in Tamil Nadu shows apparent dominance of mechanised sector (93.5%) over motorized (6.5%). The species composition of puffers was predominantly *Arothon immaculatus (*30.2%), *A. hispidus* (19.5%), *A. stellatus* (16.7%), *A. nigropunctatus* (9.6%), *Lagocephalus guentheri* (8.3%), *L. inermis* (4.3%) *Takifugu oblongus* (7.4%) and other puffers (7%). Each dry fish unit in Ramanathapuram district produces an average of 100-140 kg puffer meat every fishing day. The brined meet is transported to districts in Tamil Nadu *viz*., Coimbatore, Pudukottai, Madurai, Chennai, Tirupur and to Kerala for retailing to hotels as well as to dry fish markets.

Keywords: Brined, dressed, dry fish, toxin, white chicken

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Fishery, biology, and stock status of Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816) from the north-eastern Arabian Sea of Maharashtra coast

Ajay D. Nakhawa*, Anulekshmi, C., Akhilesh K. V., Santosh N. Bhendekar, Sunil Ail, Punam Khandagale, Prathibha Rohit and Venkatesan, V.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* ajaynakhawa@hotmail.com

Indian mackerel (*Rastrelliger kanagurta*) is widely distributed along the Indian as well as West Pacific Oceans. It contributes about 5-8% to the total Indian marine landings. Indian mackerel has a high commercial value and contributes 18% to the pelagic fish landings in the northeastern Arabian Sea of the Maharashtra coast. Studies on biology and stock assessment of Indian mackerel from the Maharashtra coast were carried out from 2014 to 2019. Stock assessment parameters were estimated using Electronic Length Frequency Analysis (ELEFAN) as included in the R package TropfishR. The length-converted catch curve and the length-based yield per recruit model were employed. The catch of Indian mackerel showed wide fluctuation–the average annual catch was 3,544 mt (1961-1989) and 19,311 mt (1990-2019). The historical maximum landings recorded was 38,355 mt (1996). Almost 68% of the mackerel landing was contributed by purse seine, followed by gill nets (17%) and trawl nets (14%). The average contribution of Indian mackerel along the Maharashtra coast before the introduction of purse seine (1960-1989) was 5% of total pelagic landings and rose to 18.1% of total pelagic landings after the introduction of purse seine (1990 to 2019). Indian mackerel having a size range of 10.8-29.6 cm in total length (TL) contributed to the fishery. Size at first maturity and sex ratio was 19.27 cm in TL and 1:0.85 respectively. The growth parameters L_∞, K and t_0 were estimated as 27.07 cm TL, 1.06 yr^{-1} and -0.0130 respectively. The growth performance index (Φ)was estimated as 2.893 and mortality parameters estimates were M= 1.45, Z = 3.02 and F= 1.57. Biological reference points such as relative stock size (B/Bmsy) and exploitation (F/Fmsy) showed that the Indian mackerel stock is healthy, but continuous monitoring of the reference points and management intervention is required to manage the stock in sustainable status.

Keywords: Arabian Sea, bycatch, Indian mackerel, stock assessment, targeted fishery

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Fishery of catfishes along north Tamil Nadu coast

Gomathy, S. and Shoba Joe Kizhakudan*

ICAR–Central Marine Fisheries Research Institute, P.B. No. 1603, Ernakulam North P.O., Kochi – 682 018, Kerala, India

*shoba.joe@icar.gov.in

The fishery of catfishes along north Tamil Nadu coast was studied based on the landings at Chennai, Cuddalore and Puducherry during 2014-2022. A total of 1275 catfish specimens were analyzed for understanding species composition and biology of the important species. Based on morphomeristic analysis and tooth pattern on the roof of the mouth, 6 genera and 18 species were recorded in the landings. Genus *Arius* (58.4% of the landings) dominated the fishery, followed by *Plicofolis* (28.3%), *Netuma* (10.0%), *Plotosus* (2.98%) and *Mystus* (0.31%). Studies were conducted on the biology of *Arius arius, Plicofollis tenuspinis, Netuma thalassina and Plotosus canius.* The size range and weight range of *Arius arius* was 74-400 mm and 216-688 g; 110-430 mm and 81-848 g for *Plicofollis tenuspinis* ; 208-647 mm and 93-2600 g for *Netuma thalassina* ; 292-650 mm and 145-1580 g for *Plotosus canius.* Male: Female ratio was highest in *Plotosus canius* (1:7.5) followed by *Arius arius* (1: 4.5), *Plicofollis tenuspinis* (1:2.5) and *Netuma thalassina* (1:0.7). Maximum proportion of mature females were noticed in *Arius arius* (45.4%). Indeterminate population was high (76.7%) in *Netuma thalassina* and immature females (77%) were more in *Plotosus canius.* The number of eggs varied for each species–*Arius arius* (20-40), *Plicofollis tenuspinis* (40-56) and *Netuma thalassina* (66-79). Oral gestation was exhibited by male fish in *Arius arius* (10-15 newly hatched larvae in the size range of 23-26 mm in the mouth cavity) and *Plicofollis tenuspinis* (38-40 eggs with heavy yolks in the mouth cavity). Gut content analysis indicated that the major prey were prawns, green mussel spats, clupeids, ribbonfish, crabs and *Acetes* in the case of *Arius arius*; *Acetes*, prawns, gastropod shells, *Pomadasys* spp., *Bregmoceros* spp., silverbellies and cardinal fishes in *Plicofollis tenuspinis*; operculum of turbinids, cowries, gastropod shells, gastropod foot, snails, squid, octopus, prawns, crablets, *Thryssa* spp., *Stolephorus* spp., silverbellies and *Bregmoceros* spp. in *Netuma thalassina.* while prawns and green mussel spat were prominent in the gut of *Plotosus canius*.

Keywords: *Arius arius, Plicofollis tenuspinis*, *Plotosus canius, Netuma thalassina*, tooth pattern, oral gestation

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Present status of elasmobranch fishery, conservation and management in Odisha

Swatipriyanka Sen Dash*, Gyanaranjan Dash, Rajesh Kumar Pradhan, Madhumita Das, Menaka Das, Biswajit Dash and Sujitha Thomas

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* swatipriyank1a@gmail.com

A total of 59 species of elasmobranchs (sharks, rays, skates, guitar fishes and saw fishes) were confirmed to be present along the Odisha coast during 2021-2023. The elasmobranch catch recorded as 2308 t during 2022 and the landings showed a decrease by 37.58% than the previous year. The gear-wise landings showed that trawl was the major contributor (83.55 %) followed by outboard gillnets (4.71 %) and other gears (11.74%) including small-scale fisheries. Among the elasmobranch resources, rays (65.79%) were the dominant group followed by sharks (33.92%) and guitarfishes (0.27%). *Scoliodon laticaudus* (44.14%), *Gymnura poecilura* (37.17%) and *Rhinobatos lionotus* (75.68 %) were the dominant species landed in sharks, rays and guitarfishes. Landed elasmobranchs were utilized fully as there is a good domestic and international market for the meat. Primarily, nine types of gears were identified to be operated to catch sharks and rays in the small-scale fisheries based on local ecological knowledge. The elasmobranch fishery reached a peak during the winter months and December to March was found as the major breeding season for sharks and rays. Currently, at management level, state fisheries and state forest department have good compliance level in implementing closed seasons, Wildlife Protection Act, marine protected waters and fin attached policy applicable to elasmobranchs. Further management measures suggested include introduction of conservation incentives for release of marine wild life protected species and also to regularize the use of bycatch reduction devices along the shark nursery grounds. The implementation of minimum legal size for capture may also be implemented. As sharks are both ecologically and economically important and display k-selected life history traits, they have to be managed separately involving local fishermen following participatory based management approach. Concurrently, research should focus on exhaustive assessment of small-scale fisheries and in identifying the critical habitats for conservation of the endangered species. The research should also focus on the estuarine and freshwater chondrichthyans such as bull shark, giant freshwater whiprays, largetooth saw fish, Ganges shark and cowtail stingrays which are known to be present in the estuarine and riverine system of Odisha for their conservation as they are vulnerable by nature of their biology and habitat requirement.

Keywords: chondrichthyans, conservation, east coast, local ecological knowledge, vulnerable

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

An integrative approach of fish identification for fishery management of Sarasakumri, a small river of Sundarban mangroves

Diamond Rajakumar Tenali*, Rajeev Kumar Singh, Rajesh Kumar and Mahender Singh

ICAR–National Bureau of Fish Genetic Resources Lucknow–226 002, Uttar Pradesh, India

*diamondraj.t@gmail.com

The Sundarban mangrove, which occupies 4260 square kilometers, is unique among the estuary zones globally. This mangrove ecosystem comprises a dense forest and its surroundings, which include streams, rivulets, shallow channels, and extensive mudflats. Several smaller river courses, which are unexplored/underexplored, are the potential source of fish diversity. The documentation of ichthyofauna of such rivers/rivulets provides an opportunity to enrich the global diversity database. A small river, Sarasakumri, was explored, and fish diversity was documented and barcoded. About 50 specimens representing 17 species belonging to 11 families were investigated using morphology and molecular approaches. Two specimens could not be reached up to species level using morpho-meristics. The tissue samples of these specimens were subjected to barcode sequence analysis. The genetic distance from congeners and phylogenetic tree recovered this species as distinct, new to science. Barcode gap and other species delimitation approaches confirmed this as a new description. Further, the barcode collection list of all available fish species in Sarasakumri was created, which will be helpful for researchers going for future explorations of Sundarban. The study demonstrates the potential of integrative taxonomy in the conservation and management of fishery resources.

Keywords: Fish taxonomy, integrated approach, molecular analysis, Sarasakumri, Sundarban

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

A taxonomic study on ornamental fishes under Cypriniformes from the Tansa River, Maharashtra

Taniya Chandra*, Anisha, M. U., Vishal, M., Dayal Devadas, Shobha Rawat, Karankumar Ramteke, Monalisha Devi S. and Jaiswar, A. K.

ICAR- Central Institute of Fisheries Education, Seven Bunglows, Versova, Andheri West, Mumbai, 400061, Maharashtra, India

*taniyachandra2000@gamil.com, 7001508340

A study was conducted on the diversity of cypriniformes in the Tansa River, Maharashtra. A total of 15 species under the family Cobitidae, Nemacheilidae, Cyprinidae, and Danionidae, belonging to 12 genera, were collected from various sites of the river stretches. A comparative study was conducted on morphology, morphometrics, meristics, hard part (otolith), and DNA barcoding. A total of 17 morphometric data were measured for six species *Schistura savona, Garra mullya, Puntius mahecola, Rasbora daniconius, Amblypharyngodon mola, Devario resupinates,* and subjected to statistical analysis. Linear Discriminant Analysis (LDA) was performed to effectively discriminate species with categorical attributes based on their significant body proportions. LDA biplot was obtained, which shows interspecific discrimination, where LD1 (63%) and LD2 (20%) contribute to the highest species discrimination. Otoliths were obtained from 13 species of Cyprinidae to see the morphological differences of otolith among the species. It has been observed that the linear otolith asteriscus was the largest among the three pairs of otoliths in the collected species, except loaches. Mitochondrial cytochrome c oxidase subunit I (COI) was amplified to develop species-specific barcodes for six species viz, *P. parrah*, *D. filamentosa*, *S. sarana*, *S. savona*, and *L. thermalis* and *P. amphibius*. The average genetic distance between species ranges from 15.5% to 32.3%. A Neighbor-joining tree was constructed to study the evolutionary history of the taxa using the Kimura 2 Parameter method. The study also extends the known distribution of the species *Pethia lutea* to the Tansa River. The study suggests a detailed investigation of diversity and a taxonomic study on cypriniformes for conservation and management. The 15 species listed have ornamental potential; however, the fishes were caught mainly for food without knowing the ornamental value of the fishes in the aquarium trade. Thus, the study suggests an awareness of the potential ornamental fishes, which can give more profit to the stakeholders and recommend responsible exploitation of fishes from the Tansa River.

Keywords: Aquarium trade, hard parts, morphology, COI, ornamental freshwater fish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Integrated taxonomic tools for the identification of selected loaches from India

Anisha, M. U.*, Taniya Chandra, Vishal, M., Dayal Devadas, Shobha Rawat, Karankumar Ramteke, Jaiswar, A. K. and Monalisha Devi, S.

ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*anishamu1112@gmail.com

This study investigates the differences in morphometric, molecular, and hard parts among 11 species of loaches of Suborder Cobitoidei collected from various rivers in India. A total of 5 species, namely, *Schistura denisoni, S. savona, Mesonoemacheilus triangularis, Lepidocephalichthys guntea*, and *L. thermalis* collected from Ulhas River, Tansa River, Nambol River, and Vaigai river were subjected to multivariate analysis. Twenty-six morphometric traits and seven meristic characteristics were measured, outliers were removed, and size-corrected data were taken for Linear Discriminant Analysis to determine the morphological variations among the five species. The prominent differentiating proportions among the five species were ratios between head length and standard length and ventral fin length with standard length. In LDA, the first discriminant function contributes 78% variation, while the second discriminant function contributes 11%. Classification accuracy was estimated using LDA, which shows an accuracy of 98.67% to their original groups and an accuracy of 96.45% to their cross-validated groups. Hard parts like otoliths (lapillus), scales (from caudal peduncle), and vertebrae were observed to discriminate among the species. DNA barcodes were generated using COI genes from 4 species under three families and four genera. The average genetic divergence value within species families is 0.2 % and 16.5%, respectively. The neighbor-joining tree is constructed based on genetic divergence value to understand the phylogenetic relationship between the species. This study suggests the need for a detailed understanding of the taxonomy of loaches for conservation and sustainable management.

Keywords: Cobitoidei, loach, morphometric differentiation, COI gene, otolith

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Taxonomic Studies and Phylogenetic Analysis of Genus *Osteobrama* Heckle, 1842 in India

Anjali Pushp*, K. V. Radhakrishnan and Himanshu Priyadarshi

[1] College of Fisheries, Kishanganj, Bihar Animal Sciences University, Patna, Bihar-855107

*anjalipushp8@gmail.com

Genus *Osteobrama* (family: Cyprinidae) includes small to medium-sized fishes distributed in India, Pakistan, Bangladesh, Myanmar, and China. In India, it is found in the northeastern and Peninsular regions only. The present study involves taxonomic validation and elucidation of phylogenetic relationships of 7 *Osteobrama* species distributed within India. The results of meristic analyses showed significant level variation between *O. cunma, O. cotio, O. belangeri, O. cotio peninsularis, O. neilli, O. bakeri, and O. vigorsii*, mainly for counts of anal fin rays, lateral line scales and in the presence/absence of barbells. The Principal Component Analysis (PCA) conducted on twenty- six morphometric ratios showed a varied pattern of clustering between the species. The results of molecular studies showed that out of 647 positions analyzed in the COI dataset for various species, 181 positions were variable (27.9%). The genetic distance between different *Osteobrama* species studied ranged from 0.5% (between *O. cotio* and *O. cotio peninsularis)* to 16.8% (between *O. bakeri* and *O. belangeri*) for COI sequences. The highest genetic distance between *O. bakeri* and *O. belangeri* could be explained by their highest geographical separation. The results of morphological and molecular taxonomy showed that *O. cotio* and *O. cotio peninsularis* could be differentiated based on morphology; they are genetically similar. *Osteobrama belangeri* showed high interspecies K2P distance from all other *Osteobrama* species, indicating that it diverged quite early from other *Osteobrama* species. The maximum-likelihood (ML) phylogenetic tree constructed using COI sequences showed that *O. belangeri* is genetically distinct from other *Osteobrama* species, corroborating with the pattern of evolution and dispersion of other Cyprinid fish species in India.

Keywords: COI, Genetic distance, *Osteobrama*, PCA, Phylogenetic tree

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Mitochondrial-based molecular signatures for cone snails from Kollam and Thoothukudi waters

Karthika Raju, Kathirvelpandian, A.* and Sarkar, U. K.

ICAR-National Bureau of Fish Genetic Resources, Centre for PAGR, ICAR-CMFRI Campus, Kochi-682 018, Kerala, India

*kathirars@gmail.com

The cone snails are predatory carnivores gastropods coming under the conidae family of Mollusca. They are highly venomous, using their venom through a hydraulically propelled hollow radular tooth to hunt and stun the prey. According to the IUCN Red List, 632 different species of Conus are coming under the Threatened species list. There is a big concern in the taxonomical identifications conducted so far, and the integrated taxonomic studies reveal the presence of cryptic species, identifying morphotype variations and the occurrence of adaptive radiations to some extent. The speciation in cone snails depends on the feeding habit and variation in the conopeptides present in the organism. Hence, the molecular signatures developed for species identification of cone snails will be helpful for accurate identification of cone snails. Sampling was carried out in Shakthikulangara, Kollam, Kayalpattinam and Thoothukudi. The present study documented five species from Shakthikulangara, Kollam (*C. indomaris, C. bayani, C. inscriptus, C. clerii, C. monile*), and six species from Kayalpattinam, Thoothukudi (*C. litteratus, C. betulinus, C. virgo, C. araneosus, C. textile, C. striatus*). Taxonomical identification was carried out using morphological parameters and confirmed with molecular identification by employing the mitochondrial CO1 gene. The species-specific molecular signatures developed in the study will be helpful for accurate identification and understanding of the evolutionary status of the cone snails from the study area.

Keywords: Cone snails, evolutionary status, mitochondrial COI, species identification

Integrative taxonomy of needlefishes (Beloniformes: Belonidae) from Indian waters

Subal Kumar Roul[1]*, Sandhya Sukumaran[1], Abdussamad, E. M.[1] and Jaiswar, A. K.[2]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*subalroul@gmail.com

The integrative taxonomic approach is the most authentic and informative tool for delineating novel species and revitalizing taxonomy when integrating with different perspectives, e.g., morphology, anatomy, and DNA sequences. This study aimed to resolve the taxonomic ambiguity among the needlefish species (family Belonidae), assess the relationships among the species based on morphological, anatomical, and molecular tools, and develop a field-level species identification key for Indian belonids. Morphometric measurements and meristic characters were recorded from 273 specimens of seven species under four genera collected between 2015 and 2018 from various locations in Indian waters, including the Andaman Islands. The specimens were identified as *Ablennes hians*, *Tylosurus crocodilus*, *T. acus melanotus*, *Strongylura strongylura*, *S. leiura*, *S. incisa*, and *Xenentodon cancila* based on morphological, anatomical, and molecular tools. The study reported the new distributional record of reef needlefish, *S. Incisa*, from the Andaman Islands and Tamil Nadu, extending its known geographical range in the eastern Indian Ocean, whereas *A. hians* was recorded for the first time from the northeastern coast of India. The molecular identification and genetic interrelationships of needlefish species based on mitochondrial COI nucleotide sequences (DNA barcodes) are reported for the first time from Indian waters. The partial sequences analysis of the COI gene of 21 specimens revealed that the seven species are genetically discrete from each other and clustered into three groups without any haplotypes sharing or overlapping. The analysis also provides sufficient phylogenetic information and evolutionary relationships to distinguish the seven needlefish species. The Neighbour Joining (NJ) phylogenetic tree indicated the most recent divergence of genus *Ablennes* and *Tylosurus* than other genera. Based on the present study and the available literature, an updated key of the members of the family Belonidae from the Indian waters is provided.

Keywords: Belonidae, COI, India, morphology, needlefish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Mitochondrial marker-based integrated taxonomy reveals distributional range extension of *Gymnocranius obesus* beyond the Coral Triangle to the Indian Ocean.

Badarul Sijad*, Najmudeen, T. M. and Toji Thomas

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sijad7@gmail.com

Obese large eye bream, *Gymnocranius obesus* has been reported in the Western Pacific Ocean only, predominantly in coral triangle. In this study, we report the first record of *G. obesus* from the Indian Ocean. Three specimens of *G. obesus* were collected from Port Blair of Andaman and Nicobar Islands in the Indian Ocean. A morphometric analysis was conducted to confirm the occurrence of *G. obesus* in the Indian Ocean. Large protruding eyes with eye diameter almost equal to inter orbital width; body with 5 to 8 dark transverse bars; prominent black spot at pectoral fin origin; caudal fin moderately forked and fins with yellowish margin are specific distinct characteristics of *G. obesus*, which helped to confirm its existence in the Indian Ocean. In addition, CO1-based molecular analysis was conducted. Phylogenetic analysis confirmed the presence of *G. obesus* in the Indian Ocean. The discovery of *G. obesus* is significant because it expands the species known range. This study is the first step in understanding the distribution and ecology of *G. obesus* in the Indian Ocean.

Keywords: CO1 DNA, first record, *Gymnocranius obesus,* Indian Ocean

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Statolith-based age and growth of the Bobtail squid *Euprymna hyllebergi* Nateewathana, 1997 (Cephalopod: Sepiolidae) from the southeastern Arabian Sea

Sajikumar, K. K.*, Geetha Sasikumar, Laxmilatha, P., Venkatesan, V., Vidya, R., Jestin Joy, K. M. and Mohamed, K. S.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*kksajikumar@yahoo.co.in

Bobtail squids of the family Sepiolidae, which includes the genus *Euprymna*, are closely related to, but distinct from the true squids (Teuthoidea). Due to their small size and ease of captive rearing, *Euprymna* species have emerged as model organisms for a range of biological studies. Among these is the Thai Bobtail squid *Euprymna hyllebergi* Nateewathana, 1997, which is distributed in the nearshore waters of the Indo-Pacific seas. Despite their importance, studies on age and growth using hard parts are limited. This study is the first attempt to use statolith increments to age *E. hyllebergi* collected from the southeastern Arabian Sea. Statoliths from 80 individuals (males=24 and females=56) with dorsal mantle length (DML) 8–50 mm and total weight (TW) 0.45–37g were extracted and processed with a statolith aging technique. The statolith ranged in size from 328 to 836 µm. The statolith morphology in *E. hyllebergi* is characterized by its short rostrum, which is covered by numerous tiny knobs. The lateral dome is well-developed. Growth rings are most clearly seen in the lateral region near the rostrum. Assuming a daily deposition of increments, growth was rapid and adult sizes were attained in around two months. The age of the individuals varied between 25 days (DML=8 mm) and 91 days (DML=37 mm) for males. In females, it ranged from 33 days (DML=10 mm) to 92 days (DML=44 mm). The growth rate ranged from 0.20-0.49 mm/day for males and 0.23-0.59 mm/day for females. Growth in length (DML) was described as an exponential function ($DML=17.921\ e^{0.0444xAge}$; $r^2=0.796$) for males and a Power function ($DML=7.0733AGE^{0.6394}$; $r^2=0.828$) for females. Growth in weight (TW) was best described by a power function for both sexes ($TW=38.396AGE^{0.2093}$ (females); $TW=31.626AGE^{0.3011}$ (males). The present investigation provides valuable information on the age and growth of *E. hyllebergi*, a small benthic Sepiolidae squid inhabiting the tropical Arabian Sea, showcasing its short lifespan.

Keywords: Age and growth, bobtail squid, growth rate, short lifespan, statolith

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Length-weight relationship and morphometrics of portunid crab *Monomia gladiator* (Fabricius, 1798) from southeastern Arabian sea

Jose Josileen*, Retheesh, T., Vijayan, M. T., Sunil, K. T. S., Najmudeen, T. M. and Dineshbabu, A. P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*drjoslin@gmail.com

Portunid crab *Monomia gladiator* appears in trawl landings as stray catches along the coastal areas of Kerala. However, in recent times occasional good landings of the species were recorded from trawlers operated from off – Cochin and samples were collected and morphometric & length-weight studies were undertaken. Though the crab is edible, in Kerala, presently consumer preference is less for the species, unlike in its other available coastal areas. The size of the male crabs varied between 51–101 mm (average 80.0 mm) carapace width (CW); 33-54 mm (average 44.39 ± 5.02 mm) carapace length (CL) and total weight between (TW) 13–101g (average 53.34 g). In females, CW ranged between 49–84 mm (average - 68.33 mm), CL ranged between 30 – 46 mm (average 38.5 ± 3.41 mm), and TW between 14–68g (average 33.42 g). CW/ CL ratio in males and females ranged between 1.55 – 1.98 (average -1.80 ± 0.06) and 1.62 -1.95 (average - 1.77 ± 0.06) respectively. The 'b' values for carapace width–weight in males, females and pooled were 2.9522, 2.7665 and 2.891 respectively and for carapace length–weight in males, females and pooled were 3.178, 3.06, and 3.162 respectively. The results show considerable deviation from the isometric growth pattern in both sexes except for CW-TW relationships in males. An analysis of covariance indicated that there is no significant difference between sexes with respect to the carapace width/ length-weight relationship. The interrelationships between various morphometric characters, *viz*., Carapace Width (CW) and Length (CL) and Chelar Propodus Length (CPL) and Height (CPH) in males, as well as Carapace Width and length and Abdominal Width (AW) and Length (AL) in females, were estimated. These relationships were positive and highly significant in both sexes. The results and inferences of this study will serve as firsthand information and will be beneficial for studying the species from different regions as well as for their comparison.

Keywords: Carapace width/ length–weight relationships, carapace width/ length ratio, *Monomia gladiator*, morphometric relationships, Southeastern Arabian Sea

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Reproductive biology of green tiger shrimp *Penaeus semisulcatus* (De Haan,1844) in Palk Bay ecosystem, southern peninsular India

Rajkumar Muthusamy*[1,2], Lakshmi Pillai, S.[1], Saravanan, R.[1], Thirumalaiselvan, S.[1], Remya, L.[1] and Shanmuganathan, K.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Kerala University of Fisheries and Ocean Studies, College of Fisheries, Panangad, Cochin – 682 506, Kerala, India

* mrajkumarcmfri@gmail.com

Penaeus semisulcatus forms a single species fishery of significant importance along Palk Bay southeast coast of India. Reproductive biology of the species was studied from the region, as parameters like ovary development, maturity stages, and spawning season is necessary for better management of the resources. The male testis of *P. semisulcatus* has eight testicular lobes with oval-shaped ampoules. Chromatin oocytes in immature females, cortical oocytes in mature females, and atreatic oocytes in mature females were observed. The dark green (or greenish brown) ovary with elongated cortical bodies in the periphery of the ova is fully mature. The spawning season is most active in the post monsoon and monsoon, with a minor peak in the pre-monsoon. The Lm_{50} determined was extremely low when compared to other studies conducted in the species, which is attributed to fishing pressure. Males mature earlier than females, and they do not have specific seasons or cyclic changes. The female-to-male ratio was not equal, and females were always found in greater numbers. Beyond 3 Nautical Miles (NM), the entire Palk Bay is designated as a spawning ground, while up to 3 NM the area is designated as a nursery ground. This species can be harvested sustainably by imposing a seasonal ban on shrimp fishing during the peak breeding season, regardless of gear.

Keywords: Breeding season, crustacean, ovary, seasonal ban, spawning ground

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Spawning seasons of commercially important demersal finfishes along the south-east coast of India

Remya, L.*, Muktha, M., Shoba Joe Kizhakudan, Gomathy, S., Yousuf, K. S. S. M., Madhumita Das, Narayana Rao, K., Nageswara Rao, T., Rajendran, U., Prakash, M. and Manojkumar, M.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* lremya9@gmail.com

Information on spawning season of fish are key inputs for understanding the vulnerability of fish to external perturbations like climate change, fishing etc., which in turn are critical for framing effective fisheries management tools for these species. Spawning season has been defined as the months in which the number of spawning capable fish was dominant in field samples. Usually spawning studies are carried out in tandem with studies on single species biology. Though single species information is important, the results of such studies would prove more effective if carried out for a larger number of species inhabiting an ecosystem. Here we present a meta-analysis of spawning season of demersal finfish species along the south-east coast of India, including the states of Tamil Nadu and Andhra Pradesh. The spawning seasons was analyzed for 46 teleosts *viz*., *Arius arius*, *Plicofollis tenuispinis*, *Osteogeneiosus militaris*, *Photopectoralis bindus*, *Eubleekeria splendens*, *E. jonesi*, *Gazza minuta*, *Secutor insidiator*, *Karalla dussumieri*, *Nuchequula gerreoides*, *Equulites lineolatus*, *Lethrinus nebulosus*, *L. lentjan*, *Parastromateus niger*, *Pampus argenteus*, *Upeneus heemstra*, *U. sundaicus*, *U. taeniopterus*, *U. sulphureus*, *Parupeneus indicus*, *Siganus canaliculatus*, *Otolithes ruber*, *Johnius carutta*, *Nibea maculata*, *Pennahia anea*, *Kathala axillaris*, *Dendrophysa russelii*, *Nemipterus japonicus*, *N. randalli*, *N. bipunctatus*, *N. peronii*, *N. zysron*, *Scolopsis bimaculata*, *Saurida undosquamis*, *S. tumbil*, *S. micropectoralis*, *Trachinocephalus myops*,, *Lutjanus argentimaculatus*, *L. johnii*, *L. quinquelineatus*, *Priacanthus hamrur*, *Psettodes erumei*, *Platycephalus indicus*, *Pomadasys kaakan*, *Drepane longimana*, *D. punctata* and six elasmobranchs *viz*., *Chiloscyllium griseum*, *Gymnura poecilura*, *Rhinobatos lionotus*, *Neotrygon indica*, *Brevitrygon imbricata*, *Iago cf. omanensis*. Of the 52 species, 48 showed high percentages of spawners in more than one month indicating that at least for these species spawning of population happened over the entire year. Seventeen of the 52 species showed highest spawner occurrence during January to March, as well as another set of 17 species during July to September indicating that this could be the period of peak spawning for multiple fish species. Only 4 species showed single peak spawning activity that happened within a month. It has been clearly established by earlier studies that tropical finfish are batch spawners,with multiple stages of eggs found in their ovaries; once a set is released, the next batch of eggs are ready for final maturation and release. Hence the concept of a spawning season for one species is not suitable for tropical finfish which show spawning activity in several months of a year. Instead, defining a spawning season for an ecosystem or marine area might be more suitable for tropical seas.

Keywords: Andhra Pradesh, batch spawners, demersal finfish, multiple species, Tamil Nadu

Comparative ovarian development and spawning behavior in landlocked and migratory female *Tenualosa ilisha*: Insights from a Tropical Shad

Gopinatha Pillai Vaisakh[1]*, Simanku Borah[2], Geetanjali Deshmukhe[3], Ashok Kumar Jaiswar[3], Amiya Kumar Sahoo[4] and Basanta Kumar Das[4]

[1] ICAR-Central Marine Fisheries Research Institute, West Hill P.O., Kozhikode-673 005, Kerala, India
[2] ICAR-Central Inland Fisheries Research Institute Regional Centre, Dispur, Guwahati – 781 006, Assam, India
[3] ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400 061, Maharashtra, India
[4] ICAR-Central Inland Fisheries Research Institute, Barrackpore-700 120, West Bengal, India

*vaisakh.login@gmail.com

Fish display substantial diversity in their reproductive characteristics in response to changes in environmental conditions. Even modest changes in the environment impart a shift in the reproductive behaviour of migratory species like hilsa. Our research was structured to illustrate the ovarian development and spawning behavior of resident hilsa populations in a reservoir ecosystem, as opposed to the migratory hilsa population. Female specimens of *Tenualosa ilisha* from two distinct habitats, namely, the Ukai reservoir (UR) for the landlocked population and the Narmada estuary (NME) for the migratory population, were collected for this study. In the landlocked hilsa population, macroscopic examination revealed four ovarian phases: immature, maturing, spawning capable and regressing. However, in the migratory hilsa population, only two ovarian phases, namely phase-1 and phase-3, were observed during the study. The Gonado-somatic index (GSI) curve for migratory hilsa showed a significant increase in July, peaking in August. In contrast, the landlocked reservoir hilsa exhibited multiple GSI peaks in February, May, and November. In the spawning-capable ovaries of landlocked hilsa, mature and immature ova were not distinctly separated, with a major mode at 0.47 mm. In the migratory population, the ova diameter frequency graph for phase 3 ovaries showed a clear separation between mature and immature ova, with a mode at 0.82 mm for mature ova and another mode at 0.13 mm for immature ova. In this study, we found that reservoir populations tend to have extended spawning seasons, in contrast to migratory populations which typically have a single spawning season. We arrived at this conclusion by analyzing ova diameter frequency and the monthly gonado-somatic index. The histological study of the ovary provided confirmation that asynchronous oocyte development is characteristic of the landlocked hilsa population. In contrast, ovaries of migratory populations capable of spawning exhibited synchronous oocyte development. Consequently, it can be suggested that migratory hilsa from the Narmada estuary tend to have a single short-duration spawning strategy (total spawner), while landlocked reservoir populations imply a fractional spawning strategy of comparatively longer duration (batch spawner). Furthermore, histology studies revealed the presence of post-ovulatory follicles (POF) in phase-3 and phase-4 ovaries of landlocked hilsa, indicating successful spawning. This study helped demonstrate the flexibility in reproductive strategies employed by anadromous hilsa shad under landlocked conditions. Notably, this research represents the first comprehensive investigation of reproductive traits in a landlocked hilsa population, validated through histological observations.

Keywords: Asynchronous ovary, landlocked hilsa, ova diameter, ovarian development, spawning behaviour

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Assessment of different maturity stages and milt characteristics of Goldlined seabream, *Rhabdosargus sarba*

Ezhil, P.*, Senthil Murugan, T.**, Dani Thomas, Aritra Bera, Raymond J. A., Thiagarajan, G. and Kailasam, M.

ICAR- Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, Chennai – 600 028, Tamil Nadu, India

*Presenting Author

**Corresponding Author: senthil.murugan@icar.gov.in

Goldlined seabream (*Rhabdosargus sarba*), is a promising finfish species for brackishwater aquaculture due to its euryhaline nature and consumer demand. Farming of this species was not established on a commercial scale due to non-availability of seed. Regular seed availability from the hatchery production will help to popularize farming of *R. sarba* among the farmers. Prior studies on the reproductive biology of this species would help to take up captive breeding and seed production of Goldlined seabream. Therefore, this study aims to assess the reproductive biology of the wild-caught *R. sarba* by analyzing different reproductive parameters such as gonadosomatic index (GSI) and sperm quality from August 2021 to December 2022. GSI values indicated that summer months showed the lowest values and the highest during the monsoon months. Male GSI indicated the lowest value during September (0.088%), depicted an increasing trend from October and reached the highest value during December (0.81%). In the case of females, the minimum and maximum GSI values were observed during March (0.29%) and December (2.94%) respectively. The results have indicated the presence of both mature males and female fishes dominantly during Northeast monsoon months (November and December), with the peak during December. Milt characteristics were analysed from November to January because the oozing males were available only during this period. Parameters such as motility percentage, motility duration, osmolality, pH, and sperm count were estimated from milt during these months. Sperm motility percentage varied between 80 and 98% with the peak during November. Sperm count ranged from $1.7x10^7$-$5.4x10^7$ cells ml^{-1} and the maximum number of sperm cells was also noticed during December and November ($5.4x10^7$ cells ml^{-1}). Sperm motility period ranged between 1.60-4.60 minutes, with the least during November (1.60 minutes) and the highest during December (4.60 minutes). The osmolality was recorded with a maximum of 581 mOsm kg^{-1} in December and a minimum of 459 mOsm kg^{-1} in November. It can be stated from the results of the present study that mature males and females of *R. sargus* together are available during November and December months. However, mature oozing males were present even up to January and thereby indicated a short breeding season of this species along the Chennai coast, Tamil Nadu, India.

Keywords: Milt, motility, osmolality, reproduction, *Rhabdosargus sarba*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Gonadal assessment of Fanged Seabream, *Sparidentex jamalensis*: a potential aquaculture candidate for Indian waters

Shilta, M. T.*, Vinod, K., Suresh Babu, P. P., Ramya Abhijith, Imelda, J. and Shoji, J.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* shiltathomas@gmail.com

Gonadal assessment of Fanged seabream, *Sparidentex jamalensis*, one of the potential aquaculture candidates from Indian waters, was studied by collecting 360 fishes from the Korapuzha estuary, Calicut, Kerala using cast net during January to December 2022. External morphology of the gonads reveals the presence of ovo-testis in *S. jamalensis.* The gonad is classified into following ovotestes types based on the morphological and histological studies: (a) active male (slight abdominal pressure release semen from the testicular region), (b) inactive male (no free running of semen from the testicular region), (c) active female (a large number of vitellogenic oocytes with some previtellogenic oocytes in the ovarian region), (d) inactive female (a large number of oocytes of chromatin nucleolar and perinucleolar oocytes in the ovarian region), (e) transitional (testicular and ovarian lobes of similar size) and (f) undifferentiated (thread like ovo-testis containing an equal portion of testis and ovary). Histological observation of transitional gonads showed signs of degeneration in the testicular lobe, proliferation of connective tissue and empty sperm ducts indicating protandrous hermaphroditism in *S. jamalensis*. Ovary and testis was classified into five maturity stages namely, resting, maturing, mature, running and spent. Gonadal development in *S. jamalensis* indicates the spawning phase from September to March with peak during December. Adult *S. jamalensis* were available throughout the year in the estuaries, whereas juveniles were observed during the November-February months. The simultaneous availability of running males and females from September to March indicates the opportunity for the development of captive breeding and seed production technology for this important commercial food fish during this season. At present, India is looking for potential native food fishes for mariculture development and *S. jamalensis* is considered as one of the priority species due to its high market demand. Understanding the reproductive biology of S. *jamalensis* is therefore important in developing standardized protocol for their broodstock development and the biological information derived from the present study will be a benchmark for standardizing commercial mariculture activities of this species.

Keywords: Gonadal development, protandrous hermaphroditism, *Sparidentex jamalensis*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Length-weight relationship and reproductive biology of *Sillago malabarica* from the Malabar region, India

Mahesh, V.[1]*, Asokan, P. K.[1], Kalavathi, N. R.[2], Najmudeen, T. M.[1], Vijisha, M[1]. and Gopalan, P. V.[1]

[1] ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Department of Fisheries Resource Management, College of Fisheries, Mangalore, Karnataka, India

*mahesh.v@icar.gov.in

Ladyfish or sand whitings (*Sillago* spp.) are valuable fishes dwelling in coastal and brackish waters. The fish is highly susceptible to unregulated exploitation due to its high consumer and market demand. Hence setting a minimum legal size (MLS) is an essential prerequisite to propose eco-friendly rational exploitation measures for the resource. In this context, the length-weight relationship and reproductive biology of *Sillago malabarica* was studied by examining 1,255 individuals collected from the estuarine and coastal water fishery of the Malabar region of Kerala during 2021-2022. The length and weight of the sampled individuals varied between 9-32 cm and 7.5-285 g, respectively. Length-weight relationship indicated a negative allometric (b = 2.854) growth. The size at first maturity of *Sillago malabarica* was estimated at 14.1 cm and 14.5 cm total length for males and females respectively. The overall sex ratio (M: F) of 1:0.75 showed dominance of males in the population. Significant numbers of mature females observed from August to April indicated that *S. malabarica* has a prolonged spawning season. Monthly variations in gonado-somatic index and monthly observation of gonadal maturity proportions revealed that the species is a batch spawner that breed from August to April with peak spawning during August to December.

Keywords: Length-weight, maturity, sex ratio, *Sillago malabarica*, spawning

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Phenology of the *Indian mackerel Rastrelliger kanagurta* (Cuvier, 1816) from the northern Kerala coast

Mahesh, V.[1]*, Asokan, P. K.[1], Vinod, K.[1], Kalavathi, N. R.[2], Vijisha, M.[1] and Gopalan, P. V.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Department of Fisheries Resource Management, College of Fisheries, Mangalore, Karnataka, India

* mahesh.v@icar.gov.in

The Indian mackerel, *Rastrelliger kanagurta* is one of the most important pelagic fish, contributing significantly to the national food basket as well as to the nutritional security of coastal people. Though the species is distributed all along the Indian coast, and exploited by a range of gears, the fishery is predominant between Quilon and Ratnagiri (south-west coast). Management of the fishery, especially in this region, is imperative to ensure sustainable fishing practices. Some of the management measures suggested and practiced is harvesting above the fixed Minimum Legal Size (MLS), minimum exploitation during peak breeding season and controlled use of certain gears that target mackerel during the peak breeding season. The basic biological parameters such as mean length in the fishery, size at maturity and peak spawning season are affected by changing climate, excessive fishing pressure, adaptive behaviour of the fish to such fishery and non-fishery related parameters. Therefore, regular monitoring of the fishery and biology, especially length distribution, maturation and spawning activity are imperative in reporting any changes from the normal pattern, to consider revision of the minimum legal size (MLS) for capture and rational exploitation of resource. Length-weight relationship and reproductive biology of *R. kanagurta* were studied by examining 3,680 samples collected from the commercial fish landings along the northern Kerala (Malabar region) coast during 2021 to 2022. The sampled individuals exhibited total length and weight ranges between 8-29cm and 3-300 g, respectively. The exponent value (b = 3.218) indicated that the growth followed a positive allometric pattern. The overall sex ratio (M:F) of 1:1.2 was skewed towards females. The length at first sexual maturity (L_{m50}) was estimated to be 17 cm and 17.5 cm total length for males and females respectively. Dominance of mature females throughout the year except April indicate that *R. kanagurta* has prolonged spawning season. Monthly distribution of gonadal maturity stages and monthly disparity in the Gonado-somatic index revealed that batch spawning occurred round the year with a peak in May-June. Fecundity of female mackerel having a total length ranging from 20 to 25 cm ranged from 75,040 to 1,14,090 eggs with an average of 86,760 eggs. The study confirmed that the length at maturity and breeding pattern of the Indian mackerel along the south-west coast has remained the same during the last decade.

Keywords: Length-weight, maturity, *Rastrelliger kanagurta*, sex ratio, spawning

Biology of the widenose guitarfish, *Glaucostegus obtusus* (Müller & Henle, 1841) (Rhinopristiformes: Glaucostegidae), from the eastern Arabian Sea

Purushottama, G. B.*, Sujitha Thomas and Shoba Joe Kizhakudan

ICAR–Central Marine Fisheries Research Institute, P. O. Box 1603, Ernakulam North, P. O., Kochi–682 018, Kerala, India.

*puru44@gmail.com

Glaucostegus obtusus, a benthic inshore batoid, lacks crucial life history information from Indian waters. This study investigates the reproductive biology of *G. obtusus* specimens collected as bycatch by shrimp trawl and gillnets operating at depths of 2–65 m. Data was recorded between 2016 and 2022 in the eastern Arabian Sea off Karnataka, India's southwest coast. This study provides insights into the reproductive characteristics of *G. obtusus* in this region. A total of 331 individuals, from 22.0 to 109.2 cm total length (L_T), 0.023 to 5.7 kg total mass (M_T) were used for the study. The length –weight relationship (LWR) of females and males did not differ significantly; therefore, a common equation was derived as $M_T = 0.000392\ L_T^{3.506478}$ (r^2=0.991). The length-at-maturity (L_{T50}) for females and males were estimated at 60.4 and 50.4 cm L_T, respectively. *G. obtusus* has two functional ovaries, and the ovarian cycle and gestation run concurrently. Pregnant females were observed in all months, which suggests a non-seasonal reproductive cycle for this species. The number of embryos ranged from 2 to 14 and size at birth was estimated to range between 22.0 and 25.0 cm L_T. Although the widenose guitarfish breeds throughout year, October–December was identified as the peak breeding season. A second breeding peak was observed in May–July. The highest abundance of widenose guitarfish was recorded in October–December (post monsoon). Overall sex distribution was found to be equal. Analysis of stomach contents revealed that *G. obtusus* feeds on a variety of prey including crustaceans (82% index of relative importance, I_{RI}) and teleosts (18% I_{RI}). The landing pattern of *G. obtusus* during the study revealed distinct segregation based on sex, and size. Understanding the relevance of Important Shark and Ray areas (ISRA), mapping of distribution of *G. obtusus* bycatch in fishing grounds was carried out that will aid in spatial marine planning to implement the conservation measures, such as 'no-fishing zones' in breeding, feeding and nursery habitats. The species is categorized in the IUCN Red List as "data deficient" and the present study will provide baseline data for fisheries management, conservation and population status assessment of the widenose guitarfish in eastern Arabian Sea.

Keywords: Arabian Sea, diet, guitarfish, length -weight relationship, maturity, marine spatial planning

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Food and feeding ecology of green tiger shrimp *Penaeus semisulcatus* (De Haan,1844) in Palk Bay, southeastern coast of India

Rajkumar Muthusamy*[1,2], Lakshmi Pillai, S.[1], Thirumalaiselvan, S.[1], Saravanan, R.[1], Remya, L.[1] and Shanmuganathan, K.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]KUFOS, College of Fisheries, Panangad, Cochin, India

* mrajkumarcmfri@gmail.com

The green tiger shrimp, *Penaeus semisulcatus*, is one of the important shrimp species that forms a unique fishery in Palk Bay, southeast coast of India. The food and feeding biology of this important species was studied four decades ago. In order to update existing information, the diet preferences of the *P. semisulcatus* was studied with respect to sex, season, gonad maturity, and size during 2016-2022. All the analyses were performed in accordance with sex, season, gonadal stages, and size. The species was found to prey on diversified components, and mollusc remnants were among the most common food items found in females, followed by crustacean remnants, whereas crustacean remnants were the most common food items in males, followed by mollusc remnants. In females, there was no significant difference in the gastrosomatic index and gonadal maturity stages between seasons, but there was a significant difference between size groups. Males showed no significant differences between seasons, gonadal maturity, and size groups. Females were more active feeders than males, and the difference was seen across the size groups. Larger groups fed more actively than smaller groups. The feeding was more active in the post-monsoon and summer monsoon seasons. This species dominates the ecosystem among the shrimps, due to its carnivorous behaviour, which helps it to sustain itself in the environment. These observations provide fundamental information on the feeding pattern of green tiger shrimp, which is helpful in developing suitable strategies for future management of these resources in the Palk Bay region.

Keywords: Crustacean, fishery, food items, gastrosomatic index, management, monsoon

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Studies on ecomorphology of some food fishes

Rekha J. Nair*, Pooja Jose, Vishnupriya, K. M., Sangeetha, A. T., Pakkirimuthu, S., Abbas, A. Mohammed, Ratheesh. T. B. and Abdusamad, E. M.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*rekhacmfri@gmail.com

Studies on the diets of species and eating habits in their natural environments offer important insights into how interactions between organisms and their surroundings affect the functioning and management of the ecosystem. The interaction of organisms and how species acquire and share resources with one another can be used to understand how communities are organised. Ecomorphology thus forms an integral part of comparative biology. Ecomorphological studies also seek to comprehend how organisms respond across individuals, populations, and species to the environment characteristics. The functional value of phenotypic features can be better understood by doing research on intraspecific variance in functional morphological adaptations to various settings. Studies to provide novel information on the ecomorphological aspects of 15 species from 11 families using several morphological measurements and gut content analysis were attempted. The species were *Sphyraena putnamae*, *Caranx hippos*, *Saurida tumbil*, *Nemipterus japonicus*, *Nemipterus randalli*, *Otolithes ruber*, *Otolithes cuvieri*, *Sardinella longiceps*, *Rastrelliger kanagurta*, *Gerres filamentosus*, *Nibea maculata*, *Daysciaena albida*, *Epinephelus diacanthus*, *Muraenesox bagio* and *Lactarius lactarius*. The mouth, teeth, gill raker pattern, digestive tract were examined and measurements taken. Recursive Partition Method was used to classify the feeding behavior. The results showed that, the highest average length of the first gill arch (mm) is recorded in carnivore and it gradually decreased in planktivores. The results showed that the maximum average number of the anterior gill rakers, in relation to the different feeding habits, is recorded in planktivore fish; which clearly decreased in carnivore and piscivore fishes. The intestine length (IL) was considered as the main parameter in classification. The information generated will contribute to the understanding of the relationships between morphology of the species and their ecology and hence development of future management and conservation practices.

Keywords: ecosystem, feeding, morphology, phenotype

Length-weight relationship and the feeding biology of fanged seabream, *Sparidentex jamalensis* from Korapuzha estuary, Calicut, Kerala, India

Shilta, M. T*., Vinod, K., Suresh Babu, P. P., Ramya Abhijith, Imelda, J., Shoji, J. and Anusree, P. C.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*shiltathomas@gmail.com

Length-weight relationship and the feeding biology of fanged seabream, *Sparidentex jamalensis* was investigated from 360 specimens collected from estuarine waters of Calicut, southwest coast of India. The fish collected ranged from 6.7–49.5 cm (mean 21.28 ± 0.57 cm) in total length (TL) and 6.1-2290 g (385.33 ± 1.32 g) in weight. Length-weight relationship for male, female and total sample of *S. jamalensis* was determined as $W=0.1575L^{3.06}$, $W=0.1422L^{3.17}$ and $W=0.156L^{3.08}$ respectively. The overall mean *b* value (3.08± 0.02) indicated isometric growth pattern (*b*=3) in *S. jamalensis* and the r^2 values ranged from 0.98-0.99. The mean condition factor of 1.8 (*k* = 1.8) obtained in the present study indicated that the fishes were in good condition. Males (15-30 cm TL) dominated smaller length classes whereas females (25-50 cm TL) dominated in classes > 25 cm TL. Small fishes, crab and shrimp were the major food items found in the stomach of *S. jamalensis* which altered according to season and size of fish. The highest value of gastro-somatic index was obtained in June (2.05±1.29) and lowest in December (0.14±0.21). The highest level of vacuity index was observed in December (75.42 ± 3.16) and the lowest in June (3.20 ± 1.28). The results of gastro-somatic index and vacuity index revealed that feeding activity of *S. jamalensis* is reduced during the spawning season. The overall values of relative length of gut ranged between 0.81-0.98 cm with an average of 0.95 ± 0.12 cm showing that *S. jamalensis* is carnivorous. The result of the present study helps in fisheries management of this species in the study area and also would be useful for its captive breeding and culture practices.

Keywords: Fanged seabream, feeding biology, length-weight relationship

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Predator-prey interactions and its implications in the emergence of red-toothed triggerfish *Odonus niger* in the fishery along the coast of Kerala

Najmudeen, T. M.*, Sunil, K. T. S., Pakkrimuthu, S., Sathianandan, T. V., Zacharia, P. U. and Shoba Joe Kizhakudan

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* najmudeentm@yahoo.com

The red-toothed trigger fish *Odonus niger* (Ruppell, 1836) is one of the emerging non-conventional fishery resources available along the coast of India, reported commonly from Wadge Bank and Gulf of Mannar. There was an unusual emergence of this resource along the coast of Kerala in 2019, recording a landing of 62,781 tonnes. The annual average catch of *O. niger* in Kerala was 15,490 tonnes during 2017-2021. About 95% of this resource was caught by multiday trawlers with a catch rate of 3-5 tonnes unit^{-1}. The fishery for *Odonus niger* along the Kerala coast continued throughout the year with high landings of the species noticed during the first and second quarter. All the specimens collected during the period were immature with a length range of 11.0-24.0 cm and a mean length of 15.9 cm. Though it is a low value resource, there was a targeted fishery for *O. niger* in the region by mechanised trawlers mainly to meet the demand for raw materials in fish meal/paste industry. In order to investigate the relation between their occurrence in the coast and its predator prey interactions, the biomass dynamics of its identified predators were studied during the period 2017-2019. For this, the stock status of the major predators as well as *O. niger* along the Kerala coast were modelled using biomass dynamics models by incorporating gear standardization parameters and gear specific catchability coefficients for handling the multigear situation in the fishery. The models fitted separately to each species gave very good fit when examined using observed and model fitted catch series. Results indicate that there is decline in the biomass of its identified predators such as four large pelagics and one shark species during the recent years. The diet of *O. niger* was also analysed, which indicated that it is bottom feeder predating on crabs (51%), squids (22%) and other deep-sea fishes and gastropods. It is reported that predator-prey interactions among size-structured populations may strongly influence factors which affect growth rates and recruitment of prey. Removal of major predators in large quantities would have been one of the reasons for the successful recruitment of *O. niger* along the region. Role of environmental changes as well as possible damage to reef habitats and other influences like changes in current pattern *etc*. need to be investigated further.

Keywords: Biomass dynamics models, diet analysis, *Odonus niger*, predator-prey interaction

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Feeding strategy of Indo-Pacific blue marlin, *Makaira nigricans* Lacepede, 1802 caught from the Eastern Arabian Sea

Surya, S.*, Prathibha, R., Abdussamad, E. M., Asha, T. L., Santhosh, B., Nayak, B. B., Manas, H. M., Jose Kingsley, H., Ambarish, P. Gop and Dispin, D.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*revandasurya@gmail.com

Blue marlin (BUM), *Makaira nigricans* a highly sought-after billfish for both commercial and recreational fisheries worldwide. In this study we analysed the diet of BUM from 292 male and 228 female fish. The Lower Jaw Fork Length of BUM ranged from 112 cm to 305 cm in the samples. The stomachs (n=520) examined were divided into three categories based on the state and amount of food: undigested or partially digested stomachs (53%), digested stomachs (34%), and empty stomachs (13%). A total of 27 fishes, three crabs, three shrimps, two squids, one cuttlefish and one species of mantis shrimp were identified from the stomach contents. Fullness index indicated that 34% of the stomachs were 3/4 Full, 20% were 1/2 Full, 19% were Full, 13% Gorged, 8% were ¼ Full and 6% were Empty. Index of Preponderance (IP), indicated that carangids (39%) were the most prevalent prey group, followed by tunas (28%), mackerel (10%), cephalopods (8%), dolphinfish (6%) and other items. The Index of Relative Importance revealed carangids (42%), followed by tunnies (19%), mackerel (13%), cephalopods (8%), squilla (7%), in the order of importance. Prey abundance similarity and Multidimensional Scaling (MDS) of prey abundance of BUM for different months showed diet is similar ($p>0.05$) for most of the months and 80% overlapping of prey during most of the months. Feeding strategy was determined from the plot of percentages of prey-specific abundance against the frequency of occurrence. The prey specific abundances (PSA) of the prey items were observed within 58-87% and the frequency of occurrence ranged within 0.5-36%. Despite high PSA, all major prey groups exhibited a low frequency of occurrence. The feeding strategy thus estimated from the diet matrix revealed the BUM as a specialist predator that feeds on specific prey species or groups of individuals specialized on selective prey types. The average Levin's Standardized Niche Breadth Index was 0.41. The index ranged from 0.22-0.44 where the highest value of 0.44 which was observed during December and January and the lowest was recorded during November. Feeding was comparatively specialized with a limited niche width in fishes during most of the months and supporting the estimated feeding strategy above. The insights produced by the current study can be useful for future researchers to create accurate ecosystem-based models by enabling them to acquire a comprehensive understanding of its tropho-dynamics along the Eastern Arabian Sea.

Keywords: Blue marlin, Fullness index, IRI, Prey Specific Abundance, specialist feeder

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Insights into feeding habits of little tuna, *Euthynnus affinis* (Cantor 1849) from Visakhapatnam Andhra Pradesh

Manas, H. M.[1]*, Shubhadeep Ghosh[2], Abdussamad, E. M.[1], Mamidi Satishkumar[1] and Indira Divipala[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Division of Fisheries, ICAR, Krishi Anusandhan Bhawan–II, New Delhi–110 012, India

* Manas.HM@icar.gov.in

Understanding the feeding behavior of fish species holds paramount importance in conserving and fostering their aquaculture practices. *Euthynnus affinis*, colloquially known as the 'little tuna,' 'mackerel tuna,' and 'kawakawa,' is a prominent tuna species found along the Indian coast. The species is landed all along the Indian coast from different gears like gillnets and hooks and lines. This study delves into comprehending its dietary patterns and feeding preferences, shedding light on the trophodynamics of this species. Such insights pave the way for policymakers to establish comprehensive management and conservation strategies to ensure the sustainable exploitation of *E. affinis*. Throughout the study, females exhibited dominance. Sampled fish were examined for empty or trace food, as well as stomachs ranging from quarter-full to gorged, reflecting gut content. Among various food items recorded from gut, unidentified and semi-digested fish were having highest %IRI (Index of Relative Importance) value. The comprehensive findings of this study provide intricate insights into the feeding habits of *E. affinis*, as observed in the context of its landing in Visakhapatnam, Andhra Pradesh. This contribution not only adds to our understanding of the species but also serves as a cornerstone for informed decision-making in the realm of conservation and management strategies.

Keywords: Large carnivore, Pelagic fish, Stomach content analysis, Trophic biology, Tuna

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Unveiling population structure of Curmuca barb, *Hypselobarbus curmuca* (Hamilton 1807) in Karnataka rivers

Jeevan, T. M.* and Jaiswar, A. K.

ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*jeevugowda6@gmail.com

Hypselobarbus curmuca (Hamilton 1807), Curmuca barb is a widely distributed fish species among the large sized barbs in Western Ghats, and forms an important fishery locally, contributing to fisher's livelihood. A multivariate statistical approach was employed to unveil the population structure of *H. curmuca* from three rivers, *viz*., Kali (n=46), Sharavathi (n=55) and Tungabhadra (n=69) in Karnataka. Linear measurements were taken manually from each specimen and truss images were also taken for analysing the population structure. Outliers were removed and size dependency was eliminated through size correction. Univariate ANOVA was performed for both truss distances and body proportions, to find the significant variables among the three rivers and those significant variables ($p< 0.001$) were taken for data reduction techniques like Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). PCA was adopted to see the structure of the three fish populations under consideration. PCA of body proportions showed that overall mixing of populations occurred, and in the case of Kali and Sharavathi fishes had more significant mixing. The PC1 and PC2 together could explain 46.2% of variation. First 6 PCs were having eigen value > 1 and could explain 77.75% of cumulative percentage. In the case of truss distance analysis PC1 and PC2 could explain 34.6% and 16.8% of cumulative variances and produced similar result of weak separation among the populations. Populations from Kali and Sharavathi tends to be more mixed than from Tungabhadra. All together 79.63% of cumulative variances were explained by first 6 PCs (eigen value>1). LDA was performed to see the classification accuracy of fitted LDA model in categorising fish populations. LDA of body proportions showed 87.65% classification accuracy with maximum misclassification between Sharavathi and Kali River with 20% of Sharavathi fish misclassified with Kali, and no misclassification observed between Tungabhadra and Sharavathi. After cross validation of the fitted model the accuracy of overall classification was reduced to 85.29%. LDA of truss distances also generated similar results with misclassification between and among rivers. The accuracy was 96.66% and 93.37% before and after cross validation of LDA model fitted to truss distance data frame. Multivariate data reduction tools employed to understand the population structure Curmuca barb revealed that weak separation or no discrete population exists individually in the rivers. Uniform management plans can be recommended for the management of Curmuca barb exploitation in the riverine fishing sector of Karnataka.

Keywords: *Hypselobarbus curmuca*, multivariate analysis, population structure, Western Ghats

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Redefining population structure of migratory hilsa shad in Hooghly-Bhagirathi River using variation in otolith shape

Sajina, A. M.*[1], Suresh, V. V. R.[1,2], Mukherjee, J.[1], Maity, T.[1], Sandhya, K. M.[1,3], Manna, R. K.[1], Banik, S. K.[1] and Samanta, R.[1]

[1]ICAR – Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal
[2]ICAR – Central Marine Fisheries Research Institute, Kochi, Kerala
[3]ICAR – Central Institute of Fisheries Technology, Kochi, Kerala

* sajnaali2000@gmail.com

The Hilsa shad (*Tenualosa ilisha*, Hamilton, 1822) is an anadromous clupeid fish having diverse distribution range including freshwater rivers, brackish water estuaries, coastal waters and seas of the Indo-Pacific region. There is ample research carried out on the population genetic structure of this shad, investigating whether the species belongs to a single stock that uses rivers, brackish water estuaries and marine waters by applying different approaches. Technological development in image analysis techniques has enabled the application of otoliths for a range of purposes including pattern recognition, ageing, and species and stock identification. The present study was undertaken to confirm whether the hilsa which migrated to the Hooghly-Bhagirathi River system belonged to a single stock, by analysing the shape variation of sagittal otolith. Specimens of hilsa were sampled from the entire stretch of Hooghly-Bhagirathi River and associated coastal waters of the northern Bay of Bengal covering 16 different locations. The specimens were categorized into four groups: marine (MA), brackishwater (BW), freshwater-tidal (FT), and freshwater (FW). Otoliths of the specimens (n=268) representing the four habitat groups were extracted and their images were taken using a camera attached to a microscope. The shape analysis of the otolith images was carried out using an open-source software package ShapeR, which runs on the R platform. From the otolith images, the closed contour outlines were extracted, smoothened, transformed into shape coefficients using both Discrete Wavelet and Normalized Elliptical Fourier transformations and the mean shape were plotted using the coefficients. To analyse the variation in shape among the samples from the different habitat groups, Canonical Analysis of Principal Coordinates (CAP) was done on the length standardized Wavelet and Fourier coefficients, followed by cluster analysis for visualizing the CAP results. The clustering of shape coefficients failed to explain any clear separation among the four groups, reaffirming that the hilsa population using the Hooghly-Bhagirathi River as their migratory route forms a single stock.

Keywords: Hilsa, Hooghly, otolith, shape analysis stock structure

Stock structuring of Unicorn leatherjacket, *Aluterus monoceros* (Linnaeus, 1758) from Indian Exclusive Economic Zones (EEZ)

Kamei Lanthaimeilu[1*], Dayal Devadas[1], Sanjenbam Bidyasagar[1], Sudhan, C.[2], Karankumar Ramteke[1] and Asha T. Langde[1]

[1]. ICAR – Central Institute of Fisheries Education, Mumbai – 400061, India
[2]. TNJFU – Fisheries College and Research Institute, Thoothukudi – 6280008, India

*lanthaimeilukamei@gmail.com

The Unicorn leatherjacket, scientifically known as *Aluterus monoceros* is a demersal marine fish found in the Indo-Pacific waters. In India it was initially considered as bycatch when caught in trawlers, however, its significance has grown since 2009 due to a sudden increase in its abundance. It has gained importance in the export market, particularly in the form of fillets and its distinctive leathery skin, which is also used in feed meal production. Consequently, its commercial value has risen significantly. In light of this, the current study was undertaken to investigate the stock structure of *A. monoceros* within Indian marine waters. The study utilized a truss-network-based multivariate analysis approach to gain insights into the population dynamics of this species. The primary goal of this research is to contribute to the sustainable management of Unicorn leatherjacket populations in the coastal regions within the Exclusive Economic Zone (EEZ) of India. For the study fish sampling was conducted from various coastal regions in India, including Gujarat, Kerala, Odisha, and Tamil Nadu, and focused on differentiating the stock of *A. monoceros*. 17 landmarks and 28 truss distances for analysis. The results of the multivariate analysis indicated that there is a single stock of *A. monoceros* in Indian marine waters. Several analytical techniques such as Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and hierarchical clustering based on Euclidean distances were employed to understand the stock structuring across four zones within the Indian Exclusive Economic Zone (EEZ). Univariate ANOVA revealed that 22 out of 28 truss measurements were statistically significant ($p<0.001$) and suitable for subsequent multivariate analysis. PCA results showed that the first six principal components explained 80.14% of the total variance. However, the biplot of the first two principal components demonstrated that the stocks were intermixing, and no distinct stocks were naturally present. Notably, certain body truss measurements, particularly in the anterior and caudal peduncle regions, played a significant role in discriminating stocks in Tamil Nadu. LDA also failed to provide evidence of stock separation, with a correct classification rate of 76.68%, and after cross-validation, the accuracy dropped to 73.12%. Cluster analysis and the dendrogram revealed that the stocks were distant from each other, forming two main clusters among the four fishing locations. Consequently, the study suggests the implementation of a uniform management plan for this demersal resource, regardless of its wide distribution in Indian waters, as there was no evidence of natural stock demarcation.

Keywords: *Aluterus monoceros*, fish truss-network analysis, multivariate analysis, stock structure

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Seasonal dynamics of optical classes and small pelagic abundance off the South Eastern Arabian Sea

Monolisha, S[1,*], Prathibha Rohit[1], Grinson George[1], Dhiju Das, P. H[2] and Ratheesh Kumar, R.[1]

[1]ICAR—Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]ICAR-Central Institute of Fisheries Technology, Ernakulam, Kochi, Kerala, India

* monasundar1426@gmail.com

Assessments of oceanographic events and fish abundance (spatial distribution) are critical components of understanding the effects of climate change on fisheries. Obtaining geo-tagged fishery data to relate to the oceanographic variables still remains a challenging factor in studying these fishery resources. In this study, we have attempted to delineate the optical classes in relation to the small pelagic fishes in the Exclusive Economic Zone of the south-eastern Arabian Sea (5-15°N latitudes and 65-80°S longitudes). The study uses the monthly climatology of Remote Sensing Reflectance (RRS) and chlorophyll datasets as an optical property from the Ocean Colour Climate Change Initiative, Version 6, for the years 1998-2021. Monthly geo-referenced small pelagic fish abundance from ring seine fishery datasets for the years 2010 and 2011 was obtained from the project "Green Fishing Systems for Tropical Seas" funded by the National Fund for Basic, Strategic, and Frontier Application Research in Agriculture (NFBSFARA), ICAR, New Delhi. These datasets were used to evaluate the dynamics of the optical classes and the fishery resources of the region. From the cluster validity measures, six was chosen to be the best cluster number to perform the optical classification of the study region. Classes 1 and 2 constitute the ocean waters above 50 m depth, and classes 3, 4, 5, and 6 are most dominant in the depths within 50 meters covering the coastal waters. Optical classes and abundance of the small pelagics tend to have significant relationship with p value as 0.01. Spatial and temporal variability was studied using comparisons between dominant optical classes, chlorophyll concentration, optical diversity, and small pelagic fish abundance in the South Eastern Arabian Sea using Point sampling tool in Q-GIS software. The abundance of small pelagics was predominant in Classes 4, 5, and 6. Class 3 tends to be distinct, existing at 9°N latitudes and 76°S longitudes during the southwest monsoon season (June to September). The monthly distribution of optical classes 4, 5, and 6 was seen to have a higher abundance of these small pelagic fishes consistently in the month of October (transition period). On further investigation, the study could pave the way for understanding these optical classes as an indicator for predicting the seasonal variability of the small pelagic fishes towards their commercial harvest and sustainable management.

Keywords: Arabian Sea, fishery, geography, optical classes, seasonal, variability

Trophic interactions of major fishery functional groups along the marine ecosystem of Gujarat: An Ecopath model approach

Vinaya Kumar Vase*[1,2], Rajan Kumar[1], Shikha Rahangdale[1], Jayasankar Jayaraman[1,2], Abdul Azeez[1], Mohammed Koya[1], Sreenath, K. R.[1], Ajay Nakhawa[1], Swathi Lekshmi, P. S.[1] and Prathibha Rohit[1,2]

[1]Mangalore University, Mangalagangotri – 574 199, Karnataka, India
[2]ICAR-Central Marine Fisheries Research Institute, Ernakulam North, P.O., Kochi-682 018, Kerala, India

* v.vinaykumarvs@gmail.com

The ecosystem models are more complete and incorporate all ecosystem components across trophic levels, from the primary producers to the apex predators. The mass-balanced Ecopath model for the fishery habitat area along the continental shelf waters of Gujarat in the northern Arabian Sea was adopted in the present study, that used 45 functional groups, including detritus, for the model construction. The fleet-wise estimates of fish catch and value of catch for 25 years (1994 to 2018) were also used as inputs in the Ecopath model (NMLRDC-CMFRI). The diet analysis was done for most functional groups (the prey values were averaged for functional groups with more than one species), but data for a few groups were adapted from published literature. The Ecotrophic Efficiency (EE) values varied between 0.149 and 0.989. Several groups recorded an EE value of over 0.9, indicative of high fishing or predator pressure in the ecosystem. The trophic levels estimated for different functional groups ranged between 1 (phytoplankton and detritus) and 4.439 (billfish). The transfer efficiency of TL II-TLX was within the range of 10-20%. The system statistics for the Gujarat ecosystem provided the key to the state of the ecosystem in terms of production, efficiency, and maturity. The total system throughput estimated for the Arabian Sea ecosystem of Gujarat was 5237 t km^{-2} $year^{-1}$, consistent with tropical marine ecosystems with high turnover. In the current model, the gross efficiency value computed was 0.002 (much higher than the weighted global average is about 0.0002), showing a fishery harvesting fish low in the food chain. The GE computed for an Ecopath model of Gujarat is higher than that estimated for the previous models in India (Karnataka and Bay of Bengal models), indicating that fishes low in the food chain were harvested, predominantly comprising of the non-penaeid prawns, clupeids, and other mesopelagic fishes. The study portrays the trophic interactions in the fishery ecosystem of Gujarat across major functional groups prioritized in the model. The mass-balanced Ecopath model developed could be further applied to investigate time-series simulation and space components for fishery resource monitoring and management in the region.

Keywords: Apex predators, EwE model, mesopelagic resources, northeastern Arabian Sea, productivity

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Exploring the dynamics of marine fish landings in Karnataka through Principal Component Analysis

Mini, K. G.*, Somy Kuriakose, Sijo Paul, Sindhu K. Augustine and Reshma, A. R.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*mini.kg@icar.gov.in

Karnataka state situated along the southwest coast of India, has 27,000 sq. km continental shelf area. The state has three coastal districts namely Dakshina Kannada, Udupi and Uttara Kannada (. With an estimated 6.95 lakh tonnes of marine fish landings in 2022, Karnataka ranks as the second-largest contributor to India's overall marine fish landings. When compared to 2021, the state witnessed a substantial increase in landings of about 1.44 lakh tonnes, setting an all-time high. The resource-wise marine fish landings data during 2000–2022, retrieved from the National Marine Fisheries Data Centre of CMFRI, was analysed using Principal Component Analysis (PCA) to visualize the dynamic behaviour of landings over time. Among the 63 resource groups, the top five were Indian oil sardine, Indian mackerel, threadfin breams, scads and ribbonfishes in sequence of the average catch from 2000 to 2022.. Indian oil sardine recorded the largest catches and demonstrated drastic variations. It had a peak catch of 1.4 lakh tonnes in 2014, very low catches in 2020 and 2021, and resurging back to about 0.5 lakh in 2022. Principal component analysis (PCA) revealed that PC-1 (54%) accounted for the majority of the variability in the data, while PC-2 (19%) and PC-3 (9%), respectively, also contributed to the variation. PC-1 had high loadings on Indian oil sardine (0.8), one of the main fisheries along the coast. PC-2 had a substantial positive association with red-toothed trigger fish (*Odonus niger*) (0.7), due to its sudden surge in landings in recent years. Additionally, it indicated a strong negative correlation with Indian mackerel (0.52). The third component has a significant association with Indian mackerel, *O. niger*, threadfin breams and *Priacanthus* spp. Thus, these three principal components could explain 82% of the variability in the data. The pattern in the PCA for the fish landings is due to the strong influence of very high landings of Indian oil sardine in 2014, Indian mackerel and threadfin breams in 2022. The year 2022 appears in PC-3, while 2019 sits apart due to the unusual emergence of the red-toothed trigger fish, along with a simultaneous reduction in landings of Indian oil sardine and mackerel. Considering the years, three clusters were identifiable, with the early years of the fishery sitting apart from the more recent ones, which can help in understanding shifts in fisheries composition and system changes over time, for making informed decisions in stock assessments and fisheries management.

Keywords: Fish landings, fisheries management, Karnataka, marine fisheries, Principal component analysis

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Assessing habitat suitability for endemic Mahanadi Rita, *Rita chrysea*, in Mahanadi River Basin, India

Rejani Chandran[1], Lalit Kumar Tyagi[1*], Kantharajan, G.[1*], Achal Singh[1], Sangeeta Mandal[1], Trivesh S. Mayekar[2], Amit Singh Bisht[1] and Sanjay Kumar Singh[1]

[1]ICAR-National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh, India
[2]ICAR-Central Coastal Agricultural Research Institute, Old Goa, Goa, India

*Presenting author

**Corresponding author: tyagilk@gmail.com

Mahanadi Rita *Rita chrysea* is a freshwater catfish belonging to the family Bagridae, which is endemic to the Mahanadi River system of India. The species has high market demand due to which it is heavily exploited in the wild, leading to its gradual decline in population. For successful implementation of conservation programmes, comprehensive knowledge of the fundamental aspects of biology like length-weight relationship, is quintessential. As part of comprehensive surveys carried out in the Mahanadi River and its associated tributaries during 2013-2019, a total of 529 specimens of *R. chrysea* were collected from 30 locations across the Mahanadi Basin. Spatial variation in "b" value was found to be highest in location Barghat (3.549) followed by Paiserghat (2.921). Land Use Land Cover (LULC) class distribution was also extracted for the study locations to the extent of 5 km buffer using the open source data (30 m resolution) in ArcMap platform. A total of 17 sites had dominance of LC (open forest, shrub land and waterbody) while 13 locations expressed dominance of LU (cropland). The growth coefficient derived by regression analysis was found to be better for locations with LC dominance. Statistical analyses were implemented to carry out micro-habitat analysis in the identified 17 sites to assess the habitat preference and suitability of *R. chrysea*. The results of the present study would help in identifying key habitat requirements for the establishment and self-propagation of this endemic fish resource. With rapid habitat deterioration prevalent in the river bodies, knowledge of the crucial necessities coupled with biological information shall help in the formulation of conservation strategies, declaration of Protected Areas (PAs), and breeding grounds.

Keywords: Biodiversity, conservation, endemism, habitat, land use land cover

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Mapping of surface water dynamics and persistent pools in the Banas River Basin, Rajasthan: a geospatial approach for conservation planning

Pathak, A. K., Kantharajan, G.*, Raghvendra Singh, Ravi Kumar, Shikha Sharma and Sarkar, U. K.

ICAR–National Bureau of Fish Genetic Resources, Canal Ring Road, Dilkusha P.O, Lucknow–226002, Uttar Pradesh, India

*kantharajanars@gmai.com

Rivers in arid and semi-arid regions are lifelines as they provide multiple Ecosystem Services (ES) to the dependent community. The ES potential of such rivers depends on the water persistence and flow dynamics in the floodplain. The persistent pools in the non-perennial rivers are considered unique micro-habitat, which hold water year-round and act as 'refugia,' providing ambient environmental conditions for the growth and proliferation of regional fish diversity. A study was conducted on the Banas River (≈512 km), a tributary of the Chambal River originating from the eastern slope of the Aravalli Range in the Bhilwara District of Rajasthan and part of the Ganga Basin. It is one of the major river systems in Rajasthan and supports a wide variety of terrestrial and aquatic biota, including Tigers in Ranthambhore National Park. This study assessed the water spread dynamics and mapped the persistent pools using the Sentinel-2 images of 3 water years (2019-2022) in the ArcMap platform. The water spread mapped in the floodplain ranged from 0.94% (2021 pre-monsoon) to 22.25% (2019 post-monsoon) to the total floodplain area. The estimated perennial water spread in the floodplain area was 2 km^2 during the study period. The persistent pools were extracted from the composite Normalized Difference Water Index (NDWI) map of the Banas River through the Water Presence Frequency approach. A total of 309 micro-habitats (>101 m^2 in size) were delineated and found to occur mainly in the downstream section of the river. Further, the fish diversity assessment of selected persistent pools of different size categories, *viz.*, Chandpura, Triveni Sangam, Rajmahal, and Isharda, revealed the habitat service potential of persistent pools supporting rich fish diversity in Banas River. The spatial map of persistent pools developed in the present study, along with its habitat characteristics and threat factors, are vital for devising guidelines for the conservation and management of the ecosystem.

Keywords: Banas River, conservation, GIS, perennial pool, surface water dynamics

Navigating the blue: spatial insights into tuna gillnet fisheries along northwest coast of India for advancing oceanic resource-led blue economy

Abdul Azeez, P.*, Mohammed Koya, K., Vinay Kumar Vase, Swathi Lekshmi, P. S., Ratheesh Kumar, R. and Abdussamad, E. M.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India.

*azeez.cr7@gmail.com

The sustainable management of oceanic resources is imperative for fostering a thriving blue economy. This study presents a comprehensive spatial analysis of tuna gillnet fisheries along the northwest coast of India, offering insights into potential pathways to enhance the blue economy through responsible resource utilization. However, the absence of comprehensive spatial information on the fishing grounds and interactions with non-target species has posed challenges to achieving sustainability in resource usage. To bridge this knowledge gap, spatially explicit data was collected from tuna gillnetters' fishing grounds from 2011 to 2023, enabling the quantify catches and gain valuable insights. The study enhances our understanding of the spatial extent of gillnet fisheries in the NWCI by providing crucial information on species composition, seasonal variation, and the nature of interrelationships in catch incidences. Furthermore, spatial and temporal variations in catches of various species groups were examined, shedding light on their distribution patterns. Interactions between sensitive species such as dolphins and turtles and gillnet tuna fisheries were of particular concern. The nature and strength of these interactions were assessed, and geospatial layers were generated, highlighting regions abundant with these species close to gillnet fishing grounds. These findings suggest a promising way to enhance the blue economy through responsible ocean resource management. By utilizing spatially informed decision-making, stakeholders can work towards ensuring sustainable resource utilization while considering the environment. Active engagement of fishers in collecting precise fishery data further contributes to community-driven initiatives, fostering sustainable practices and paving the way for a prosperous and ecologically sound blue economy.

Keywords: Tuna fisheries, spatial data, mammals, blue economy, Arabian Sea

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Spatio-temporal distribution of croakers along the Gujarat coast of India

Shikha Rahangdale*, Zacharia, P. U., Rajan Kumar and Vinaya Kumar Vase

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*shikharahnagdale@gmail.com

India is one of the major fishing nations in the Indian Ocean. India accounts for almost 60% of the croakers caught in the Indian Ocean. The North-west coast of India, including Gujarat, is known to be the most productive fishing ground for croakers along the Indian Ocean. Croakers comprise two broad groups, namely large and lesser sciaenids. Lesser sciaenids form the bulk of the croakers catch along the Gujarat coast, with significant contributions coming from around half a dozen species. The abundance of lesser sciaenids is not uniform in space and time; hence, their spatiotemporal distribution studies are critical to ensure an effective harvest strategy. The present study is based on haul-wise data collection of lesser sciaenid catch from the bottom trawlers along the Gujarat coast. The geo-tagged catch rates were subjected to interpolation (kriging) to generate a thematic map of the season-wise abundance of lesser sciaenids in the coastal waters of Gujarat. Central Gujarat can be considered the richest ground for croaker fishery along the Gujarat coast. The high abundance zones of croakers are off Mangrol and Porbandar in the low depth (<50 m) category during post-monsoon season. Good catch also realized off north Gujarat. During winter, there is a general decline in catch rates, and high-abundance zones are shifted to deeper waters. With the commencement of summer-monsoon, the productive zones start shifting to the shallower depth region. North Gujarat has recorded the highest catch rates for croakers during the summer monsoon season. The presented study would form key input towards sustainable resource harvest and facilitate Marine Spatial Planning in the marine fishery sector of India.

Keywords: Bottom trawl, Gujarat, lesser sciaenids, spatio-temporal

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Insights into the reproductive areas of the critically endangered guitarfishes recorded from the Chavakkad coast, Kerala, India

*Livi Wilson, Sujitha Thomas, Najmudeen, T. M., Pakkrimuthu, S., Sunil, K. T. S. and Shoba Joe Kizhakudan

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*liviwilson@gmail.com

Chavakkad is a shallow coastal area in Kerala along the southeastern Arabian Sea, characterized by nutrient-rich waters from convective mixing and eutrophication, particularly during the monsoon season. It is connected to the Chettuva estuary, which replenishes the coast with fresh water from three rivers: Karuvannur, Kecheri, and Puzhakkal. Data collected over the period 2020–2022 shows that three critically endangered guitarfishes, namely *Acroteriobatus variegatus*, *Rhinobatos annandalei*, and *Glaucostegus obtusus*, have a plausible reproductive area along the Chavakkad coast near the Chettuva estuary during the months between October and December. The study found that all female guitarfishes in the three species encountered were mature individuals with advanced-stage embryos, 10-11 embryos per fish for *R. annandalei*, and 5-6 embryos per fish for *G. obtusus* and *A. variegatus*. The size of females observed was 76–84 cm TL for *R. annandalei*, 89–92 cm TL for *G. obtusus*, and 65–70 cm for *A. variegatus*. During these months, guitarfishes and their pups were frequently spotted around the shallow coastal waters. Neonates were observed in the area's shallow (0-2 m deep) habitats, particularly in the sandy habitats around the Chettuva estuary. Five neonates were spotted during the same period in size range of 18-21 cm for *R. annandalei*, while two neonates were observed across the size range of 19-20 cm for *G. obtusus*. More research and sampling are needed to substantiate the reproductive habitat of these threatened species.

Keywords: *Acroteriobatus variegatus*, Chettuva estuary, *Glaucostegus obtusus*, reproductive habitat, *Rhinobatos annandalei*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Insight into the fish seed availability and resource mapping along the coastal stretch of the Gulf of Mannar

Vinothkumar R.*, Ranjith, L., Kavitha, C. Rajkumar, M. and Remya, L.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*vinothanars16@gmail.com

Marine finfish farming is a well-developed sector that provides significant potential for addressing the globe's demand for food in the near future. The two most prevalent seeds in the Pamban region were collected for capture-based aquaculture of milkfish and mullet. The milkfish, *Chanos chanos*, is one of the most significant prospective species for capture-based aquaculture in India. There are many seed collection centres like Uppur, Dhanushkodi, Karaiyur Karsettupaalam, Kundhukal, Chinnapalam Creek, Munthal Munai (Therkuvadi), Vedhaalai (Pillaimadam), Periyapattinam, Sethukarai, Keelakarai (Aathupalam), Ervadi, Vaalinokkam, and Idham Paadal. The diverse vegetation around the Pamban coast and the Chinnapalam Creek render them the most productive spots to collect milkfish seeds. The present investigation was carried out during a period of four years, from 2016 to 2019, to understand the seasonal availability and seed quantity of milkfish along Ramanathapuram District's Sites 1–Munthal Munai (PT) and 2–ThangachiMadam Harsettu Bridge, Site 3–Chinnapalam, and Site 4–Kundhukal. The primary season extended from March to June, and the secondary season ran from November to December. During these seasons, the average size of the seeds was 15-30 mm. An average of 1352500 seeds was collected during Season 1 annually, while during Season 2, an average of 823500 seeds was collected. The largest quantities of seeds were collected at Site 1–Munthal Munai (PT) and Site 4–Kundhukal, which are rich in *Avicennia* sp, *Pempris* sp, *Thespesia populnea*, *Cocos nucifera*, *Prosopis Juliflora*, *Phoenix sylvestris*, and other plants that serve as nurseries and shelters for the seeds. While the vegetation in the Munthal Munai (PT) and Kundhukal is distinct, the quantity of seed collected has decreased in recent years due to habitat degradation spurred by various factors limiting seed collection. The size of the milkfish nursery ground has declined over the last few years due to urbanization and habitat degradation, reducing the number of milkfish seeds available along the Pamban coast. The natural environment supporting milkfish seed resources might deteriorate further with more damage. The nursery ground in the milkfish wild seed collection region and its ecology and other anthropogenic activities along the coast of Ramanathapuram district need to be determined and delineated through an exhaustive year-round survey. The sites ought to be documented and protected against pollution and human influence.

Keywords: Associated coastal vegetation, capture based Aquaculture, Gulf of Mannar, nursery ground, spawning ground

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Spatio-temporal analysis of ichthyoplankton abundance and its relation to environmental factors in Visakhapatnam waters, Andhra Pradesh

Indira Divipala[1]*, Muktha, M.[1], Loveson L. Edward[1], Manas, H. M.[1], Jasmin, F.[1], Pralay Ranjan Behera[1], Suresh Kumar, P.[1], Shubhadeep Ghosh[2], Safet Padhan[1] and Grinson George, P.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Division of Fisheries, ICAR, Krishi Anusandhan Bhawan–II, New Delhi–110 012, India

*indira.divipala@icar.gov.in

The conservation and augmentation of natural resources require a profound understanding of the intricate interactions between the biotic and abiotic worlds. From initial observations, data sampling, and documentation to the subsequent analysis of records, the goal is not just to ensure the sustainability of the resource but to foster its flourishing while nurturing the ecosystem it calls home. Among these resources, the marine inhabitants are a vital source of animal protein, contributing significantly to food security and bolstering the nation's foreign exchange reserves. However, growing concerns have arisen regarding the sustainability of these resources and the intricate biotic and abiotic interactions crucial for their successful survival and recruitment of the fishery. Given this backdrop, the present study endeavors to comprehend the spatio-temporal distribution and abundance of ichthyoplankton in the waters off Visakhapatnam. Monthly samples were collected from the research vessel (RV Cadalmin-I) by filtering through plankton net and fixed in 10% formalin. The average plankton concentration was estimated, facilitating qualitative and quantitative assessments. This study explores seasonality, occurrence patterns, and associations with various environmental parameters. Canonical Correlation Analysis (CCA) highlights a close relationship between fish eggs, megalopa, and fish larvae with water transparency. Nauplius had a correlation with CHL-a levels, pH, and Biological Oxygen Demand (BoD), while prawn zoea exhibits correlations with water temperature and depth. Most early life stages of finfish and shellfish primarily appear to be influenced by water parameters such as water temperature, dissolved oxygen levels, turbidity, and water depth. This research enhances our understanding of the balance between ichthyoplankton and its environment, which is crucial for informed resource conservation and management strategies.

Keywords: Abundance, distribution, ichthyoplankton, marine, spatio-temporal

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Studies on trawl codends with T0 and T90 meshes along Kochi, Kerala

Madhu, V. R.*, Vishnupriya, M. S., Mohammed Jabir and M. P. Remesan
ICAR-Central Institute of Fisheries Technology, Matsyapuri, W. Island, Cochin – 682029
*Madhu.VR@icar.gov.in

Modifying the mesh size or shape in the codend is a widely employed technique to improve the selectivity of trawl codends. Most studies on trawl codend selection focus on the use of T45 codends. These codends have demonstrated positive results in increasing the mean selection length of various species. As a result, several states in India have made it mandatory to use T45 codends for trawlers within their respective jurisdictions. The availability of T45 codends poses a challenge due to the non-availability of readymade codends. Hand fabrication requires skill and is time-consuming. Non-availability of T45 codends in the markets may be one of the reasons for its poor adoption. On the contrary, T90 codends are much easier to make since this doesn't involve any modifications to the existing T45 codends, and the efficacy of the T90 codend has been reported in studies conducted elsewhere. However, there are no reports on the effectiveness of this codend in the Indian trawl fisheries. This study reports the trials conducted in the coastal waters off Cochin, using T0 and T90 codends with a mesh size of 30 mm, rigged to a 48m traw. Alternate hauls were carried out using the two codends in the traditional fishing grounds at depths ranging from 35-40m. Catch ratio and catch comparison studies were carried out for two species, where sufficient data was available. The analysis indicated significant differences in the capture efficiency for the T90 codend for *Metapenaeus monoceros*. The Minimum Legal Size (MLS) for *M. monoceros* is 11 cm (TL), and considering this, the results are encouraging. However, there was no difference in the length-dependent capture for *Epinephelus diacanthus*. In addition to the catch comparison and catch ratio analysis, a dominance analysis was carried out to understand the overall biodata affected using the two codends. The significance of the results and the efficacy of T90 codends to improve the selectivity of trawl codends is discussed.

Keywords: Catch comparison, MLS, trawling, T90 codend, Cochin

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

The promising role of V-Form Double-Slotted Otter Boards

Remesan, M. P.*, Paras Nath Jha, Dhiju Das, P. H., Sreejith S. Kumar, Subinlal, A. V. and Ajay Krishna
ICAR-Central Institute of Fisheries Technology, Matsyapuri P.O., Willington Island, Kochi-682029, Kerala, India
*mpremesan@gmail.com

Over the past five decades, India's marine fisheries sector has witnessed remarkable growth. Trawl fishing, in particular, has played a significant role in boosting the country's economy. However, this energy-intensive method, often powered by diesel engines, contributes to carbon dioxide (CO_2) and other greenhouse gas emissions, exacerbating climate change and impacting air and marine environments. An essential accessory of the trawl system, the otter boards are instrumental in keeping the trawl net open. However, traditional wooden boards are neither efficient nor durable, and the inherent drag contributes significantly to fuel consumption. Recognizing the need for more fuel-efficient and eco-friendly otter boards, the ICAR-Central Institute of Fisheries Technology (ICAR-CIFT) has made strides toward a changeover from wooden boards to more energy-efficient otter boards. The introduction of V-form double-slotted otter boards (VSOB) by the ICAR-CIFT provides a significant improvement over the existing otter boards in India. This innovative design combines the benefits of both V-form boards and slotted boards, potentially yielding even greater fuel efficiency and emission reductions with better trawl opening. Experimental studies indicate impressive savings of approximately 3 liters of diesel per hour of trawling and 15-20 liters per day, signaling a positive impact on the fishing industry's environmental footprint. This article detailed the development and popularization of VSOB as a replacement for existing boards to enhance the efficiency and economics of trawling operations. By reducing drag, fuel consumption, and greenhouse gas emissions, these innovative design is a significant step towards greening the fishing industry. This article also highlights the efforts of ICAR-CIFT in promoting this eco-friendly design throughout the maritime states of India.

Keywords: Drag, otter board, trawl opening, VSOB

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative analysis of catch in experimental trials of the CIFT-Turtle Excluder Device

Remesan, M. P., Madhu, V. R., Paras Nath Jha, Dhiju Das, P. H. and Subinlal, A. V.*
ICAR-Central Institute of Fisheries Technology, Head Office, Willington Island, Kochi-682029, Kerala, India
*subinlal75@gmail.com

Turtle Excluder Device (TED) is a specialized device that helps facilitate the escapement of turtles from trawl net while allowing the capture of shrimps and other fishes. This study compares the catch of an experimental trawl net fitted with and without a fine-tuned CIFT-Turtle Excluder Device (TED). Trials were carried out onboard CIFT research vessel R.V. Matsya Kumari-II with a length over all (LOA) of 17.7 meter and engine power of 325 hp, using a shrimp trawl net of 25mm codend mesh size. An alternate haul method was adopted with a tow duration of 1 hour. Thirty-two trials were conducted on the same fishing grounds, and the catch samples collected were evaluated in this study. Throughout the study, all operational parameters were kept constant in both hauls with and without TED. The overall length of the warp was 283.75±31.50 meters, the operational depth was 30.52±2.60 meters, and the vessel's speed during the hauls was 2.85±0.32 knots. Notably, the experimental trials revealed a variance of 19-144kg in total catch across different instances, with a mean value of 41.38±25.99. ANOVA was used to comprehensively evaluate the variation in the total length of the 62 separate species, including various fishes, shrimps, mollusks, and crabs collected during the experimental trials. The study found no significant difference in total catch and total length of the species caught at the $P<0.05$ level. Furthermore, the comparative analysis found no statistically significant difference in catch composition between hauls with and without TED. This study provides valuable insights into the potential benefits of employing the CIFT-TED as a tool for sustainable and selective trawl fishing practices.

Keywords: ANOVA, codend, LOA, trawl net, Turtle Excluder Device (TED)

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Testing the efficiency of TED, using dive evaluation along the Kerala coast

*Dhiju Das P. H., Nobi P. S., Madhu V. R. and Remesan M. P.
ICAR-Central Institute of Fisheries Technology, Cochin-29
*dhijudas@gmail.com, Ph.: +91 9895735937

Sea-turtles bycatch is a major concern in marine fisheries worldwide, necessitating strategies to reduce unintentional capture. This article discusses a novel diving methodology for observing and assessing the performance of Turtle Excluder Devices (TED) in trawl fishing operations. The study aims to improve the understanding of bycatch mitigation. It focuses on measuring the efficacy of TED in minimizing sea turtle bycatch by conducting the first-ever underwater evaluation of TED in India. The study was conducted along the offshore waters of Poovar, Thiruvananthapuram District, Kerala. The study location was selected after a continuous underwater site selection survey conducted along the Kerala coast in search of the turbidity-free sandy sea bottom. Skilled SCUBA (Self-Contained Underwater Breathing Apparatus) divers were deployed with underwater cameras to study the performance of TEDs at various depths and speeds. The exclusion efficiency of the fine-tuned TED was investigated using an imitation turtle. Design and operational details of the prototype gear and accessories used for the trials were discussed in this paper. This study provides scope for testing the efficiency of various fishing gears, accessories, and Bycatch Reduction Devices in the actual fishing gear operational environment.

Keywords: Conservation, Sea turtle bycatch, Sustainable fishing practices, Turtle Excluder Devices (TED), Underwater evaluation

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Candidate species research on sea urchins from the Gulf of Mannar and the Palk Bay for the echiniculture opportunities

Saravanan, R.*

Marine Biodiversity & Environment Management Division, ICAR-Central Marine Fisheries Research Institute, Mandapam – 623 520, Tamil Nadu, India

* saravanan.r@icar.gov.in

World over, blue economy is a much talked about subject which primarily means the economy derived from the ocean ecosystem. The Gulf of Mannar and the Palk Bay are the two important ecosystems located along the southeast coast of India that offer a wide scope for sustainable approaches in innovative mariculture opportunities. Sea urchin aquaculture commonly called echiniculture has been in practice in European nations, owing to the high price the sea urchin gonad fetches in their domestic and international markets. The present study was undertaken to assess the suitability of sea urchin species for possible aquaculture, and two sea urchin species from the Gulf of Mannar and the Palk Bay were selected *viz*., *Salmacis virgulata* and *Temnopleurus toreumaticus* and their reproductive cycle and biological parameters were studied for two years between 2015 and 2017. The overall sex ratio of *S. virgulata* and *T. toreumaticus* did not depart from 1:1 in the current investigation. Both of the sea urchin species have semi-annual reproductive cycles. In the Gulf of Mannar ecosystem, *S. virgulata* has a reproductive season from February to March and from September to January, whereas *T. toreumaticus* has a reproductive season from December to January and October to March. The following conclusion has been drawn based on the rearing experiments conducted and *T. toreumaticus* is more suitable in a closed culture enclosure since it does not exhibit cannibalism, and is tolerant of crowded environments when compared to *S. virgulata*. Thus, it can be said that future research and development for aquaculture should focus more on *T. toreumaticus*.

Keywords: Echiniculture, Gulf of Mannar, sea urchin, sea urchin aquaculture, sea urchin roe

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Gooseneck barnacles: overlooked and lesser known crustacean in India

Teena Jayakumar, T. K.[1*], Ardra Gopal[2], Rekha M. U.[1], Arun Sudaghar, S.[1], Ajith Kumar, T. T.[1] and Uttam Kumar Sarkar[3]

[1]Centre for Peninsular Aquatic Genetic Resources, ICAR-National Bureau of Fish Genetic Resources, Kochi, Kerala, India
[2]Department of Marine Biology, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala, India
[3]National Bureau of Fish genetic Resources, Lucknow, Uttar Pradesh, India

*teenajayakumar@gmail.com

Barnacles of the family Lepadidae and Pollicipedidae are known as 'gooseneck barnacles', 'leaf barnacles' and 'goose barnacles. The species in the family Pollicipedidae are intertidal and those in Lepadidae are pelagic, commonly found associated with floating objects such as ships, buoys, wood, animals, marine debris and macroalgae. There are five genera and 20 species in Lepadidae and three genera and 6 species in Pollicipedidae. Eight species (4 genera) of Lepadidae and one species (1 genus) of Pollicepadidae are reported so far from the Indian waters. Few species commonly found in Indian coast are *Lepas indica*, *Hyalolepas bengalensis*, *Conchoderma indicum*, *C. hunteri*, *Dosima guanamuthui*, *Oxynaspis indica*, *Octolasmis grayii*, *O. warwickii*, *Platylepas decorate*, *Pollicipes polymerus* and *Paralepas xenophorae*. These gooseneck barnacles are part of the diverse marine life along the Indian coast, and they play significant role in the ecosystem by providing habitat and food for other organisms. During exploratory survey, marine crabs infested with pedunculate barnacle *Octolasmis* spp. were encountered from landing centres in Kochi. The epizoic relationship between octolasmids and the commercially important crabs, such as *Callinectes sapidus*, *Scylla serrata* and *Portunus pelagicus*, have garnered considerable global interest. The large gooseneck barnacle *Pollicipes* spp. was encountered from the Kollam landing centre. *Pollicipes* sp. is considered as a culinary delight in various nations, with its flesh bearing a flavour profile akin to that of lobster meat, making it a delectable and sought-after option for consumption. It is abundant in Atlantic and Pacific coasts and is a potential fishery. With rising demand and restricted local harvesting, the global acceptance of cultivating gooseneck barnacles has gained traction. Presently, there is a surge in efforts towards their cultivation due to their significant economic value in the culinary industry. There is a paucity of extensive research on gooseneck barnacles native to India. It is imperative to conduct in-depth research on the diversity, distribution, behaviour, biology and ecological importance of barnacles along the Indian coast, as they hold untapped potential for aquaculture.

Keywords: Aquaculture, gooseneck barnacle, Lepadidae, Pollicipedidae

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Obscurity to opportunity: optimizing the utilisation of Congrid Eel fish resources in India

Paramasivam Kodeeswaran[1]*, Ajith Kumar, T. T.[1] and Uttam Kumar Sarkar[1]

[1]ICAR–National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh–226 002, India

* kodyvenkat1995@gmail.com

The Conger eels (Congridae Kaup, 1856) are small to large-sized animals, with their habitats extending throughout the temperate and tropical waters, particularly from the continental shelf or slope to the deep sea, along the world's oceans. At present, there are 232 valid species of Conger eels, belonging to 32 genera under three subfamilies. However, information on their taxonomy, biology, ecology, and precise distribution is scanty. The present study aims to document the diversity of marine Congridae eel distributed along Indian waters. Sampling has been done at various major landing centres along the Indian coast during 2020-2022 to perceive their true diversity. In the present study, 37 species belonging to 16 genera have been documented. Amongst this, 10 new species and four new records have been described and documented in the last 3 years. The genus *Ariosoma* dominates the species diversity with 9 species, followed by *Rhynchoconger* (5 species), *Bathycongrus* and *Heteroconger* with 3 species each. Even though there were 32 genera in the family Congridae, only a few genera such as *Conger* and *Ariosoma* possess minor commercial fishery, but distinct statistical data is not available. Hence, the recently discovered new species belonging to the genus *Ariosoma*, *Conger* and *Rhynchoconger* have fleshy body, that can be used for commercial purposes. Also, value-added products such as fish balls, crackers, burgers and Congrid grills, which are already delicious seafood in Western Pacific countries, can be thought of as good options in our country to promote consumption of these groups.

Keywords: Congridae, seafood, diversity, taxonomy

Productivity estimates of Chaliyar River in Kerala, India

Thankam Theresa Paul*, Deepa Sudheesan, Ajoy Saha and Das, B. K.

ICAR-Central Inland Fisheries Research Institute, Kochi Centre, ICAR-CMFRI Campus, Ernakulam, Kerala-682 018, India

*thankamtheresa@gmail.com

Gear-based catch and productivity estimates have been extracted from eight stations spread across three stretches in Chaliyar River in Kerala. Primary survey across different stations identified 104 active fishers in Chaliyar. Fishery productivity of Chaliyar River was estimated at 4.34 kg km^{-1} whereas the average catch day^{-1} $person^{-1}$ recorded was 7.81 kg. Catch estimates indicated that lower stretch recorded 350 kg day^{-1}, followed by middle stretch (211.25 kg day^{-1}) and upper (134.12 kg day^{-1}). The fish productivity in upper and middle stretches were contributed by fishes belonging to the order Cypriniformes, whereas lower stretches were contributed by fishes of the order Perciformes. Gillnet is the major gear operated in the river (47.4%). Hook and line is the second major gear used by both active and part time fishers while castnet is the major gear used in monsoon season. The CPUE (Kg $person^{-1}$ hr^{-1}) was high in Azhinjillam (1.3) followed by Areekode (1.25) in the lower stretch. In the middle stretch, Nilambur and Mambad recorded a CPUE of 1.78 followed by Edavanna. Canoes were used as fishing crafts in middle and lower stretches. The analysis indicated that the fish productivity increased towards the lower stretch (7.69 kg km^{-1} in upper to 18.97 kg km^{-1} in the lower).

Keywords: Chaliyar, CPUE, gear estimates, productivity, stretch-wise diversity

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Loss of indigenous fish diversity from a flood plain wetland of Muzaffarpur, Bihar-A case study

Archana Sinha*, Prajna R. Swain, Ganesh Chandra, Pranab Gogoi, Archan K. Das and R. K. Manna

ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India

*sinhaarchana@yahoo.com

Bhusramaun, a seasonally opened Maun is located along the bank of Baghmati River in the Gayghat block of Muzaffarpur district of Bihar. This Maun has an area of 70 ha with a water depth of 2.85 meters. The Maun is under the ownership of Department of Fisheries, Govt of Bihar, and the fisheries management and access right is leased to Gayghat Prakhand Matsyajeevi Sahyog Samitee Limited. Seventy fisher families are dependent on this Maun for their livelihood. The Cooperative has given fisheries management rights to 12 member committee. Fishing is mainly done in group of 5-7 fishers and through drag netting. About 100 days fishing is done in a year with an average catch of 65 kg day^{-1} dragnet^{-1}. The fishes like Rohu, Catla, Mrigal, Reba and exotic carps form the predominant catch. A low biodiversity of fishes has been observed in this wetland. However, this Maun exhibits a good benthic population with a biomass of 60–500 individuals m^{-2} with a calculated Shannon biodiversity of 1.9. Although, fishes have been stocked in this wetland, especially the carps, but complete harvesting has been practiced by the fishers. Also, sporadic incidences of disease-induced fish kill have been observed in this Maun. In case of plankton, Cyanophyceae and Coscinodiscophyceae are the two dominant class with Coelastrum and Anabaena as dominant species. An observation was made regarding loss of small indigenous fishes during fishing for the commercial carps. The local fishers catch and sell the commercial food fish, but a large number of small varieties of fish are thrown away as trash leading to a considerable loss of important small indigenous fish species, which is a cause of great concern.

Keywords: Bihar, discard, flood plain wetland, small indigenous fishes, trash fish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Assessing the invasive potential of Alligator Gar in the Indian Subcontinent

Mohamed Nisin, K. M. N.*[1,2], Sreenath, K. R.[1] and Miriam Paul Sreeram[1]

[1]ICAR–Central Marine Fisheries Research Institute, Ernakulam North P.O., Kochi – 682 018, Kerala, India
[2]School of Marine Science, Cochin University of Science and Technology, Kochi-682 022, Kerala, India

*nisinnisai@gmail.com

Among the five direct drivers of biodiversity loss, invasive species emerge as one of the most critical factors with regional and global ramifications, according to the IPBES 2023 assessment report. However, invasive species do not get the attention it deserves due to their indirect and passive influence on the ecosystem. Climate change, land and sea-use change, and pollution, combined with anthropogenic stressors, aid in introducing, expanding and establishing non-native species outside their native range. In this work, the habitat suitability of Alligator Gar, *Atractosteus spatula* (Lacepède, 1803), a commonly traded ornamental fish, in the Indian subcontinent was assessed. There were reports of Alligator Gar being unintentionally released into the river network of Kerala during the 2018 floods. The predatory nature, large body size, and diverse diet preferences, combined with its ability to survive in a wide range of ecological niches, make it a formidable threat to the fauna and livelihood of the region. Few studies have been conducted to assess the invasive potential of the species. Therefore, the habitat suitability for the species in the Indian Subcontinent was studied using environmental niche modelling. A group of nine models, including machine learning, regression and classification, and environmental envelope algorithms were used. The individual models were combined using the ensemble modelling approach to form an accurate and better-performing ensemble model. Individual models were built, combining the occurrence record of the species and nine environmental variables. This study finds the Indian subcontinent with sub-optimum habitat suitability for Alligator Gar. Thus, Alligator Gar do not pose an invasion risk in the region. The mean temperature of the wettest quarter (BIO8) was identified as the most crucial variable determining habitat suitability in the ensemble model. Nevertheless, the predictions are based on models built on the correlation between the presence of species and the bioclimatic variables and do not factor in biotic interactions and traits of the species. A multitude of factors determine the successful establishment and proliferation of a non-native species in a novel setting. The results form a baseline data for initiating effective and efficient invasive species management and eradication.

Keywords: Biological pollution, Biomod2, invasion, management, modelling

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Opisthobranchs of Karnataka, India

Divya Viswambharan*, Geetha Sasikumar and Prathibha Rohit

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* divyaarinu@gmail.com

Opisthobranchs, commonly called as sea slugs are mesmerizing marine Gastropods. These organisms have undergone major evolutionary changes that have resulted in the loss or significant reduction of their shells. This captivating group plays crucial role in benthic marine ecosystems by grazing on macroalgae and bryozoans. With their vibrant colours often signalling toxicity, reef habitats are especially rich in sea slugs. India is home to 611 reported sea slug species belonging to 183 genera and 62 families. However, documentation of sea slug diversity has been inconsistent along the west coast of India, with only limited data available specifically for the Karnataka Coast. To address this gap, exploratory surveys were conducted between 2018 and 2022 in the vicinity of selected rocky reefs and coral reefs along the Karnataka Coast. Underwater visual census surveys were conducted, involving 80 SCUBA-assisted dives, documenting sea slugs through photographs and recording the benthic substrates hosting these creatures. The identification of species was achieved by referring to the characteristics listed on the web-based portal 'The Sea Slug Forum.' The study compiled a comprehensive checklist of sea slugs reported along the Karnataka Coast by combining data from the present survey with information from previous literature and citizen science projects. The survey discovered nine commonly occurring sea slug species, found in both inshore and offshore reef areas, at depths ranging from 1m to 18m. Despite the abundance of ideal habitats along the Karnataka Coast, sea slugs continue to be one of the least studied marine molluscs. The checklist documented opisthobranch sea slugs from various coastal ecosystems in Karnataka, with Nudibranchia being the dominant order. Most of these sea slugs were spotted between the post and pre-monsoon months (October to May), feeding on macroalgae, encrusting sponges and bryozoans abundant in coastal reefs. Coral reef areas had the highest number of sea slug records, followed by rocky reefs. Given their elusive nature and habitat preferences, it is likely that the number of sea slugs in Karnataka waters is underestimated. By shedding light on the diversity and distribution of sea slugs in this region, the study contributes to our understanding of these fascinating marine organisms and emphasizes the importance of protecting their distinct ecosystems.

Keywords: Coral reef, Eastern Arabian Sea, Nudibranchia, rocky reef

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Diversity indices and biomass variation of macrofoulers on test panels between fish farm site and the reference site at Karwar, west coast of India

Sonali, S. M.[1,2*] and Dineshbabu, A. P.[2]

[1]ICAR-Central Marine Fisheries Research Institute, Ernakulam North (P.O.), Kochi-682 018, Kerala, India
[2]Department of Biosciences, Mangalore University, Konaje, Mangalore.

[*] sonamdkar@gmail.com

The present research attempts to study the diversity indices and biomass variation of macrofoulers recruited on test panels installed in sea cage farm at Karwar, west coast of India. The monthly diversity indices of the fish-farmed site and reference site were compared by taking the density of macrofoulers on the panels installed in both sites. The density (numbers/100cm^2) of the macrofoulers and biomass (grams/100cm^2) were analyzed using PAST-2.14 software. A total of 23 macrofouling communities were identified from both sites. Abundance-wise, Hydroids dominated on the test panels, and biomass-wise, green mussels dominated. The statistical analysis was carried out to compare the biomass of macrofoulers between the sites and depths. The biomass of the communities showed a significant difference between the depths of the two sites ($p<0.05$). Biomass was higher in the fish-farm site when compared to the reference site. The highest biomass was 686±90grams/100cm^2 at 6 m depth, and the lowest biomass was 0.03±0.01 grams/100cm^2 at 3 m depth. Heavy fouling of green mussels (*Perna viridis*) was observed on test panels of fish farm sites, where higher levels of nutrients were available. In the fish-farm site, the dominance index was high in December (1) due to the dominance of hydroids. In November, dominance index was high (1) due to green mussel dominance on 3 m and 6 m depth test panels. The diversity index was lowest (0) during December in 1m depth test panels and also during November in 3 m and 6 m depth test panels. Evenness was high in June and July. At the same time, the richness index was higher (1.72) in May in the reference site. Understanding the diversity and biomass pattern of macrofoulers will serve as a useful preliminary support-tool in initiating further research for improvising feasible husbandry mechanisms in cage culture farms in India. The results of the study will help in designing new integrated farming technologies and revising net maintenance protocols, thereby increasing the feasibility of sea cage farming operations.

Keywords: Biomass, diversity, fish-farm site, macrofoulers, test panels

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Seasonal variation in gastropod abundance in relation to seaweed density along the rocky intertidal area of Thikkodi, south west coast of India

Fasila, P.[1,2*], Vinod, K.[1] and Asokan, P. K.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Ernakulam North (P.O.), Kochi – 682018, Kerala, India
[2]Cochin University of Science and Technology, South Kalamassery, Kochi-682 022, Kerala, India

*fasila005@gmail.com

The study was conducted in the Thikkodi rocky intertidal area which is characterised by diverse macroalgal growth and located along the coast of Kerala, India. Gastropods were found to be one of the most abundant groups of macrofauna in this habitat, and the present study was aimed to understand the seasonal change in numerical abundance of gastropods in relation to seaweed density. Monthly sampling was carried out from October 2021 to September 2022 during low tide using 1m x 1m quadrats from sampling points fixed along the transect lines. Numerical abundance of gastropods and wet biomass of seaweeds were estimated. Statistical analysis was carried out using PRIMER +v.7. PEMANOVA test detected significant differences in seasonal variation of seaweed biomass (P(perm) = 0.0107; Pseudo-F=4.99) and gastropod numerical abundance (p=0.0059; Pseudo-F=5.25). Seasonal variation of seaweed biomass was correlated with numerical density of gastropod species by RELATE test which detected significant difference within the level factor season (season-Spearman rank (r)=0.627, p=0.01* sig.p < 0.05*). BEST analysis revealed that *Littoraria undulata* is more associated to *Cladophora vagabunda*, *Ulva intestinalis* and *Ulva compressa* (r=0.497) than *Cellana radiata* (r=0.324). *Clypeomorus batillariaeformis* and *Clypeomorus bifasciata* were more correlated to the seaweeds *C. vagabunda*, *Valoniopsis pachynema*, *Chaetomorpha crassa* and *Caulerpa sertularioides* (r=0.489). *Turbo intercostalis* was more correlated to *V. pachynema* and *Lychaete herpestica* (r=0.294), while *Trochus radiatus* was closely associated to *C. vagabunda* and *V. pachynema* (r=0.369). The gastropod *Anachis terspsichore* was found to be associated with *V. pachynema*, *Caulerpa chemnitzia* and *Padina tetrastomatica* (r=0.681). The present study clearly indicated seasonal change in gastropod abundance in relation to seasonal change in seaweed density in the study area. It is evident that the presence of a particular population is governed by a specific set of ecological conditions prevailing at that period of time and it also reflects the habitat characteristics. The present study therefore provide insights to the relationship between gastropods and seaweeds in a rocky intertidal habitat and helps to forecast the gastropod abundance based on seaweed species succession and abundance.

Keywords: Gastropods, rocky shore, seasons, seaweeds, Thikkodi

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Rare occurrence of gastropod pearls from *Turbinella pyrum* and *Chicoreus ramosus*

Kavitha, M.*, Laxmilatha, P., Linga Prabu, D., Asha, P. S., Kalidas, C., Ranjith, L. and Vinoth Kumar, R.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* kavifish@gmail.com

Natural pearl is an exceptional gemstone that is generally produced by freshwater and marine bivalves. The occurrence of gastropod pearls is a rare event except in abalones. During our regular gastropod sampling in the field, fishermen informed about the presence of pearls from gastropods, *Turbinella pyrum* and *Chicoreus ramosus*. The gastropods with pearls were collected from the commercial gastropod catch at Kalavasal landing center, Gulf of Mannar, exploited by skin diving. The pearls were noticed during the removal of meat from the shell which is the common process before trading the shells. Three spherical, light orange-colored pearls were observed from the tissue part of three *T. pyrum* shells. The size and weight of the pearls were 13 mm & 4.3 g; 14.2 mm & 5.2 g and 17.7 mm & 6.5 g from *T. pyrum* with the size of 168 mm & 680 g; 203 mm & 840 g; 172 mm & 704 g, respectively. Two types of pearls and nacreous lumps on the operculum were noticed in *C. ramosus*. First type is a light pinkish-coloured spherical shape pearl (3 mm) which was observed in *C. ramosus* of 165 mm and 678 g. The second type of pearl had an irregular shape that resembled a white rose flower (12 mm) in *C. ramosus* measuring 180 mm & 924 g. Apart from this, the presence of whitish pink-colored nacreous lumps with a thickness of 5-7 mm was found in the operculum of three specimens of *C. ramosus*. Like pearl-producing bivalves, pearl production in marine gastropods occurs through the accidental trapping of extraneous material in the body that becomes pearl by the secretions of its mantle tissue. This is evident from the nacreous lumps found in the operculum that has entrapped net filament in it, which stimulates the nacreous secretion over it by the mantle tissue. Pearls and nacreous lumps from *T. pyrum* and *C. ramosus* are the rarest and less-known natural pearls in the world. Marine gastropod pearls (except abalone) are rarely reported from *Melo melo*, *Strombus gigas*, *Pleuroploca gigantea, Cittarium pica* and *Buccinum undatum*. Though gastropod pearls are mostly non-lustrous unlike bivalve pearls, due to their rarity it fetches very high price in the market. The FTIR analysis was carried out to find out the chemical nature of the material and the peak value of 714 cm^{-1},852 cm^{-1}, 1081 cm^{-1}, and 1454 cm^{-1} confirmed the aragonite nature of pearls.

Keywords: Aragonite, gastropod, nacreous, operculum, pearl

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Mangrove associated avian fauna of Korapuzha Estuary, Calicut, Kerala

Ramya Abhijith*, Vinod, K., Bindu Sulochanan and Shilta, M. T.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*ramyakovilody@gmail.com

The present study recorded a total of 79 species of avian fauna from the Korapuzha mangrove forest which belonged to 57 genera, 30 families and 12 orders. The order Passeriformes was represented by 23 species (29.1%), while 21 species belonged to the order Charadriiformes (26.5%). The most dominant families recorded from the study site on a monthly basis were Phalacrocoracidae, Ardeidae, Laridae, Accipitridae and Scolopacidae. Of the 57 genera, 18 genera (32%) belonged to the order Passeriformes, while 11 genera (19%) belonged to the order Charadriiformes. Of the 30 families, 14 families (47%) belonged to the order Passeriformes and three families (10%) belonged to the order Charadriiformes. Of the 79 species of birds recorded from the study sites, 51 species were local resident fauna (65%), 8 species showed local migration (10%) and the remaining 24 species (30.9%) are migratory. Among the birds of the Korapuzha mangrove forests, Black capped kingfisher *Halcyon pileata* is listed as Vulnerable (VU) in the IUCN Red List of Threatened Species. The Oriental darter *Anhinga melanogaster*, Eurasian curlew *Numenius arquata* and Black-headed Ibis *Threskiornis melanocephalus* are listed as Near Threatened (NT) while the rest 75 birds (94.9%) are considered as Least Concern (LC). Four species are listed under Schedule I, two species in Schedule V and 73 species (92.4%) are listed in Schedule IV of the Indian Wildlife (Protection) Act, 1972. The most dominant species recorded from the study site are Great Crested Tern followed by Little cormorant and Little Egret. Generally, birds can be considered as one of the indicators of habitat health and the present study will be useful for the managers to develop management plans for the conservation of avian fauna of Korapuzha estuary.

Keywords: Avian fauna, Biodiversity, Estuary, Korapuzha, Mangrove

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Microplastics: A growing concern for marine ecosystem and Biodiversity

Shubham Kanaujiya[*], Anshika Pathak[1], Sayan Roy[2] and Shri Kant Yadav[3]

[1]ICAR-National Bureau of Fish Genetic Resources, Lucknow-226002,Uttar Pradesh, India
[2]Department of Fisheries Resource Management, College of Fisheries, Mangalore, Karnataka, India
[3]Department of Aquaculture, CCSHAU, Hisar, Haryana, India

*sfisheries117@gmail.com

Microplastics, defined as small plastic particles less than 5 mm in size, have become a significant environmental concern due to their widespread presence in marine ecosystems. This abstract aims to provide an overview of the impact of microplastics on the marine environment. It synthesizes current research and highlights the various ways in which microplastics affect marine organisms, ecosystems, and the overall health of our oceans.

Microplastics enter the marine environment through a variety of sources, including the fragmentation of larger plastic items, industrial processes, and the breakdown of synthetic fibers. These particles have the potential to persist in the environment for hundreds of years, posing a long-term threat to marine life. Once introduced into the ocean, microplastics can accumulate in various habitats, including surface waters, sediments, and the digestive tracts of marine organisms. The ingestion of microplastics by marine organisms is a key concern. Filter-feeding organisms, such as plankton and bivalves, often mistake microplastics for food particles, leading to bioaccumulation and biomagnification of these particles within the food web. The presence of microplastics in the digestive systems of marine animals can cause physical damage, impair nutrient absorption, and disrupt feeding behaviour, ultimately affecting their growth, reproduction, and survival. As a result, the toxicological effects of microplastics extend beyond their physical impact, potentially leading to chemical contamination and adverse health effects on marine life. Microplastics also have the potential to alter marine ecosystems at a broader scale. They can modify the physical properties of sediments, affecting benthic communities and sediment-dwelling organisms. Additionally, microplastics can alter microbial communities, potentially disrupting important ecological processes, such as nutrient cycling and primary production. Mitigating the effects of microplastics requires a multi-faceted approach. Efforts should focus on reducing the production and consumption of plastic materials, improving waste management practices and developing innovative technologies for microplastic removal. Additionally, further research is needed to better understand the fate and behavior of microplastics in marine environments, their interactions with marine organisms, and the potential long-term consequences for ecosystem health. In conclusion, the presence of microplastics in the marine environment pose significant threats to marine organisms, ecosystems, and human well-being. Urgent actions are needed to reduce the input of microplastics into the oceans and mitigate their adverse effects. Addressing this global challenge requires international collaboration, policy interventions, and public awareness to protect and preserve the health and integrity of our marine ecosystems for future generations.

Keywords: Ecosystem damage, marine debris, shore seine, swept area

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Impact of fishing harbour activities on the coastal water quality of Tuticorin, south east coast of India

Asha, P. S.*, Usharani, A., Reeta Jayasankar, Kalidas, C., Ranjith, L., Linga Prabu, D., Kavitha, M., Vinoth Kumar, R. and Ramar Muniwaran, B.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*asha.ps@icar.gov.in

Thoothukudi fishing harbour is one of the major fishing harbours in east India. The elaborate harbour activities are causing considerable contamination of the coastal waters here. Periodic monitoring of the water quality conditions is necessary for improving the management of harbours; hence, the present study was conducted to analyse the impact of fishing harbour activities on the coastal water quality. Four stations were selected for the studies. The calm and turbid northern side of the harbour is selected as St.1 (Lat.08^{o}47'800"N; Long.078^{o}09'629"E), the central portion of the harbour towards the jetty is selected as St.2 (Lat.08^{o}47'695"N; Long.078^{o}09'603"E); the extended part of the finger jetty towards the southern side of the harbour area as St.3 (Lat.08^{o}47'558"N; Long.078^{o}09'678"E). The unpolluted coastal waters at the Inigonagar were fixed as control (St.4–Lat.08^{o}47'444"N; Long.078^{o}09'678"E). Monthly sampling was conducted at these stations from January 2021 to December 2022. Sixteen water quality parameters and oil and grease content were analysed following standard procedure. The coastal waters around the fishing harbour were relatively polluted as most of the water quality parameters were abnormal. Lower values of significantly varied dissolved oxygen concentrations ($p<0.05$) were noticed at the harbour stations. Higher values of total suspended solids, total chlorophyll, BOD and CO_2 were recorded. Except for silicate, nutrients like nitrite, nitrate and phosphate levels were also higher inside the harbour stations. Ammonia concentration was above the permissible limit in the harbour stations for most of the period. It varied from a minimum of 0.84 µg l^{-1} at the control station to a maximum of 7.6 mg l^{-1}at the southern tip (St.3). The oil and grease content were comparatively higher and significantly varied ($p<0.05$) at the harbour station. It ranged from 0.020 to 4.030 mg l^{-1} at the harbour station and 0.002 to 0.760 mg l^{-1} at the control station. The highest mean value of 1.279±0.36 mg l^{-1} was recorded at St.2. Altogether, the impact of harbour activities was highest at the Southern tip of the fishing harbour area, which reported poor water quality conditions for sixteen months of the study period. The central portion of the harbour (St.2) was the second impacted station, followed by St.3. The control station exhibited fair water quality conditions for most of the period.

Keywords: Coastal water quality, impact, nutrients, oil and grease, Tuticorin Fishing harbour

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Assessing benthic marine debris: A case study from RK Beach, Visakhapatnam

Loveson L Edward*, Pralaya Ranjan Behera, Suresh Kumar Pilli and Vishal Yadav

Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam-530 003, Andhra Pradesh, India

*loveson_edward@yahoo.co.in

The Ramakrishna Beach (RK) on the Visakhapatnam coast stretching nearly 3700 m near the Dolphin's Nose point on the East coast of the Bay of Bengal (17° 42 51N 83° 19 25E) is the most popular beach of Andhra Pradesh. Thousands of tourists and locals visit the beach and Visakhapatnam is known as the beach city of Andhra Pradesh. This also results in the increasing contribution to marine debris and the impacts on the coastal ecosystem are of growing concern. The paper attempts at using a shore seine gear engaged by the traditional fishers of the coast as a tool to understand the quantity of benthic marine litter distributed in the near shore waters and types of materials (rubber, plastics, metals). The study was conducted from November to March only, as the fishing practice was seasonal and restricted to this period. The operation of the shore seine is manually done from the beach by taking one end of the net to a distance into the sea and encircling and returning to the shoreline, a little away from the originating point. The two ends are then hauled closer to drag the bag of the net near shore, and the fishes are collected. The method adopted, covers an area equivalent to an equilateral triangle with the shore line distance as its base and the sides decided by the point where the net take a U-turn towards the beach (hauling distance). The total area of the bottom substrate swept will be dependent on the length of the hauling rope together and the area of the equilateral triangle formed by the net. The total bottom swept area was estimated through the calculation of the area of the triangle and rectangular imaginary forms (Sparre and Venema, 1989). The study covered observations from 41 hauls, which covered a seabed stretch of 20.54 kilometres and an effective area of 18.78 square kilometres. The paper discusses the details of the quantities of the types of materials collected, the share of beach litter and other sources and the methods followed. The observations and data generated will be an important information for the local administration, for effective management and preparation of guidelines for tourists and the public, shore managers, academics and marine biologists. The assessment of ecosystem damages, evaluation of the resultant losses, tracing of the sources and fixing responsibility are the long-term plans of the study.

Keywords: Ecosystem damage, marine debris, shore seine, swept area

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Microplastics from abandoned Fibre glass reinforced plastics (FRP) fishing boats: Emerging concern for the marine environment

Manju Lekshmi, N.*, Sreejith S. Kumar and Muhamed Ashraf, P.

[1]ICAR-Central Institute of Fisheries Technology, Cochin- 682029, Kerala, India

*manjuaem@gmail.com

Fibreglass reinforced plastics (FRP) is a widely acceptable material for the construction of fishing boats. However, due to the high costs and recycling challenges associated with thermosetting composites, many end-of-life FRP boats are abandoned in coastal zones, significantly contributing to marine litter. There is very little information on the occurrence, fate and effects of FRP in the marine environment, and especially regarding microplastics. This study aims to quantify and characterise the microplastics at the disposal sites of abandoned fishing boats in a small-scale fish landing centre of Kerala. High concentrations of plastic debris and microplastics have been found on and within the beach in the vicinity of boat disposal sites. The polymer content of selected, fractionated microplastics of various shapes, colours and sizes from the disposal sites was determined by attenuated total reflectance Fourier Transform infrared (ATR-FTIR) spectroscopy and the results revealed the presence of various resins (e.g., alkyd, polyester, epoxy). At the disposal sites, 1179 pieces of plastic debris were recovered, of which about 87% were FRP. Paint associated with FRP had variable contents of copper and lead, with concentrations of the latter being sufficient to contaminate sediments from a few mg kg^{-1} up to about 400 mg kg^{-1}. The relatively high density of FRP and its association with glass fibres and metal-bearing paints results in particles with potentially different fates and toxicities to more "conventional" (non-composite) thermoplastics. As concerns grow regarding the disposal of FRP fishing boats, this study provides valuable insights into the environmental impacts caused by their abandonment. The findings could contribute to the formulation of regulations and standards aimed at addressing these issues effectively.

Keywords: Abandonment, disposal, FRP, marine litter, microplastics

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Unveiling hidden plastic: Investigating the footprint of microplastics in India's cave waters and its implications for heritage sites

Bejawada Chanikya Naidu*, Sahana, M. D., Asha T. Landge and Martin Xavier, K. A.

ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*chanikya.frmpb006@cife.edu.in

Microplastic particles constitute a pervasive global issue, extensively documented in both marine and terrestrial ecosystems. Yet, the realm of microplastic pollution within caves and aquifers remains an understudied domain. To enhance our comprehension of this concern, we conducted a comprehensive investigation into microplastics within the cave waters of iconic heritage sites, specifically the Karla Caves, Lohagadh, and Ajanta Caves on the West Coast of India, and the Borra Caves situated on the East Coast of India. Furthermore, we examined the presence of microplastics within the resident fish populations. The methodology involved a meticulous process of microplastic extraction from both water and fish samples. This procedure encompassed digestion, filtration, sonication, density separation, and subsequent re-filtration, culminating in the application of Nile red staining. The stained filters were subjected to florescent microscopic examination, following the removal of organic matter. The microplastics were meticulously characterized based on attributes such as shape, color, and size, employing visual identification techniques. Our findings revealed the occurrence of microplastics within the cave waters of the West Coast, with concentrations ranging from 3 to 118 microplastic particles per liter, while the cave waters on the East Coast exhibited concentrations ranging from 11 to 78 microplastic particles per liter. Moreover, the *Nemacheilus* sp fish inhabiting these environments displayed an average microplastic concentration of 2.5 ± 1.9 particles per individual. Notably, a significant proportion of the recovered microplastics, comprising 67.61% from fish and 61% from cave waters, manifested as fibers falling within the <100 µm size category. These fibers were identified as being composed of materials such as low-density polyethylene (LDPE), polypropylene, polyamide, and polystyrene. These results underscore the presence of microplastics within heritage caves, emphasizing the importance of our study. Furthermore, we introduce a cost-effective and non-invasive analytical technique for the extraction and isolation of microplastics from cave waters and fish. This method offers valuable insights for assessing the environmental risks posed by microplastics within cave ecosystems. Importantly, our study represents the inaugural report on microplastics within the cave waters and fish of Indian caves, contributing to the broader scientific understanding of this critical issue.

Keywords: Enzymes, eco-friendly, green method, sustainability, waste management

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative life cycle assessment of small scale FRP and FRP sheathed fishing boats of Kerala

Sreejith S. Kumar*, Dhiju Das, P. H., Paras Nath Jha and Manju Lekshmi, N.

ICAR-Central Institute of Fisheries Technology, Head Office, Willington Island, Kochi-682029, Kerala, India

*sreejith1083@gmail.com

The study presents a concise Life Cycle Assessment (LCA) of Fiberglass Reinforced Plastic (FRP) and FRP sheathed plywood boats used in Kerala's small-scale fishing sector. As FRP is a thermosetting plastic, there is no viable recycling options in India, especially in the context of FRP sheathed boats. Common disposal methods in Kerala, such as backyard burning and landfilling, have significant adverse effects on the marine environment. This research evaluates the environmental impacts across the entire life cycle of these boats, encompassing production, operation, and disposal phases, using LCA approach. The LCA method was adopted for different impact categories like acidification potential, abiotic depletion potential, eutrophication potential, global warming potential, human toxicity potential etc. Primary data from 10 boat building yards and secondary data from published literature sources were used to create life cycle inventories for two distinct boat categories: FRP sheathed boats (7-year lifespan) and FRP boats (30-year lifespan). The study highlights notable differences between the two boat types. For instance, a 7-meter FRP boat exhibits an annual Global Warming Potential of 35 kg CO_2-Equiv, while a similar-sized FRP sheathed boat records 63 kg CO_2-Equiv (180% higher) annually. Likewise, the Human Toxicity Potential per year is significantly higher for FRP sheathed boats, with 4.5 kg DCB-Equiv (225% higher), compared to 2 kg DCB-Equiv for FRP boats. These findings underscore the pronounced environmental impacts of FRP sheathed boats due to their short lifespan. Urgent attention is needed to establish standards and regulations for the construction (quality and quantity), recycling, and disposal of FRP fishing boats, taking into account of their environmental footprint in the marine fishing sector. This research advocates for the adoption of sustainable practices in boat construction and disposal, identifying key environmental concerns and opportunities for improvement throughout their lifecycle.

Keywords: Boat disposal, environmental impact, Fiberglass-Reinforced Plastic (FRP), Life Cycle Assessment

XVI ASC | T6S1-148

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative life cycle assessment of *Litopenaeus vannamei* farming: Evaluating environmental sustainability

Razia Mohamed, A.*, Dhiju Das, P., Manoj P. Samuel, Leela Edwin and George Ninan

[1]ICAR–Central Institute of Fisheries Technology, Matsyapuri P.O., Willingdon Island, Kochi – 682029, Kerala, India

*razia.mohamed.a@gmail.com

The global demand for seafood has fueled the expansion of India's seafood export industry, with significant contributions from *Litopenaeus vannamei* (whiteleg shrimp) production. However, growing concerns regarding the environmental ramifications of this industry have spurred a comprehensive assessment. This study employs a life cycle assessment (LCA) framework to thoroughly evaluate the environmental performance of *Litopenaeus vannamei* production, encompassing both upstream and downstream processes. In this study, surveys on 10 Biofloc Technology (BFT) units with intensive culture and 10 earthen ponds with semi-intensive culture were conducted, and the data inputs were used to conduct a cradle-to-farm-gate LCA by means of software Gabi and application of CML Inventory Analysis (CMLIA), with the robustness of results scrutinized through sensitivity analysis. Data encompassing resource consumption, energy usage, and emissions were meticulously gathered for each phase of shrimp production. The study revealed that feed production and energy consumption are the main contributors to the environmental footprint of aquaculture, while acidification, eutrophication, and global warming potential are the most dominant impact factors. Intensive and semi-intensive systems exhibit trade-offs in resource use and management, with some impacts increasing–especially energy consumption potential, with higher production intensities. Natural pond cultivation can reduce feed costs and water consumption by 18-20% through resource-efficient feed management and wastewater recycling. Similarly, in biofloc systems, nutrient cycling and organic byproduct utilization enhance shrimp growth and reduce external nutrient inputs by 26-30%, improving productivity and water quality. The study underscores the need for environmental friendly solutions across sectors like electricity generation, aquatic feed production, manufacturing, water management, and transportation. To ensure sustainability and a circular economy, the study recommends environment-friendly, nutrient-recycling aquaculture systems that use renewable and green energy sources for intensive culture. These insights provide essential guidance for policymakers, industry stakeholders, and environmental advocates, aiding in the formulation of strategies to mitigate seafood export's environmental impact.

Keywords: Aquaculture, environmental footprint, Life Cycle Assessment, sustainability

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Unlocking new horizons: Exploring in-situ growth studies of limited mobility crustaceans through 'Marine Citizen Science' data integration–A case study of *Solenocera choprai* in the Southeastern Arabian Sea

Dineshbabu, A. P.*

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*dineshbabuap@yahoo.co.in

The use of 'Citizen Science' in marine fisheries research has aided public participation in natural resource management, resource conservation, environmental preservation and decision-making around the world. The potential of a "Marine Citizen Science" platform, which incorporates the expertise and data supplied by innovative, well-trained commercial fisherman organizations, rekindles a feasible chance for academics to monitor the fishery with a low financial investment. Crustaceans, unlike finfish, lack a bony structure that records an impression of internal or environmental changes, allowing age to be determined directly. Crustaceans grow during the moulting process; however, in general, growth on penaeid shrimps is thought to follow a sigmoidal growth pattern similar to that of fishes, and the VBG formula is widely acknowledged as the only valid approach for determining their growth. Tagging (release and recapture procedures) and studying their growth in captivity were some of the ways examined for measuring shrimp growth, but they each had their limits when compared to growth in the wild. *In situ* growth evaluation in the natural ground is the best alternative for studying shrimp growth in its natural habitat, but high expenses in data collection generally forced researchers to do away with this option. Using "Citizen Science data" in marine fisheries research has opened up many possibilities for in situ growth and migratory investigations, especially for species with limited spatial distribution, by tracing the trends in size groups in a given fishing area. The current study demonstrates the value of combining geo-tagged 'Citizen Science data' on the *Solenocera choprai* fishery with traditional landing data to illustrate its great potential for gaining considerable spatial information on the resource. Using MCZ data support, the growth data derived from the von Bertalanffy growth function (VBGF) was compared with in-situ mode shifting in the natural fishing ground. Slow-moving bottom-dwelling fishes, lobsters, bivalves, gastropods, and echinoderms can all benefit from the spatial data assistance provided by "Citizen Science". Institutionalized data collection processes, together with a well-organized scientific research program for "Citizen Science" data analysis, can pave the way for broad areas of research in marine fishery resources and fishing grounds that have been put on hold owing to a lack of funding.

Keywords: Growth studies, marine citizen science, resource distribution, *Solenocera*, trawl fishing

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Self-governance of brown mussel *Perna indica* resource along southwest coast of India

Gomathi, P.*, Anil, M. K., Geetha Sasikumar, Laxmilatha, P., Shalini, O. and Krishnapriya, P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*gomathimfsc@gmail.com, Mobile:7401178609

Perna indica (brown mussel) is one of the two important mussel species distributed and exploited along the Indian Coast. The Vizhinjam-Kovalam region, southwest coast of India, is one of the important brown mussel fishing areas, and this resource has a limited distribution from Kollam on the southwest coast to Tiruchendur on the east coast. This age-old mussel fishery currently supports the livelihood of 300 fishermen in the area. These fishermen have organised and registered as a "Diving Worker's Welfare Society" (Reg. No.TVM/TC.1514/2014) for self-governance of the resource. Decisions are made here to effectively manage the fishery in a timely manner. The committee has formulated the rules and regulations to be adopted and disseminated to the members through posters at the landing centre since 2019. In 2022, the quota system was introduced by the society. The quota system allows each fisherman to collect a maximum of 40 kg (2 baskets [kutta] of mussels per head). This is a voluntary management measure that is followed without enforcement by the government or any other institutions. Further, there are other rules and regulations that are followed voluntarily that limit the collection of juvenile mussels, a closed holiday for fishing on Fridays and, restriction on fishing by outsiders, restriction on fishermen to collect both lobster and mussels on any day. Rules are framed not only for mussel pickers, it also make buyers responsible by making them pay a fine for buying juvenile mussels. Since it is self-regulated and voluntary in nature, no single violation was observed, though a fine of Rs.2, 000-10,000/- has been decided by the committee.

Keywords: Brown mussel, fishermen, *Perna indica*, self-governance, southwest coast of India

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Co-creation of solutions to challenges in small scale fisheries through community engagement

Nikita Gopal*[1], Rejula, K.[1], Sandhya, K. M.[1], Madhu, V. R.[1], Bindi Shah[2], Deepayan Bhowmik[3], Bethan O'Leary[4], Richard James MacCowan[5] and Paul Kemp[2]

[1]ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India
[2]University of Southampton, UK
[3]Newcastle University, UK
[4]University of Exeter, UK
[5]Biomimicry Innovation Lab, UK

*nikita.gopal@icar.gov.in

Engaging the community in co-creation of solutions to identified challenges is a bottom-up approach that has the potential for greater success in implementation strategies. A study funded by the Royal Academy of Engineering, United Kingdom tried to understand socio-economic and cultural changes in small-scale fishing over time in Kerala, and identify potential for co-created solutions to identified challenges. In total 66 interviews and 6 workshops were conducted with fishers (men) and fish processors (women) to improve understanding of gender-specific perceptions, challenges and solutions in the small-scale fishery sector in Kerala and help co-create potential solutions to identified challenges. Men identified hike in operational expenses of fishing; exploitation by middlemen; financial issues; need for government interventions; attack by dolphins; health issues and others like climate change, poor weather forecasting and plastic pollution as the problems in fishing: They suggested solutions like improved infrastructure facilities; active involvement of state government; prompt weather warning system; assurance of safety at sea (e.g. provision of life jackets). Women identified poor/ insufficient access to inputs and infrastructure; poor/ insufficient access to capital; poor facility for waste management; health issues and drudgery; climate change related issues; and food safety issues as problems experienced in fish processing:. They suggested solutions like subsidised loan and other financial aid to women; scientific waste disposal and production of feed from waste; regular supplier of fish for procuring fish from the harbour at a reasonable price; equipping women with proper fish drying tools and techniques; better marketing strategies, product diversification, labelling etc., and improving training and awareness in food safety standards. The utility of stackable fish drying tools and access to storage for women fishers was identified and these have been manufactured and/ or purchased with project funds and supplied to the women to be used through a facilitation centre (local cooperative society). The existing relationships between ICAR-CIFT and the local community were tapped into for facilitating the field work. Through the workshops, the voices of women engaged in the small-scale fishery sector could be strengthened. The impact has been that improved mechanisms for feedback from local community to ICAR-CIFT to improve societal conditions for those engaged in the small-scale fishery sector could be established. Other spin-offs like the utility of development of an android mobile app for use by fishers in Kerala, among whom smartphone use is widespread is being explored.

Keywords: Co-creation, fish drying racks, fishermen, fisherwomen, small scale fisheries

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Fisheries-based Aqua Tourism–an emerging entrepreneurship opportunity in Odisha, India

Ashmita Pandey[1*], Shubham Soni[1], Amjad Balange[2] and Layana Porayil[1]

[1]ICAR-Central Institute of Fisheries Education, Mumbai-400 061, Maharashtra, India
[2] Division of Animal, Poultry and Fisheries Science, ICAR–Indian Agricultural Research Institute, Dirpai Chapori, Dhemaji, Assam, India

* ashmitapandey11@gmail.com

India is known to have vast aquatic resources, and among these is the state of Odisha, which holds an unique position in India's fisheries sector. With its extensive coastline stretching over 480 km and abundant aquatic resources, Odisha encompasses 6.86 lakh ha of inland freshwater resources, including tanks, reservoirs, lakes, and rivers, and 4.18 lakh ha of brackishwater resources comprising Chilika lake, estuaries, and aquaculture areas. The state has remarkable per capita annual fish consumption of 16.24 kg and is the fourth-largest fish producer, yielding 8.16 lakh tonnes annually. Recently, aqua tourism is gaining prominence, particularly the fisheries-based aqua tourism, offering an avenue for additional income for fishermen and farmers. It integrates tourism activities with fisheries and encompasses marine, coastal, and freshwater experiences. This sector promises to drive economic growth, create employment, and foster sustainable development in coastal and inland areas. Despite the ongoing efforts in Odisha to promote aqua tourism, there is still a need for systematic awareness and improvement towards fisheries-based aqua tourism. To address this, a study was undertaken to assess the awareness of 52 fisheries stakeholders, particularly department officials, on fisheries-based aqua tourism in Odisha through an online questionnaire-based survey. Results showed that 65% of respondents were familiar with aqua tourism, with 45% participating in beach vacations and lake boating activities. However, only 40% were aware of fisheries-based aqua tourism, and among them, 45% had visited aquafarms. Encouragingly, 85% believed that fisheries-based aqua tourism could create entrepreneurship opportunities in Odisha. The study also identified challenges in developing fisheries-based aqua tourism, wherein lack of awareness and marketing (62%) and inadequate infrastructure (48%) emerged as top concerns. Respondents proposed solutions, including improved government policies (75%) and increased marketing efforts (53%). The study also identified potential avenues for both inland and marine aqua tourism. For inland sector, suggested aqua tourism avenues encompassed recreational reservoir fishing, river rafting, sport fishing, aquaculture theme parks, and immersive experiences like "Make-Your-Own Pearl Jewel," involving hands-on pearl crafting. In marine sector, proposals included fishing experiences on fishing boats, underwater plogging, seaweed and lobster picking. This study highlighted the potential of aqua tourism as an emerging entrepreneurial opportunity in Odisha. Strengthening infrastructure and implementing effective policies and marketing strategies are crucial to harness this potential fully. The proposed fisheries-based aqua tourism activities in both inland and marine sectors offer diverse experiences that can attract tourists and drive economic growth.

Keywords: Aqua tourism, entrepreneurship, fisheries, Odisha

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Ecological characteristics of the newly established "Dugong Conservation Reserve" in Palk Bay, Tamil Nadu

Thirumalaiselvan, S.*, Raju Saravanan, Rajkumar, M. and R. Ratheesh Kumar, R.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* aquathiru4u@gmail.com

On 21st September 2022, the Government of Tamil Nadu notified the establishment of the country's first 'Dugong Conservation Reserve' in the Palk Bay region, in order to protect the endangered Dugong species and its marine habitats in Palk Bay. The Reserve cover the coastal waters offshore to a 10 km distance starting from Adirampattinam (Thanjavur District) to Ammapatinam (Pudukkottai district), with an area of 448.34 square kilometres. The maximum water depth of this area is 12m and the bottom soil characteristics is clay muddy and sandy in nature. The predominant seagrass species in this region are *Cymodocea* sp., *Syringodium isoetifolium* and *Halophila* sp. Nearly fifty percent of the seabed has been found to be covered with loosely packed clay muddy bottom to a depth of 0.5 to 3m. This Conservation Reserve receives freshwater inflow from small seasonal rivers along its coast. The coast has luxuriant growth of mangroves, especially *Avicennia marina*. This paper discusses the baseline information on ecological characteristics of Dugong Conservation Reserve in the Palk Bay.

Keywords: Dugong Conservation Reserve, ecological characteristics, Palk Bay, seagrass

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Nesting of Olive Ridley Sea turtle (*Lepidochelys olivacea*) in Car Nicobar Island, Andaman and Nicobar Islands

Kiruba-Sankar, R.*, Sirisha Adamala, Jessica Barman, Saravanan, K., Praveenraj, J., Ramakrishna, Y., Karunakaran, D. and Zamir Ahmed, S. K.

ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India

*rkiruba.sankar@icar.gov.in

The study reports the solitary nesting of the Olive ridley sea turtle (*Lepidochelys olivacea*) in Car Nicobar Island. During the nesting season of Olive ridleys, the tribal fishermen in Car Nicobar were sensitized on the sea turtle nesting habitats and advised the fishermen to inform us in case they spot turtle nests and eggs on the beaches. Based on the inputs from fishermen, we recorded a new nesting site of Olive Ridley turtles, on the Teetop village in Car Nicobar Island. The turtle made two nests on the sandy beach of Teetop; separated within less than 5m. The nesting and hatchlings were observed during the month of April 2023. The hatchlings were observed following a non-invasive survey through visual observation, photographs, and the assistance of local indigenous fishers. The turtles were identified as olive ridley turtles based on their number of costal scutes which were more than five. Approximately around 100 olive ridley neonates moved to sea after hatching, which was witnessed during the field observations. The location where we found the two nesting sites in Teetop village is adjacent to a fish landing point of the local tribes who are involved in fishing using their traditional crafts locally known as Hodi, as well as a few motorized fishing boats. This information was shared with the local governing administration providing details of the geographical coordinates of the turtle nests, since this report on olive ridley nesting could potentially assist the decision-makers in marine spatial planning and coastal land-use in Car Nicobar. In our subsequent surveys, we could locate nests with leftover egg rubbles on Kimios beach, but could not identify the species that have nested. Our further attempts would involve promoting the conservation of sea turtles with the help of local indigenous people. Such attempts can benefit the tribal communities who depend on marine resources for their food security and livelihood on a long-term basis.

Keywords: Car Nicobar, endangered, hatchlings, island, nests, traditional community, turtle

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Marine mammal-fishery interaction and indigenous mitigation measures followed by fishers along the west coast of India

Prajith, K. K.*, Paras Nath Jha, Rithin Joseph, Hrishikesh, M. and Zainul Abid

ICAR-Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri P.O., Kochi-682 029, Kerala, India

*prajithkk@gmail.com

Marine mammals function as key indicators of ocean health and play a vital role in ecosystems. Worldwide, 130 species of marine mammals are identified from various oceanic regions. Out of 130 species, 26 species are reported from India. Globally, many marine mammal species enjoy conservation status and are highly vulnerable to human activities. Fishing is one of the events which results in incidental catch and mortality of marine mammals. A survey was conducted along the Kerala coast to study and document the various mitigation measures followed by the fishers. The interviews were carried out with a pre-tested structured questionnaire which covers the technical aspects and operational details of major fishing types. The discussions were held in the local language Malayalam. Gillnets and ring seines are more susceptible to marine mammal interaction. Indo-pacific humpback dolphin, Spinner dolphin, Finless porpoise, Risso dolphin, Indo pacific bottlenose dolphin, common dolphin and whales are the major mammal groups interacting with fishing systems. The major mitigation measures followed by the fishers are the use of Dolphin Wall Net (DWN), making noise with sticks, feeding the dolphins, throwing stones in water, and avoiding fishing grounds etc. Study revealed that fishers are aware of the importance of marine mammals and conservation needs. Both positive and negative interactions were reported during the study. The indigenous mitigation measures followed by the fishers are simple and effective and do not cause any harm to the mammals. Use of modern mitigation measures like pingers is not reported during the survey, except from one site in the Kollam district. The present study suggests the need for a scientific assessment of the efficacy of ingenious mitigation measures and trials with modern mitigation measures.

Keywords: Conservation, dolphins, fishery resource management, marine mammals, responsible fisheries

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Indian Seas' Spinners: Studying *Stenella longirostris* distribution and habitat

Durga, V.*, Sreenath, K. R., Ratheesh Kumar, R., Mohamed Nisin K. M. N., Vinayak, S., Rahul Rajan, Jayashankar, J., Jeyabhaskaran, B., Vivekanandan, E. and Gopalakrishnan, A.

ICAR- Central Marine Fisheries Research Institute, Ernakulam North P.O., Kochi – 682 018, Kerala, India

*durgav12071999@gmail.com

Marine mammals represent a diverse group of warm-blooded organisms that have evolved to inhabit oceans and seas, thriving across various oceanic habitats. As apex predators, they play a pivotal role in ecosystem health, nutrient cycling, and shaping the community structure of the oceans. The Spinner Dolphin, *Stenella longirostris* (Gray, 1828), a prevalent cetacean species, is notably abundant in warm open waters of Indian Ocean. However, spinner dolphins face multiple threats, encompassing ship collisions, coastal development, pollution, and other anthropogenic activities. Despite their ecological significance, there is a lack of comprehensive data regarding their habitat and range along the Indian coast. While evidence from sightings and strandings exist, the precise distribution and habitat preference in the region remain ambiguous. To address this gap, our study endeavors to determine the habitat suitability of Spinner dolphins in Indian waters using ensembled Species Distribution Modelling (eSDM). We integrated datasets on occurrence and predictive variables such as sea surface temperature, current velocity, depth, salinity, chlorophyll, among others, to construct an ensemble model. Ten specific algorithms (ANN, CTA, FDA, GAM, GBM, GLM, MARS, RF, SRE, MAXENT and XGBOOST) were used to build the ensemble model. The study reveals that the distribution of Spinner dolphins is significantly influenced by oceanographic factors including temperature, salinity and total suspended matter. These findings particularly highlight the habitat suitability of Spinner dolphins off the west coast of India, the Lakshadweep Sea, proximate to the Gulf of Mannar, Sri Lanka, and Southeast India. The derived projections offer a robust foundation for pinpointing spinner dolphin habitats along the Indian shoreline. This research can guide future surveys to regions with higher species presence probability, assess species responses to habitat changes, and identify vital areas for conservation prioritization.

Keywords: Arabian Sea, Bay of Bengal, cetaceans, environmental predictors, Species Distribution Modelling

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Evaluating the distribution and habitat suitability of the Humpback Dolphins, *Sousa plumbea* and *Sousa chinensis*, in Indian waters

Utthamapandian, U.*, Sreenath, K. R., Ratheesh Kumar, R., Mohamed Nisin, K. M. N., Rahul Rajan, Jayasankar, J. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* utthamapandian17@gmail.com

Humpback dolphins, commonly found in coastal seas, have recently been identified as multiple distinct species. Prior research suggested that the Indian Peninsula demarcates the distribution of two humpback dolphin species: *Sousa plumbea* and *Sousa chinensis*. This study evaluates this proposition by assessing the habitat suitability of both species along the Indian coastline. We utilized an ensemble of 11 Species Distribution Models (ANN, CTA, FDA, GAM, GBM, GLM, MARS, MAXNET, RF, SRE, XGBOOST) for our analysis. Occurrence records were sourced from the open-source databases, while environmental variables were derived from the Bio-Oracle. Our findings reveal that *Sousa plumbea* exhibits higher habitat suitability in the northwestern Indian Ocean and along India's western coast, while *Sousa chinensis* prefers the northeastern Indian Ocean and India's eastern coast. Contrary to previous understanding, our models show niche overlap and partial habitat suitability for both species on both coasts. Identifying these areas of suitability and overlap can guide policymakers and conservationists in effectively allocating resources and devising protective measures for humpback dolphins and their crucial habitats. By mapping habitat suitability, our study delineates the potential environmental determinants for both species along the Indian coast, serving as a benchmark habitat projection reference for future research.

Keywords: Arabian Sea, Bay of Bengal, coastal cetaceans, determinant variables, Species Distribution Model

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Sperm Whales in Indian Waters: habitat and distribution analysis

Zainul Abid, P. M.*, Sreenath, K. R., Ratheesh Kumar, R., Mohamed Nisin, K. M. N. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* alaaqua1999@gmail.com

The Indian seas are home to a wide variety of marine life including rich marine mammal diversity, due to its expansive maritime domain. The sperm whale (*Physeter macrocephalus*), a sentinel species of healthy marine ecosystems, is of significant interest due to its ecological importance and conservation status. Despite extensive research on sperm whales in the Atlantic, Pacific, and sections of the Southern Oceans, their distribution in the Indian Ocean remains inadequately explored. This research employs an integrative Species Distribution Modelling (SDM) approach that combines remote sensing data and the occurrence data of the sperm whales to elucidate the habitat suitability and distribution patterns of sperm whales in Indian waters. Eleven modelling algorithms were built combining data collected from the literature and open-source databases. The models were constructed using a set of 10 environmental covariates, sourced from Bio-oracle. Thereafter, an ensemble species distribution modelling approach was employed to combine the different models. The ensuing model underlines the sperm whales' distinct inclination towards deep-water regions, especially those adjacent to continental slopes. Importantly, waters near the Andaman and Nicobar Islands, southern regions around Sri Lanka, and the southwestern Indian coast emerge as crucial habitats. In an era marred by escalating human-induced threats such as ship strikes, marine pollution, and acoustic disturbances, our findings accentuate the need for strategic conservation initiatives and insightful marine territorial planning to safeguard these marine giants and their habitats.

Keywords: Conservation, Indian Seas, marine mammal, *Physeter macrocephalus*, SDM

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Exploring ecological attributes and optimal fishing scenarios for the multispecies fisheries of Gayatri Reservoir, India

Preetha Panikkar[1]*, M. Feroz Khan[1], Vijaykumar, M. E. [1], Jesna, P. K.[1], Ajoy Saha[2] and Das, B. K.[2]

[1]Regional Centre of ICAR-Central Inland Fisheries Research Institute, Hessarghatta Lake Post, Bengaluru-560 089, Karnataka, India
[2] Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal, India

* preetha.panikkar@icar.gov.in

A static model of Gayatri Reservoir ecosystem in Karnataka, India was constructed and parametrized using 14 functional groups. Ecological analysis integrated in Ecopath with Ecosim was used to examine different indicators which describe the trophic flows and ecosystem attributes. The trophic impact routine showed that the top predators, fish eating birds has a high negative impact on *Notopterus notopterus,* Indian major carps (IMCs) and *Oreochromis niloticus*. Catfishes have a highly negative impact on the freshwater prawns, *O. niloticus*, minnows and to a lesser extent on barbs. Murrels (*Channa punctata* and *C. striata*) showed a negative impact on most of the fish groups, especially the IMCs and minnows. The presence of *N. notopterus* in the reservoir had a negative impact on barbs and minnows, as well as on other planktivores. It was attempted to model changes in the reservoir ecosystem due to fishing as a part of move towards ecosystem based management of fisheries. Simulation modelling was done to assess the impact of fishing effort on the biomass and catch under different scenarios. With an increase in fishing effort, the biomass of catfishes, *N. notopterus, O. niloticus*, and prawns decreased but the biomass of murrels and barbs remained stable. Doubling the fishing effort has a significant negative impact on the biomass of minnows, murrels, and *N. notopterus*, depleting their stocks in a couple of years. Reducing fishing effort levels can help to replenish the stocks of catfishes and *N. notopterus* to achieve MSY levels in the next two decades. Stocks of *O. niloticus* and prawns will remain below the MSY levels for the next 15 years and 3 years, respectively, even if fishing effort is reduced. Fishing effort has a significant impact on the biomass of different fish species, and sustainable fishing practices are necessary to maintain the stocks at maximum sustainable yield levels.

Keywords: Mass balanced model, Simulation model, Electivity index, Trophic level

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

National Repository of Fish cell lines: An integrated cell bank for *in vitro* applications and cellular agriculture

Murali S. Kumar[1], Ravindra Kumar[1], Basdeo Kushwaha[1*], Vijay Kumar Singh[1], Akhilesh Kumar Mishra[1], Uttam Kumar Sarkar and Jena, J. K.[2]

[1]ICAR-National Bureau of Fish Genetic Resources, Canal Ring Road, PO- Dilkusha, Lucknow, Uttar Pradesh
[2]Division of Fisheries Science, ICAR, Krishi Anusandhan Bhawan–II, New Delhi

*basdeo.kushwaha@icar.gov.in

Fish being a rich source of proteins, healthy fats, iodine, vitamin D, calcium etc. is considered the '*nature's superfood*'. To meet the growing demand for fish and fisheries products, we need to sustainably and efficiently harness the aquatic biodiversity and also explore new innovations utilizing cutting-edge technologies, such as cellular agriculture. Fish cell lines have traditionally been recognized as one of the best alternatives for biological research on whole animals. They have widely been employed in biological research, involving disease diagnosis and virus isolation; cytogenetic and genotoxicity studies; toxicology and gene expression studies; biobanking and cryopreservation studies etc. This is also reflected by the increased interest in the development of fish cell lines, wherein over 900 fish cell lines have been reported worldwide. Recently, cell lines have been evaluated for cellular agriculture by production of cell-based meat and there are a few attempts of developing cell-based seafood by a few start-up companies. One of the constraints for cell-based meat manufacturers is the availability of well-characterized cell lines, which they can then be used and engineered for the production process. National Repository of Fish Cell Lines (NRFC), a fish cell line bank was established with DBT support at ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow, India, in 2010 with the aim to maintain, develop and distribute authenticated fish cell lines. Today, NRFC has the world's largest collection of fish cell lines with 81 cell line accessions representing 40 fish species. These collections belong to 30 freshwater species, 7 marine species and 3 brackish water species. Tissue-wise collection includes fin tissues (27), gill tissues (10), heart (7), eye (6), spleen (5), caudal peduncle (4), kidney (4), muscle (4), brain (4), thymus (4), liver (2), testes (1), peritoneal (1), blood lymphocytes (1) and barbel (1). NRFC is a designated repository by Ministry of Environment and Forests, Government of India for Fish Genetic Resources category under Sub section (1) of Section 39 of Biological Diversity Act, 2002 dated 8 Nov. 2006. In last five years, the NRFC has accomplished over 70 cell line requests by providing authenticated, mycoplasma-free well-characterized fish cell lines to researchers. NRFC also offered technical support and hands-on training so that more and more researchers can use cell line resources effectively. These characterized fish cell lines, especially the muscle cell lines, are a valuable resource for evaluating cell-based food products in the fisheries sector.

Keywords: Cellular agriculture, fish cell line, ICAR-NBFGR, *in vitro* application, NRFC

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Gene Expression Atlas: A comprehensive gene expression resource for brackishwater aquaculture

Nimisha, K.*, Vinaya Kumar, K., Ashok Kumar, J., Mukhila, A., Karthic, K., Sudheesh Kommu, P., Gangaraj Karyath, P., Syama Dayal, J., Raymond Jani Angel, J. and Shashi Shekhar

ICAR–Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R A Puram, Chennai–600 028, Tamil Nadu, India

*nimishabalan131@gmail.com

Gene expression is a fundamental process that provides valuable information about an organism's phenotypic characteristics. While numerous gene expression databases and tools exist for various species, the brackishwater aquaculture sector lacks such resources to gain insights into expressed genes. To address this gap, a dedicated Gene Expression Atlas (GEA) has been developed exclusively for the brackishwater aquaculture sector covering important species including *Penaeus vannamei*, *Lates calcarifer*, and *Mugil cephalus*. Its primary purpose is to provide a centralized repository of gene expression data, enabling researchers to access valuable insights and information related to the expression profiles of these key species. This capability is instrumental in shaping experimental design and enhances our understanding of how a gene may contribute to specific biological processes. GEA contains information on both constitutive gene expression, which refers to the baseline expression levels of genes, and differential gene expression, which highlights changes in gene expression under specific conditions or circumstances. The inclusion of multiple species enhances the comparative aspect of gene expression analysis and allows researchers to identify shared and species-specific patterns of gene expression. To conduct the analysis, a genome-guided approach was employed, utilizing the Tuxedo Suite, which consists of TopHat, Cufflinks and Cuffdiff tools. More than 100 RNA-Seq data were collected from NCBI and utilized for this study. Constitutive gene expression analysis focuses on the expression levels (FPKM or TPM) observed across different tissues, developmental stages, and stress conditions (biotic and abiotic). Differential gene expression analysis, on the other hand, aims to identify genes that exhibit significant changes in expression levels based on $\log_2$-fold change and p-value under specific conditions or treatments. This process involves creating structured tables that capture the expression levels of genes, which are then utilized to build a comprehensive database in the webserver. By leveraging this database, users can conveniently access and explore the gene expression data, enabling a user-friendly interface for in-depth analysis and interpretation.

Keywords: FPKM, Gene Expression Atlas, RNA-Seq, Tuxedo Suite

Identification and characterization of LmO2 (Rhombotin-2) gene for its role in cellular growth in *Clarias magur*

Vishwamitra Singh Baisvar, Murali S Kumar, Ravindra Kumar*, Satyamvada Maurya and Basdeo Kushwaha

ICAR-National Bureau of Fish Genetic Resources, Canal Ring Road, PO- Dilkusha, Lucknow, Uttar Pradesh, India

Ravindra.kumar1@icar.gov.in

Clarias magur, popularly called as magur, is an important catfish species distributed throughout India with good demand and aquaculture potential. Growth rate, defined in terms of increase in body weight, is an important trait for aquaculture. Though the whole genome information of this species is available, but limited information exists on genes and genomic processes affecting growth. *LmO2* (LIM Domain Only 2) is a gene that codes Rhombotin-2 protein, which is highly conserved and has critical role in hematopoietic development. This gene has been associated with RNA synthesis, DNA binding, metal ion binding, endothelial cell proliferation, fin regeneration, embryonic hemopoiesis, erythrocyte development etc. Hence, an attempt was made in the present study to mine *LmO2* gene from the available *C. magur* genome data and RNA-Seq data generated from muscle tissues of fast and slow growing magur specimens and further characterized. This *in silico* mining and its alignment with *Danio rerio* genome resulted in the identification of 6.807 kb size *LmO2* gene region from magur genome. *In silico* amplification was done, which generated 7,818 bp fragment confirming *LmO2* gene having full coding region with 3 exons between 811 to 7618 bp positions, TSS at 301 bp position and polyA tail at 7774 bp position. Promoter analysis was done by identification of Transcription Factor Binding Sites (TAATT) in *C. magur*. A total of 12 SSRs and 40 SNPs could be identified on this gene which may be useful for population genomics study. Methylation studies showed that four stretches of the gene were hyper-methylated, while two stretches were hypo-methylated. Phylogenetic analyses using *LmO2* gene in 25 fish species belonging to 24 families revealed that the *C. magur* is closely related to other catfishes, such as *Ictalurus punctatus*, *Tachysurus fulvidraco* and *Silurus meridionalis*. *In silico* mining and identification of *LmO2* gene along with SSR and SNP markers from NGS data can be useful in understanding the growth pattern in different magur populations and may enable screening faster growing individuals for rearing and breeding purposes. Further studies will be required to validate the role of *LmO2* gene in growth for use as biomarker.

Keywords: Cell growth, *Clarias magur*, *LmO2* gene, phylogenetic evolution, SNP, SSRs

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Isolation and characterization of heterotrophic sulfur-oxidizing bacteria: An unexplored resource for improving soil fertility

Anusree, V. N. *, Aisha, K. M., Sumithra, T. G., Amala, P. V. and Sanil, N. K.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* anuadithya2004@gmail.com

Sulfur is the fourth essential plant nutrient after nitrogen, phosphorus, and potassium. It is required for adequate growth, metabolism, and development in plants. However, plants can absorb sulfur only in the form of inorganic sulfate (SO_4^{2-}) ions through the roots. Accordingly, sulfur-oxidizing microbes (SOMs) capable of converting different forms of sulfur into sulfate are the primary regulators of sulfur transformation in the soil. Therefore, various SOMs have the potential to be explored as soil bioinoculants to improve soil fertility. Additionally, SOMs can be successfully applied in multiple biotechnological applications such as waste treatment, bioremediation, agriculture, and water quality improvement in aquaculture. Even though several scientific literature available on the isolation and characteristics of chemolithotrophic SOM, corresponding data on heterotrophic SOM is very scarce. In this context, the present study was conducted to isolate and characterize potential heterotrophic SOM from different samples, namely fish waste (fish market, Kochi), mangrove sediment (Mangalavanam, Ernakulam), and compost from organic waste. The results on sulfate production showed that mangrove sediments are a promising source for isolating different heterotrophic SOMs. Accordingly, the isolation was attempted from mangrove soil in the specific medium. Five potential SOMs were selected out of twenty-one isolates for downstream research based on their ability to produce sulfate and reduce the pH of the media used. The potential isolates were identified based on molecular and biochemical characterization as *Klebsiella pneumoniae, Bacillus cereus, and Priestia megaterium.* The present study also identified the physiochemical conditions such as temperature, pH, and organic and inorganic substrates for optimal growth and sulfate production by each of these five SOM. Of the five isolates, two strains were classified as facultative chemolithotrophs because of their enhanced growth characteristic in very high thiosulphate concentration (100 mM). The ability to oxidize different reduced inorganic sulfur compounds and organic compounds and function at various temperatures and pH adaptabilities of these isolates showed that they could act as good biological sulfur-oxidizing microbial candidates for improving soil fertility and as natural deodorizing candidates. The pH-reducing property of the heterotrophic SOMs of the present study also highlighted their potential application for the reclamation of alkali soils, improvement of soil mineralization, and absorption of other essential nutrients.

Keywords: *Bacillus cereus*, *Klebsiella pneumoniae,* mangrove soil, *Priestia megaterium,* soil sulfate

Variations in global gene expression profiles of *Catla catla* kidney tissues induced by low temperature

Mohindra, V.[1]*, Chowdhury L. Mog[1], Chauhan, N.[1], Paul, A., Kumar, R.[1] and Jena, J. K.[2]

[1]ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR), Canal Ring Road, Dilkusha, Lucknow 226002, India
[2]Indian Council of Agricultural Research (ICAR), Krishi Anusandhan Bhawan–II, New Delhi 110 012, India

*Mohindra.Vindhya@icar.gov.in

Indian major carps form the major support system of freshwater aquaculture in India. The improvement of sustainability of aquaculture operations, which are more productive than before, lower risk of diseases and environment concerns, cannot be achieved without infusion of modern technologies. In the present study, the gene expression profiles of Catla (*Catla catla*), kidney tissues, at two different temperatures 20^{o}C and 30^{o}C for 45 days, were studied with high-throughput transcriptome sequencing. Transcriptome analysis identified 5092 differentially expressed genes (DEGs) (2460 upregulated and 2632 downregulated), out of which 64 and 11 were innate and adaptive genes, respectively. Genes with maximum up-regulation were NACHT, LRR and PYD domains-containing proteins (innate) and MHC class I proteins (adaptive). Functional characterization of DEGs identified 144 Gene Ontology (GO) terms under biological processes, 98 under molecular function and 52 under Cellular components. The molecular KEGG pathway analysis of DEGs revealed 22 critical pathways under Organismal Systems Immune category with maximum number of 35 DGEs under NOD-like receptor signaling pathway, followed by 32 genes under Chemokine signaling pathway and 31 genes under Platelet activation. A total of 57 significant clusters were observed through protein-protein interaction analysis, with maximum number of DEGs under Apoptosis and Pattern recognition receptor signaling pathway (16 DEGs). These results provide valuable information about molecular mechanisms and pathways regulating immunity, in response to temperature fluctuations in Catla, which in turn would facilitate selecting the best management practices in these species.

Keywords: Differential gene expression, functional characterization, gene clusters, immune genes

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Whole Mitogenomes reveal high genetic structure and evidences of purifying selection in *Lates calcarifer* populations in India

Rajeev K. Singh*, Anamika Bhordia, Raj Kumar, Kantharajan, G. and Sarkar, U. K.

ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR), Canal Ring Road, Dilkusha, Lucknow 226002, India

*rajeevsingh1@yahoo.com

The Asian seabass *Lates calcarifer* (Bloch, 1790), also known as "bhetki," (family Latidae; Order Perciformes) is a commercially important species and is widely distributed across the Asia-Pacific region. Being among the most important food fish of SE Asia and Australia, its culture is also progressing. Many times, the seeds are obtained through imports also. This makes necessary to delineate the diversity below-species level, which is vital for identifying evolutionary significant units, populations with high genetic variability and more importantly the effective broodstock management. This species thrives in varying environmental regimes, which might act as selective pressure to shape the genetic structure of wild populations. In this study, we sequenced and analysed 33 *L. calcarifer* samples collected from various locations within the Indian waters *i.e.* east coast, EC (18), west coast, WC (11) and Andamans sea, AS (4). Multiple sequence alignment of concatenated dataset of mitochondrial protein-coding genes (10883 nucleotides) revealed 19 haplotypes, displaying 85 variable sites, 60 parsimony sites and 25 singleton sites. The mean nucleotide composition was A (26.5%), T (26.8%), C (32.2%), and G (14.5%). Hierarchical analysis of molecular variance (AMOVA) demonstrated substantial genetic differentiation among sites (F_{ST}=0.3345), indicating a substantial level of genetic structuring among the EC, WC and AS. No evidence of recombination was observed in 19 haplotypes, using GARD. Various algorithms such as, CODEML, SLAC, FEL, FUBAR, and MEME were used for identifying estimates for selection. Significant pervasive purifying selective sites were detected using FEL and FUBAR methods. The dN/dS ratio of the concatenated fragments indicated that individuals were under strong purifying selection. These preliminary findings on the genetic differentiation and selection of *L. calcarifer* populations may be utilised in appropriate fishery management and conservation of this important resource across its natural habitats.

Keywords: Asian sea bass, genetic differentiation, population structure

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Shrimp Nutrient Metabolic Pathway Database (SNMPdb): A repository of genes related to nutrient metabolism in shrimp

Suganya Panjan Nathamuni*, Ashok Kumar Jangam**, Gangaraj Karyath Palliyath, Vinaya Kumar Katneni, Syama Dayal Jagabattula, Kizhakkekarammal Puthiyedathu Sandeep, P S Shyne Anand, Monendra Grover and Mudagandur Shashi Shekhar

ICAR-Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, MRC Nagar, Chennai, Tamil Nadu 600028.

*Presenting Author

**Ashok.jangam@icar.gov.in

The Shrimp Nutrient Metabolic Pathway Database (SNMPdb) is a comprehensive collection of genetic information on nutrient metabolic pathways in four shrimp species. This database contains annotated information of genes associated with carbohydrate metabolism, amino acid metabolism, lipid metabolism, cofactors and vitamins and other amino acids pathways for four economically important shrimp species, namely *Penaeus vannamei*, *Penaeus indicus, Penaeus monodon and Penaeus chinensis*. Whole genomes and annotated proteins are available for these shrimp species in public domain. The emphasis on nutrient metabolic pathways is due to their importance in energy production, energy storage, biomolecules synthesis, growth and development, maintenance of homeostasis, and immune response. Annotation and pathway assignment were carried out by homology search against InterPro, EggNOG, GO and KEGG databases for all the downloaded protein files from Genbank using the Omicsbox software. Fields like Accession ID, KEGG ID, Gene name, pathway information, and protein name were extracted from the annotation results and converted to database format using MySQL. Scripting language PHP was used to develop database retrieval system. SNMPdb features species-wise search, metabolism-wise search and blast search for unknown sequence. Search against SNMPdb provides annotation of all the genes related to nutrient metabolic pathways along with protein sequence. This database enables researchers from different fields of science to easily search genes of their interest involved in nutrient metabolism in shrimps. This information is also useful in understanding the species level differences and their specialized mechanisms to utilize the nutrients for different metabolic activities. SNMPdb is available for public access at http://bioinfo.ciba.res.in/snmp.

Keywords: Genetic information, gene annotation, Metabolic Pathway Database, penaeid shrimps

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

From the depths to genes: Mitogenomic blueprint of the Japanese blunt-horn lobster *Palinustus waguensis* sheds light on its evolution

Jeena N. S.[1]*, Wilson Sebastian[2], Summaya Rahuman[1], Sajeela, K. A.[1], Joe K. Kizhakudan[1] and Gopalakrishnan, A.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]CMLRE, Kochi, Kerala, India

*jeenacmfri@gmail.com

This study presents a comprehensive analysis of the genetic and evolutionary aspects of the rare deep-sea blunt-horn spiny lobster, *Palinustus waguensis* Kubo, 1963 belonging to Palinuridae family. It inhabits rocky environments and deep continental slopes in the Indo-Pacific waters at depths between 100 and 200 meters. Notably valued for both its ornamental and edible qualities, this lobster species remains relatively unexplored in terms of genetics. Here, we report the first complete mitochondrial genome of *P. waguensis* collected from the Bay of Bengal (12.78°N, 80.25°E) using low-coverage Illumina sequencing. Complete mitogenome assembly employed the NOVOPlasty pipeline, and the resulting mitochondrial genome rich in AT (adenine-thymine) content of 68.08%, spans a length of 15,541 base pairs (bp). Mitogenome encompasses the standard genetic elements, including 13 protein-coding genes (PCGs), 22 transfer RNA molecules (tRNAs), two ribosomal RNA sequences (rRNAs), with a 633-bp intergenic space identified as the D-loop, or control region. The genomic architecture reveals a distribution of 22 genes on the heavy strand and the remaining on the light strand. Furthermore, the gene order observed closely mirrors the conjectured Pancrustacean ground pattern. Comparative analysis of the mitochondrial PCGs yielded Ka/Ks ratios below 1, indicating purifying selection and underscoring the functional importance of these genes in the species adaptation. To explore the evolutionary relationships, a maximum likelihood phylogenetic analysis was executed using mitochondrial PCGs. The results of this analysis exhibit promising phylogenetic informativeness, particularly within the Achelata suborder, to which *Palinustus waguensis* belongs. Collectively, this study not only contributes to a deeper comprehension of the genetics and evolution of this intriguing lobster species but also provides insights into broader genealogical connections within the Achelata group.

Keywords: Bay of Bengal, blunt-horn lobster, mitogenome, phylogeny

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative transcriptomic analysis of acute salinity and temperature stresses in *Penaeus indicus*

Ashok Kumar Jangam*, Gangaraj Karyath Palliyath, Panjan Nathamuni Suganya, Vinaya Kumar Katneni, Syama Dayal Jagabattula, Sravanthi Oduru, Kizhakkekarammal Puthiyedathu Sandeep, P S Shyne Anand, Monendra Grover, Mudagandur Shashi Shekhar and Muralidhar Moturi

ICAR-Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, MRC Nagar, Chennai, Tamil Nadu 600028.

* Ashok.jangam@icar.gov.in

Abiotic and biotic stresses largely affect growth and development of culture animals. Among abiotic stresses, pond water salinity and temperatures are reported to be vital. Stress caused due to aberrations in optimal salinity and temperatures is a major factor of several diseases in aquatic animals. Sudden changes in these water quality parameters happen very often during the culture period due to surface weather parameters like rain fall, minimum and maximum temperature *etc*. Studying molecular mechanisms in shrimp due to changes in the growing environment could provide a basis for taking ameliorative measures. In the present study, it was intended to understand the molecular responses due to acute salinity and temperature stresses in *P. indicus* through RNAseq approach. Shrimp cultured in indoor tanks were used for the study. For salinity experiment, acute salinity stress was induced by shifting the animals from control water salinities of 30 ppt to low and high adjusted water salinity tanks of 5 ppt and 45 ppt respectively. Similarly, in temperature experiment, shrimp were shifted from control temperature of 27°C to low temperature tank and high temperature tanks with adjusted water temperatures of 22°C and 32°C, respectively. After 3 hours of creating acute stress in both experiments hepatopancreas tissue samples were collected and RNA-seq data was generated. Independent comparisons of control group with treatments revealed 793 and 910 DEGs for salinity and temperature experiments respectively with log2Foldchange value above 2 and adjusted p value below 0.05. Study documented Gene Ontology terms and metabolic pathways associated with DEGs. Pathway enrichment analysis of salinity stress revealed up-regulation Ferroptosis and Glycine, serine and threonine metabolism pathways, Fatty acid degradation, Collecting duct acid secretion, Lysosome, Peroxisome, Arachidonic acid metabolism and Steroid hormone biosynthesis pathways. In case of temperature stress, Thiamine metabolism, mRNA surveillance pathway, Spliceosome, Adipocytokine signaling pathway, Purine metabolism, Circadian rhythm, Ribosome biogenesis in eukaryotes, Proximal tubule bicarbonate reclamation were found to be up-regulated. The pathway information generated through this study could be a valid resource for devising stress ameliorative measures.

Keywords: Acute stresses, comparative analysis, *Penaeus indicus*, salinity, temperature, Transcriptomics

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Development of Polymorphic Microsatellite marker for stock identification of Green chromide, *Etroplus suratensis* using Next Generation Sequencing Technology.

Magdeline Christo[1,2], Divya, P. R.*[2], Rekha, M. U.[2] and Sarkar, U. K.[3]

[1]Kerala University of Fisheries and Ocean Studies, Panangad Kochi- 682506, Kerala, India
[2]PAGR Centre, ICAR-NBFGR, CMFRI Campus, Kochi, Kerala, India
[3]ICAR-National Bureau of Fish Genetic Resources Centre, Lucknow, Uttar Pradesh, India

*divyanbfgr@gmail.com

The Green chromide, *Etroplus suratensis*, is an indigenous cichlid food fish widely cultured in fresh and brackish water environments of India and Sri Lanka. The existing wild stocks seem to be threatened by water tourism, dredging of lake bottoms for the lime shell, habitat destruction, land reclamation, pollution, and also threats due to the introduction of exotic fish species like tilapia. The present status of a population can be well documented by using genetic methods such as microsatellites which are powerful tools in population genetics and phylogenetic conservation studies. Microsatellite markers were developed in *E. suratensis* through Illumina Sequencing with a mean read quality (Phred score) of 35.8 and the microsatellite primers were designed from the sequenced information, considering various attributes such as the number of repeats, Tm, GC content, Product size, etc using the software PRIMER 3.0 web tool. A total of 100 microsatellite primers were developed; consisting of 44 di repeats, 26 tri repeats, 20 tetra repeats, and 10 penta repeats. Screening of the designed 100 primers was carried out for developing validated microsatellite marker panels for genetic stock identification in *E. suratensis* from three different locations in Kerala, *viz*., Vembanad, Ashtamudi, and Ponnani. Analysis of genetic diversity is critical for carrying out captive breeding programmes in order to conserve the natural gene pool aiming at commercial pearl spot production. This article elucidates the development of a well-characterized marker panel of 30 polymorphic primers to study the genetic aspects of the pearl spot intending to improve its overall aquaculture production through proper conservation and management.

Keywords: Germplasm Conservation, genetic diversity, microsatellite, population genetics, pearl spot

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Development of novel microsatellite primers for genetic characterization of endangered and endemic yellow catfish, *Horabagrus brachysoma* and *Nilgiri mystus*, *Hemibagrus punctatus* (Bagridae)

Divya Merin Jose, Magdeline Christo, Adithya, P., Anjali Anil, Parvathi, K. O. and Divya, P. R.*
PAGR Centre, ICAR-NBFGR, CMFRI Campus, Kochi, Kerala, India
*divyanbfgr@gmail.com

Yellow catfish, *Horabagrus brachysoma* and *Nilgiri mystus, Hemibagrus punctatus are* endemic to the Western Ghats freshwater ecoregion of Peninsular India. Their distribution is restricted to lowland rivers and their associated backwaters. These species are threatened by habitat degradation by excess siltation, excess fishing, and dam construction. The IUCN classifies *H. punctatus* and *H. brachysoma* as critically endangered and vulnerable, respectively. In the current scenario, information on the genetic diversity and population structure of this species is crucial for the rehabilitation of species, as we have prioritized the species for captive propagation under the agrobiodiversity platform. Microsatellite markers are considered the suitable marker of choice for genetic stock structure analyses. An attempt was made to identify microsatellite markers in *H.brachysoma* and *H.punctatus* using Illumina Sequencing technology and a total of 10KB read data was generated. In *H. brachysoma*, a total of 5,89,509 SSRs were identified, whereas, in *H.punctatus*, a total of 48,357 SSRs were identified, with 472 and 350 contigs containing perfect repeat sequences, respectively. A total of 200 microsatellite primers were designed using PRIMER 3 software consisting of repeats 120; tri repeats 32; tetra repeats 28 and penta repeats 20 in *H.brachysoma whereas* a total of 100 microsatellite primers were designed consisting of di repeats–45; tri repeats- 30 and tetra repeats–15; penta repeats–10 for *H.punctatus.* Out of which, 31 SSR loci were found to be polymorphic and they were validated with 20 individuals from Vembanad, Chalakkudy, and Shasthamkotta in *H. brachysoma* whereas in *H.punctatus,* 27 SSR loci were found to be polymorphic and they were validated with 20 individuals each from Hemmigae and Hogenakkal. The allele numbers per locus in *Horabagrus brachysoma* ranged from 9 to 16 whereas 8 to 14 in *H.punctatus.* The observed and expected heterozygosities in *H. brachysoma* were 0.8482 and 0.8539 respectively, *whereas* in *H.punctatus* it was found to be 0.763 and 0.7285. The identified polymorphic loci in both species had PIC values >0.75. Validation of these microsatellite markers proved that these markers can be used as a significant tool for analyzing genetic variability and stock structure of the selected fish species.

Keywords: Conservation, microsatellite markers, population study, threatened fish species

Metagenomics analysis unveils comparative haloarchaeal diversity of two solar salterns in Tamil Nadu, south-east coast of India

Neethu, K. P.[1,2,3*], Sobhana, K. S.[1], Jasmine, S.[1] and Ranjith, L.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Cochin University of Science and Technology, Cochin University P.O., Kochi–682 022, Kerala, India
[3]Zoological Survey of India, Southern Regional Centre, Chennai-600 028, Tamil Nadu, India

*neethunambiar26@gmail.com

Archaea are a group of microorganisms renowned for their remarkable ability to thrive in extreme environments. Recent advancements in metagenomic tools have revolutionized our understanding of the intricate complexity and adaptability of extremophile communities. Among these, haloarchaea stand out as a group of microorganisms that thrive in environments with salt concentration nearing saturation. In this study, we conducted a comparative analysis of the haloarchaeal diversity in two solar salterns located in Manakudy and Thoothukudy, situated in Tamil Nadu, south India, using metagenomic tools. Brine samples were collected from both the saltpans and subjected to comprehensive metagenomic analyses. DNA extraction was carried out using the PowerLyzerR PowerSoilR DNA Isolation kit (QIAGEN), amplified using archaeal specific primers (20F, 1492R, 518R, 915R) and PCR products were sequenced on Illumina NovoSeq platform using a 2x150 paired-end configuration. Raw reads were rigorously preprocessed, adapter sequences removed and read pairs were quality trimmed and merged. The fastq files of both samples were imported in to QIIME2 (Quantitative Insights into Microbial Ecology, version 2) and "Dada2" (Divisive Amplicon Denoising Algorithm, version 2), was used for 'denoising' the sequences. QIIME pipeline was used to align pair-end reads, assign taxonomy, generating taxonomic plots, and phylogenetic tree was generated using Fasttree program. We used a classifier model trained on the SILVA 99% Archaea reference database for the feature/OTU taxomomic classification. This comprehensive analysis yielded data on relative taxonomic abundance and count across Kingdom, Phylum, Class, Order, Family, Genus, and Species. Taxonomy Krona plots were generated to represent the distribution of different taxonomic levels within each sample. The phylogenetic tree inferred maximum-likelihood phylogenetic relationships from alignments of the Feature/OTU sequences with known genera. Alpha diversity was assessed through various metrics including the Chao1 estimator; observed Features/OTUs; Shannon index and Simpson index. Taxonomic abundance was found to be higher in Thoothukudy saltpan compared to Manakudy. Krona plots clearly illustrated that the most abundant Haloarchaeal genus in the Manakudy saltpan was *Halorubrum* (36%), closely followed by *Natrinema* (27%). Conversely, Thoothukudy saltpan displayed a different distribution with *Haloalkalicoccus* (46%) emerging as the most abundant genus, followed by *Haloquadratum* (9%), *Halorubrum* (9%), and *Natrinema* (9%). Metagenomics has emerged as one of the most data-rich and pervasive techniques for unraveling the taxonomic and functional diversity of microbial communities. This approach also offers the unique advantage of estimating the abundance of unculturable archaeal groups present in an ecosystem, further expanding our understanding of these microorganisms.

Keywords: Alpha diversity, Chao1 estimator; extremophiles, features, OTUs, Shannon index, Simpson index, saltpan

Exploring MicroRNA expression in *Channa striata:* Insights into habitat manipulation and spawning mechanisms

Gowrimanohari Rakkanan*, Gitanjali Behera, Rajesh Kumar, Ipsita Iswari Das, Lakshman Sahoo, Jackson Debbarma and Jitendra Kumar Sundaray

ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar-751002, Odisha, India

* gowrimanohari.rk@gmail.com

MicroRNAs, typically around 22 nucleotides long, serve as vital post-transcriptional regulators of gene expression despite their classification as small non-coding RNAs. These miRNAs actively participate in a broad spectrum of biological processes, encompassing critical functions such as gonad development and reproduction. *Channa striata*, a prominent species for freshwater aquaculture, holds significant importance in climate-resilient aquaculture due to its ability to thrive in adverse water conditions. In this study, during the spawning season, the *C. striata* species were cultured in captive conditions with two different habitats: one with a soil bed and hydrophytes, whereas the habitat considered as the control was provided with only a water medium. To understand the adaptation to habitat manipulation and its importance in spawning, this study aims to identify and characterize micro RNA (miRNAs) between habitats. A total of ten samples from female *C. straita* organs (brain and gonad) were subjected to small RNA sequencing. On average, 173 conserved miRNAs were identified using reference sequences from all fish miRNAs, while 26 novel miRNAs were predicted from unmapped reads. Differential expression analysis was performed using the edgeR package in R Studio, and the putative targets were predicted using Miranda, with gene annotations sourced from the UniProt database. Among the 146 differentially expressed (DE) miRNAs, 36 were upregulated, and 37 were downregulated in the gonad with 50730 potential targets. In the brain, 124 miRNAs exhibited differential expression, resulting in 45 upregulated and 28 downregulated miRNAs with 41728 mRNA targets. To be mentioned, 72 control-specific DE miRNAs were observed in the brain, whereas 52 were found in the treatment-specific brain of *C. striata*. Conversely, the gonad tissues had 58 control-specific miRNAs, whereas 88 treatment-specific differentially expressed miRNAs were identified. These sequencing results underscore the elevated expression of miRNAs in the gonad tissues with treatment, i.e., providing a soil bed and hydrophytes. However, the results should be further validated. This result will help future studies on the influence of habitat manipulation in the post-transcriptional mechanism in *C. striata* and provide a reference miRNAome of *C. striata* for future studies

Keywords: *Channa striata*, habitat manipulation, micro RNA, small RNA sequencing

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Deciphering the functional role of opsin gene in vision, growth and reproduction of Penaeid shrimp *Fenneropenaeus indicus*

Sajeela, K. A*., Hareeshma, K. H., Paulton, M. P. and Jeena, N. S.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sajeelaka@gmail.com

The survival of an organism in different environmental conditions and habitats and the physiological changes of organisms in the due course of its life are mainly dependent on the expression of various functional genes. The study of genes of physiological importance is relevant in studying the adaptive mechanisms in different life forms. Opsins are the protein moiety in visual pigment, with various subgroups and spectral forms. Long Wavelength sensitive opsins (LW-opsins) are associated with vision in the benthic zone where the shrimp live and reproduce after their post-larval stage. The opsin gene proved to have essential roles in vision and other biological functions. In this study, we examined the expression level of the LW-opsin gene in different tissues (eyeball, eye stalk, muscle, heart, gill and gonads) of male and female *Fenneropenaeus indicus* and the differential expression of LW-opsin in the eyes and ovary during ovarian maturation stages. LW opsin transcription detected in all the tissues in very low expression, shows that it has non-visual biological functions in other tissues. The expression level in the eyes was increasing during growth irrespective of sex. In females, opsin expression declines in the eye during ovarian maturation and increases in the ovary. This differential expression underlines the role of LW-opsin in the growth and reproduction of the candidate species. The results show that LW-opsin in the eyes acts as a receptor that modulates growth and reproduction in response to daylight intensity and duration (photoperiodism). This stands as the first study on expression profiling of the opsin gene from the candidate species and will provide insights into the functional relevance of the opsin gene in *F. indicus*.

Keywords: *Fenneropenaeus indicus*, Opsin, qPCR

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Meta-analysis to unravel core transcriptomic responses in *Penaeus vannamei* exposed to biotic and abiotic stresses

Gangaraj, K. P.*, Jangam, A. K**, Katneni, V. K., Nimisha, K., Nathamuni, S. P., Jayaraman, R., Jagabattula, S. D., Moturi, M. and Shekhar, M. S.

ICAR-Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, MRC Nagar, Chennai, Tamil Nadu 600028.

*Presenting author

**Ashok.jangam@icar.gov.in

Different abiotic and biotic stress factors affect shrimp farming, a dominant economic activity in coastal areas. Under poor management conditions, these stressors could affect the growth and health of farmed animals. Understanding the common gene expressions in response to stress, regardless of the specific stress factor, holds significant importance in functional genomics. This study aims to identify the core transcriptomic responses in the shrimp species *P. vannamei* exposed to various abiotic and biotic stress conditions and decipher their functional importance. We gathered and analyzed multiple RNAseq datasets related to twelve abiotic and nine biotic stress conditions to achieve our objective. Through the in silico meta-analysis, we predicted 961 differentially expressed genes (meta-DEGs) for abiotic stress conditions and 517 meta-DEGs for biotic stress conditions, respectively. These meta-DEGs represent genes that are commonly expressed across different stress factors and indicate the organism›s general response to stress. For abiotic stress, significant pathways associated with the stress response include tryptophan metabolism, starch and sucrose metabolism, fatty acid degradation, carbohydrate digestion and absorption, phenylalanine metabolism, drug metabolism–other enzymes, arachidonic acid metabolism, and fatty acid elongation. Similarly, for biotic stress, metabolism of xenobiotics by cytochrome P450, pentose and glucuronate interconversions, steroid hormone biosynthesis, and drug metabolism–cytochrome P450 were found to be significant pathway associations. In addition, the study also predicted 17 stress regulatory motifs present in the identified meta-DEGs. These motifs have significance in determining the stress responses of the organism. Through the in silico meta-analysis, we successfully identified core transcriptomic responses in *P. vannamei* exposed to various abiotic and biotic stress conditions. The differential gene expressions observed across different stress factors provide valuable insights into the organism›s general stress response mechanisms. The significant pathways and stress regulatory motifs identified in this study could be a valuable resource for developing stress management approaches in shrimp aquaculture.

Keywords: Abiotic stress, biotic stress, meta- analysis, Meta-DEGs, *Penaeus vannamei*, RNAseq

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Heritability estimates of random regression coefficients for the growth trajectories of *Clarias magur*

Rameez Roshan*[1] and Shrinivas Jahageerdar[2]

[1]Department of Aquaculture, Faculty of Fisheries Science, KUFOS, Kochi – 682506, Kerala, India
[2]Fish Genetics and Biotechnology Division, ICAR-CIFE, Mumbai – 400061, Maharashtra, India

*rameez.roshan@kufos.ac.in

A Mixed Linear Random Regression (MLRR) model allows for estimating the genetic covariance function (CF) matrix for an infinite-dimensional trait. In the context of MLRR models, a second-order Legendre polynomial effectively captures the trajectory shape of such traits, such as longitudinal measurements of body weight. Specifically, the zeroth, first, and second orders of the Legendre polynomial correspondingly represent the intercept, slope, and first-order curvature of growth trajectories. Within the MLRR framework, the regression coefficients serve as random variables that account for variations in the intercept, slope, and curvature of individual trajectories. The present study aimed at estimating the genetic variation in the growth trajectories of magur. This study employed an MLRR framework utilizing a second-order Legendre polynomial to construct a genetic CF matrix for the growth trajectories of magur. The data originates from the base population of an ongoing genetic selection program at ICAR-CIFE, Mumbai, India. Heritability estimates for the regression coefficients are derived from the CF matrix of genetic and permanent environmental effects, assuming a homogeneous variance structure for residuals. The high heritability scores for the intercept (0.57), slope (0.39), and curvature (0.32) signify a substantial additive genetic variance concerning the trajectory shape. Examining the percentage contribution of Eigenvalues for the regression coefficients (: 87.34%; :10.12%; : 2.55%) reveals that the predominant genetic variation in the growth trajectory results from differences in the intercept, followed by a minor genetic variation in linearity and a minimal heritable variation in trajectory curvature. These results demonstrate the potential to shift the growth trajectory of magur above the mean while altering its shape through optimal selection.

Keywords: Eigenvalue, heritability, MLRR, regression

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Non-additive genetic effects in enhancing stress tolerance in *Macrobrachium rosenbergii*

Rajananad Sivaprasad, Rameez Roshan, P. M. and Shyla, G*.

Department of Aquaculture, Faculty of Fisheries Science, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala, India, 682506

*Shyla.g@kufos.ac.in

The giant freshwater prawn (*M. rosenbergii*) culture in India faces various production challenges, including larval mortality resulting from low-stress tolerance levels. This reduced larval quality is thought to be a direct consequence of genetic deterioration resulting from domestication and inbreeding. This study explores the potential of non-additive genetic effects to enhance stress tolerance genetics in *M. rosenbergii* larvae. The current data originates from a population of giant freshwater prawns produced through a complete three-by-three diallelic cross involving stocks from Kerala (KR), Orissa (OR), and Andhra Pradesh (AP). This cross yielded three pure-bred lines (KRKR, APAP, and ORORO) and six hybrid lines (KROR, KRAP, APKR, APOR, ORKR, ORAP). Stress tolerance assessments were conducted at the fifth and tenth larval stages, considering variations in temperature, salinity, and ammonia levels. KRKR and KROR exhibited the highest temperature tolerance (LT50 of 37.6°C) for both larval stages, with ORORO closely following. Salinity tolerance was highest in KROR, followed by ORKR. Regarding ammonia tolerance, KRKR had the highest LC50 value at the fifth stage, while KRKR and KROR displayed similar tolerance levels. Overall, KRKR demonstrated the highest tolerance to all stressors among the pure-bred lines. Additionally, the study revealed that tolerance to temperature and salinity was notably higher at the tenth stage compared to the fifth stage for pure-bred and hybrid lines. These results highlight the potential for harnessing non-additive genetic effects in *M. rosenbergii* to develop breeds with enhanced stress resilience, offering valuable insights for breeding programs in the future.

Keywords: Breeding programs, giant freshwater prawn, hybrid lines, pure-bred lines

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative RNASeq studies on common carp cultured in low saline environments

Angom Lenin Singh*, Mujahidkhan Pathan, Gopal Krishna and Aparna Chaudhari
ICAR- Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (west), Mumbai 400 061
leninsingh@cife.edu.in

India has ~9.38 million hectares of salt-affected land. Though unsuitable for agriculture, this terrain has become a valuable aquaculture resource. The common carp *Cyprinus carpio* is a prominent global aquaculture species with resilience to up to 12 ppt salinity levels with minimal adverse effects on growth and survival. This characteristic makes common carp a potential candidate for low-saline inland aquaculture. A comparative transcriptomics was done to profile gene expression in common carp grown at two salinities, 2-4 ppt (low saline or LS) and 8-10 ppt (high saline or HS). The fish were sourced from Aarey Fish Farm, Maharashtra. At each salinity, fingerlings (~30 g) were stocked in hapas placed in earthen ponds (300 fish/ hapa (@ 1 fish m^{-2}) at CIFE Rohtak Centre in August 2021. The fish were PIT tagged in March 2022 and cultured in two ponds maintained at desired salinities. After a 365-day culture period (August 2022), all the fish (229 HS and 245 LS) were sampled. Four males and two females with the highest BW from the HS pond (~534 g and 591 g, respectively) and four males and two females with the highest BW from the LS pond (~567 g and 651 g, respectively) were sampled. Five major tissues (brain, muscle, gills, liver, and kidney) were collected, and tissues of two males were pooled, while the female was processed separately. Thus, for each salinity, three transcriptomes were generated on the MiSeq Illumina platform. A total of 30 GB raw data was generated, and 129,366,975 clean reads were obtained. The reads were assembled against the reference genome of *Cyprinus carpio*, yielding mapping percentages ranging from 76.68% to 91.67%. A total of 40433 contigs were annotated using BLAST2GO. KEGG analysis revealed enrichment in pathways associated with ion transport and osmolyte production, enabling the organism to adapt to the elevated osmotic pressure. Comparison of HS and LS contigs in Venny 2 revealed 455 unique genes in HS high performing group and 991 in LS high performing group. The total aligned reads of transcripts were calculated (RPKM value), which is directly related to transcript expression in HS and LS groups. Changes above log2 fold change were considered significant to identify differentially expressed genes. A total of 434 genes were downregulated and 205 upregulated in the HS fish. The DEGs were screened for growth, reproduction, stress, and osmoregulation genes. The data is being used to assess long-term physiological changes in common carp adapted to higher salinity and to correlate the expression profile with growth performance.

Keywords: Common carp, inland saline, transcriptome

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

An *In Vitro* Protein Expression Profile of cultured muscle cells developed from *Labeo rohita*

*Yashwanth, B. S.[1], Nevil Pinto[1], Sathiyanarayanan, A.[1], Kiran D. Rasal[1], Sanjeeva, S.[2], and Mukunda Goswami[1]**

[1] ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

2Indian Institute of Technology, Bombay, India

* mukunda@cife.edu.in

A new cell line developed from the muscle tissue of *Labeo. rohita* was utilized to understand in-depth proteome. Comparative proteome analysis was carried out for LRM cells at different passages (1, 15 and 25) using label free quantitative proteomics. A total of 138 proteins containing ≥ two unique peptides were used for metaboanlyst software for abundance at different passages. Hierarchical clustering of the top 25 proteins with significantly different abundances was plotted across the different passages with a fold-change of 1.5. Protein-Protein interactions of significant abundant proteins with respective KEGG pathways were represented (based on STRING). The metascape depicts the network of significantly enriched proteins with the functional annotation of protein-coding genes. Functional analysis of differentially abundant proteins was marked as glycolytic (eno1 and eno3), metabolic (pgm, smyd1, ak1, aldob and bpgm), cytoplasmic ribosomal (rpl27, rpl3 and eifa5) and carbon metabolic (pdh) pathways were observed across passages. The expression of ribosomal proteins like eif5a, rps8a, rpl30, rpl27, rpl3 in LRM cells participates in skeletal muscle growth and maintenance by altering the translational capacity of the cell. The cytoskeletal proteins such as annexin and tropomyosin are involved in the adhesion and reorganization of the cytoskeleton signaling processes during the early differentiation of LRM cells. The proteins observed across the pathways were correlated with the differentiation of LRM cells during myogenesis. The current study provides insight to determine the different groups of proteins that are expressed during the development of myotubes and the developed muscle cell line could be a benchmark for understanding the *in vitro* myogenesis for cultivated meat production.

Keywords: DAPs, *In vitro* Myogenesis, Label Free Quantification, LRM Cell Line, Protein-Protein Interaction

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Differential expression of steroidogenic enzymes genes and gonadotropin receptors during ovarian development of grey mullet *Mugil cephalus*

Sherly Tomy*, Ezhil, P., Aritra Bera, Dani Thomas, Thiagarajan, G. and Kailasam, M.

ICAR- Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, Chennai – 600028, Tamil Nadu, India

* sherly.tomy@icar.gov.in;

Grey mullet *Mugil cephalus*, an economically important aquaculture candidate species, is an annual spawner. Female grey mullet usually exhibits reproductive dysfunctions in captivity and approaches using administration of exogenous reproductive hormones, such as gonadotropin releasing hormone agonists (GnRHa) along with domperidone (to overcome the dopaminergic inhibition), has been attempted to overcome them. Steroid sex hormones are key regulators of sex differentiation and reproduction in fish. Biosynthesis of these hormones involves a complex cascade of oxidative enzymes converting cholesterol into different functional steroids and is initiated with the rate-limiting transport of cholesterol from the outer to the inner mitochondrial membrane by steroidogenic acute regulatory (*StAR*) protein, where it is cleaved into pregnenolone by the cytochrome P450 side chain cleavage enzyme (*cyp11a1*), and subsequently converted to other steroid hormones by a number of steroidogenic enzymes including 3β-hydroxysteroid dehydrogenase/ D4- D5 isomerase (*3β-HSD*), which converts D5 -steroids into D4 -steroids, cytochrome P450/ 17α-hydroxylase/ C-17,20 lyase (cyp17) that catalyses the sequential 17alpha-hydroxylase and C17,20-lyase reactions and aromatase (*cyp19a*, the "ovarian" form) which converts testosterone to estradiol. Gonadotropins exert transcriptional regulation on these steroidogenesis-related genes. To understand the steroidal regulation of ovarian maturation in *M. cephalus*, the expression of four key steroidogenic genes namely *cyp11a1*, *3β-HSD*, *cyp17* and *cyp19a* along with *StAR* and gonadotropin receptors (follicle stimulating hormone receptor-*fshr* and luteinizing hormone–*lhr*) were examined by real-time quantitative PCR in the ovaries of pre-vitellogenic (Stage I; Ova diameter 30-110 µm) and vitellogenic (Stage III; Ova diameter: 180-650 µm) females. The results indicated that the expression levels of ovarian *fshr* and *lhr* were significantly high in vitellogenic ovaries compared to the pre-vitellogenic stages. The expression patterns of all the ovarian steroidogenic enzyme genes exhibited an increasing trend with advancement of maturation, indicating a gonadotropin-dependent role in ovarian maturation. Furthermore, the presence of all four steroidogenic enzymes in ovary and their positive correlation to changes in serum estrogen levels during maturation, suggest ovary to be a primary steroidogenic source of the circulatory E2 levels during the reproductive cycle in female grey mullet.

Keywords: Estradiol, fish, ovarian development, steroidogenic enzymes

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Evolutionary rescue by local adaptation could confer climatic resilience on Indian oil sardine, *Sardinella longiceps*– Clues from genome scans

Wilson Sebastian, Sandhya Sukumaran*, Abdul Azeez, S., Muraleedharan, K. R., Dinesh Kumar, P. K., Zacharia, P. U. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sandhyasukumarancmfri@gmail.com

Marine fishes are considered to be highly dispersive and exhibit significant gene flow. However recent evidence using advanced genomic tools indicated the presence of locally adapted populations in many marine species in spite of high levels of gene flow. This happens as adaptive alleles occur in tightly linked regions of the genome where recombination is not possible. We investigated the adaptive genetic variation in response to heterogeneous habitats of the Indian Ocean using ddRAD sequencing to understand the subpopulation structure, stock complexity, mechanisms of resilience, and vulnerability in the face of climate change. A total of 100 *Sardinella longiceps* samples were collected from the five eco-regions of the Indian Ocean, mainly, Oman Sea (OMAN), North Eastern Arabian Sea (NEAS), South Eastern Arabian Sea (SEAS), Southern Bay of Bengal (SBoB), and Northern Bay of Bengal (NBoB). ddRAD sequencing was carried out using the high-quality DNA extracted from each sample (20 samples each from OMAN, NEAS, SEAS, SBoB and NBoB) and the data analysed using standard software packages. Samples from Gulf of Oman were significantly diverged from other Indian Ocean samples. SNP allele-environment correlation revealed the presence of candidate loci correlated with the environmental variables like annual sea surface temperature, chlorophyll-*a*, and dissolved oxygen concentration which might represent genomic regions allegedly diverging as a result of local adaptation. The genetically differentiated *S. longiceps* from the Indian ocean can be considered as two locally adapted populations; the OMAN population adapted to a habitat with low temperature (24–27 °C) and high food availability (Chl-*a*) and the Indian coastal population (NEAS, SEAS, SBoB and NBoB) adapted to high temperature (26–30 °C) and low food availability (Chl-*a*). Furthermore, the association of candidate loci with environmental gradients suggests an important role of SST, Chl-*a* and DO concentration in the genetic structuring of *S. longiceps*. Most of the candidate loci identified was associated with cellular energy metabolism, transcription, cell growth and signalling potentially indicating the selective pressures to cope up with the heterogeneous oceanic realm. Climate change is capable of altering the ecological interactions, inducing physiological stress, and bringing about changes in phenology and seasonal timing. Knowledge regarding genetic structure at a spatial and temporal scale can be used to monitor climatic impacts as shifts in the stable structuring can happen due to climate change-induced localized extinctions and recolonizations. Extirpation of local populations causes irreversible changes in the gene pool, impairing the potential for adaptive evolution.

Keywords: ddRAD sequencing, local adaptation, Indian oil sardine, population genomics

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative cell cycle analysis of two novel humpback grouper (*Cromileptes altivelis*) fin cell lines by flow cytometry

Priyanka Poulose[1, 2*], Sobhana, K. S.[1], Grinson George[1] and Gopalakrishnan, A.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Cochin University of Science and Technology, Cochin University P.O, Kochi – 682 022, Kerala, India

*priyankapoulose20@gmail.com

Among commercially valuable marine species, groupers are particularly susceptible to exploitation. The humpback grouper *Cromileptes altivelis,* is the sole representative of the Cromileptes genus in the Epinephelidae family, having a unique morphology and high economic value. Fish cell lines are indispensable, cost-effective *in vitro* research tools for biotechnology, developmental biology, toxicology, and virology. The cell cycle, a complex sequence of events by which a cell divides and duplicates its cellular contents is pivotal in understanding cell growth, differentiation, senescence, and apoptosis. Proliferating cells sequentially undergo a transition through G1→S→G2→M phases involving DNA synthesis, preparation for cell division, and subsequent mitosis. Flow cytometry is a powerful tool that allows the sorting of cells based on their nuclear DNA composition in each cell cycle phase. Chromosome analysis of cell lines often uncover abnormal chromosome numbers, particularly aneuploidy indicating cellular transformation. The current study focused on the cell cycle and chromosome analysis of the two novel fin cell lines, CA1F3Ex and CA1F4Tr, derived from *C. altivelis.* Cells in the logarithmic phase of growth were arrested using colchicine treatment and processed for preparation of metaphase spreads. Chromosome analysis revealed a range of 33 to 75 chromosomes, with modal chromosome numbers of 53 and 69 for CA1F3Ex and CA1F4Tr cell lines respectively, revealing aneuploidy indicating cellular transformation. Flow cytometric analysis of the propidium iodide (PI) stained CA1F3Ex and CA1F4Tr cells cultured for different durations of 72 h and 120 h demonstrated that the cells cultured for 120 h had a lower percentage of cells in the S phase compared to 72 h, suggesting the cells achieved confluence at 72 h. Additionally, the observation that CA1F4Tr cells had a comparatively higher percentage of cells in S phase at 72 h, than CA1F3Ex cells, suggests that comparatively larger portion of CA1F4Tr cells were actively engaged in DNA synthesis at that point, indicating differences in growth rates or cell cycle dynamics between the two cell lines. The higher percentage of S phase cells in CA1F4Tr cells at 72 h suggests that these cells required comparatively more time to reach confluence, possibly due to their lower proliferation rate or response to the culture conditions. The utilisation of advanced analytical tools like flow cytometry, has provided a deeper understanding of the behaviour of these transformed cell lines, shedding light on their growth patterns and cell cycle dynamics. This information is valuable for further research and applications involving these cell lines.

Keywords: Aneuploidy, CA1F4Tr cell line, CA1F4Tr cell line, chromosome analysis, DNA synthesis, propidium iodide staining

Muscle cell culture system from *Lates calcarifer* (Asian seabass) for cultivated seafood development

Pawaskar, D. K.*, Arvind Sonwane, Kiran Rasal, Sanjeeva, S., Yashwant, B. S., Nevil Pinto, Sathiyanarayanan, A. and Mukunda Goswami

ICAR- Central Institute of Fisheries Education, Mumbai- 400061, Maharashtra, India

*darshanpawaskar05@gmail.com

The growing demand for fish has led to overfishing, which in turn lowers the ocean biomass content. Due to global warming, there is a decrease in the wild stock of fish. Hence, there is a need to produce fish sustainably. Cellular aquaculture could address the global demand for animal dietary protein by the sustainable production of lab-based seafood. Moreover, the production of seafood through cellular aquaculture could greatly reduce greenhouse gas emissions. *Lates calcarifer* is an economically important food fish in India and the Indo-Pacific region. In this study, a cell culture system was developed using muscle tissue of Asian seabass (SBM). The SBM cells have been maintained in a complete growth medium using Leibovitz's-15 medium and Fetal Bovine Serum (FBS). The optimum growth condition of the SBM cells was studied by growing the cells at different temperatures (20, 24, 28 and 32°C), FBS (5, 10, 15 and 20%) and bFGF (basic fibroblast growth factor) (0, 5, and 10 ng ml^{-1}) concentrations. The optimum growth condition was found to be at a temperature of 28°C, 10 % FBS and 10 ng ml^{-1} bFGF. The SBM cells were authenticated using the mitochondrial gene cytochrome c oxidase subunit I (COI) gene. Further studies on the SBM cells can also be carried out to evaluate their efficiency in large-scale production using a bioreactor, myogenic and adipogenic gene expression.

Keywords: Asian Seabass, bFGF, Fetal Bovine Serum, muscle cell culture

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Thiamine deficiency in fishes- a symptom of dysfunctional aquatic ecosystems

Megha S. Vinod*

ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road,Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*megha.fntmb204@cife.edu.in

Thiamine, an essential vitamin involved in carbohydrate metabolism majorly, has many more physiological, biochemical and functional roles to play in the fish body. Through this article, the deficiency of thiamine and how it is a reflection of a distraught environment will be discussed. Thiamine deficiency was first documented in 1968 in the salmonids of Great Lake. Thereafter more documentation and research has been done in this line taking into consideration its effects on fish ranging from impaired growth and metabolism, energy imbalances, neurological syndromes to early life mortality disorders. For the source of thiamine in the fish body, diet presumed to have been obtained from the aquatic environment after synthesis by prokaryotes, algae and plants or gut microbiota is important. Since diet is ultimately affected by environmental manipulations, any change in physical and biological parameters in and around fish will have intense implications on gut microbiota in producing enough thiamine. Further, stress can impede proper utilisation of feed for thiamine recovery. Changes in food and feeding habits due to grappling environmental issues like variations in temperature, salinity and oxygen, attack of invasive species, and migration of species and pollution worsens the situation. Also, fishes that feed at the lower trophic level exhibits thiaminase I activity that diminishes the thiamine content of the body. Teleosts of Anguilliformes, Clupeiformes, Cypriniformes, and Siluriformes are more likely to exhibit thiaminase I activity than basal euteleosts like Esociformes, Osmeriformes, and Salmoniformes or neoteleosts like Gadiformes, Gasterosteiformes, Perciformes, and Scorpaeniformes. The flow of vitamin B_1 through the food web is constrained by anthropogenic pressures of increased nutrient input and is driven by climatic change, increased light attenuation by dissolved substances transported to marine coastal systems and fishing pressure on piscivorous fish through increased abundance of planktivorous fish that overexploit mesozooplankton, low mesozooplankton biomass, picoalgae prevailing among primary producers and low fluctuations of population numbers of planktonic organisms. So as far as we understand, the deficiency syndrome is making the population go more vulnerable and therefore it is high time that we devise suitable management strategies to solve this issue. Better research into the etiology will help create more baseline data for further analysis to prevent any unlikely occurrence of mass extinction in the wild.

Keywords: Prokaryotes, salmonids, teleosts, Thiamine, water hardening

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Effect on hemato-biochemical indices of *Labeo catla* reared in different culture systems

Siddhartha Shankar Sahoo, Sujata Sahoo*, Singh, D. K., Pailan, G. H.
ICAR-Central Institute of Fisheries Education, Kolkata Centre- 700091, West Bengal
*sujatasahoo@cife.edu.in

Catla is a promising aquaculture candidate species, having a high growth rate, good meat quality, high consumer preference and excellent nutritional profile. Catla, being an Indian major carp, is a highly preferable and abundantly cultured species in India. Over the years, it has contributed to the fishery economy and livelihood of the communities that depend on it. Catla is cultured mainly in extensive, semi-intensive and sewage-fed aquaculture in India. The overall homeostasis and health of fish are highly influenced by their surroundings and culture environments. Knowing how the culture conditions and environmental parameters affect stock health is vital for growth and production sustainability. The health status of fish stock can be assessed by observing the haematological and stress parameters. The fish samples of *Labeo catla* were collected from three different culture systems viz sewage-fed, semi-intensive, and extensive systems in North 24 Praganas and nearby areas of West Bengal. Then, the blood and serum parameters were analyzed for haemato-biochemical profiling. Significant differences ($P<0.05$ level) in the haemato-biochemical profile of the fish were observed in the three farming systems. In the sewage-fed system, leucocyte count is significantly higher, and erythrocyte count, haemoglobin and hematocrit value were significantly lower than in other systems. Glucose content was significantly higher in sewage-fed systems. Other parameters like bilirubin (total and direct), ALT, AST, and LDH are significantly highest in the sewage-fed system and lowest in the semi-intensive system, indicating fish under more stress in sewage-fed ponds. Total protein, albumin: globulin ratio, calcium, phosphorus, sodium, and potassium are significantly lower in the sewage-fed system but highest in semi-intensive systems. The study suggested that hemato-biochemical parameters can be good indicators of the health status of fish and can be used to monitor the well-being of cultured Catla.

Keywords: Aquaculture systems, biochemical indices, health assessment, hematology, Labeo catla

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Mitigating effects of dietary Zinc nanoparticles on arsenic, ammonia, and temperature Induced Stress in fish using molecular signatures

Neeraj Kumar*, Supriya Tukaram Thorat, Pooja Bapurao Patole, Samiksha Chavhan, SA Kochewad, Kotha Sammi Reddy

[1]ICAR-National Institute of Abiotic Stress Management, Baramati, Pune-413115, Maharashtra, India

*neeraj_journal@live.in

Aquatic ecosystems are facing major challenges due to pollution and climate change, posing a significant threat to the existence of aquatic organisms in recent times. Climate change and pollution have led to the extinction of many fish species, with water quality and temperature being the primary driving factors behind these effects. In light of these concerns, our study aimed to investigate the impact of arsenic, ammonia, and high-temperature stress on *Pangasianodon* hypophthalmus. To address these issues, we synthesized nano zinc using fisheries waste to developed zinc nano feed. We formulated and prepared diets containing 0, 2, 4, and 6 mg kg^{-1} of zinc nanoparticles (Zn-NPs). The fish were exposed to arsenic (As) and ammonia toxicity as well as temperature stress, and were fed control and Zn-NPs diets for a duration of 120 days. We determined the gene expression of growth hormone regulators 1 (GHR1) and b (GHRb), growth hormone (GR) in the liver and gill, as well as myostatin (MYST) and somatostatin (SMT) in muscle. The results showed noticeable alterations in gene expression, with the 4 mg kg^{-1} Zn-NPs diet leading to improvements. Additionally, stressors such as As, NH_3, NH_3+T, As+T, and As+NH_3+T upregulated the expression of antioxidative genes (CAT, SOD, and GPx) in liver and gill tissues, but these genes were significantly improved with the dietary Zn-NPs diet. Furthermore, stress protein genes (HSP70), DNA damage-inducible protein, and inducible nitric oxide synthase (iNOS) were significantly upregulated, but the Zn-NPs diet helped correct the gene regulation. Similarly, immune-related genes such as interleukin (IL), tumor necrosis factor (TNFα), toll-like receptor (TLR), and immunoglobulin were highly affected by stressors. However, the 4 mg kg^{-1} Zn-NPs diet showed improvements in the expression of all immune-related genes and helped mitigate the effects of stressors in fish. To evaluate the efficacy of dietary Zn-NPs in immunomodulation, we injected *Aeromonas hydrophila* into the fish after the 120-day experimental trial. The results indicated that the Zn-NPs at a concentration of 4.0 mg kg^{-1} diet showed enormous potential in modulating the effects of arsenic, ammonia, and high temperature stress, providing protection against pathogenic infections in fish. In conclusion, our investigation suggests that the Zn-NPs diet at 4.0 mg kg^{-1} has significant potential in mitigating the impacts of arsenic, ammonia, and high-temperature stress, while also enhancing immune response and protecting against pathogenic infections in fish.

Keywords: Anti-oxidative gene, fish, growth gene, immunomodulation gene, nano-zinc, stress

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Physio-immunological response of *Nelumbo nucifera* leaf extract-fed *Oncorhynchus mykiss* challenged with pathogenic *Aeromonas hydrophila*

Mudasir Maqsood Hakim[1,2], Nazir Ahmad Ganai[1], Syed Mudasir Ahmad[1], Oyas Ahmad Asimi[1], Riaz Ahmad Shah[1]

[1]Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir
[2] The Neotia University Kolkata, West Bengal

*hmudaisrm@skuastkashmir.ac.in

In production animals, an attempt to find alternatives for antibiotics and synthetic antimicrobials has been going on since past decade. Plant substances provide a sustainable solution to synthetic immunostimulants which are used in animal feed. The survival, physiological and immune responses of *Oncorhynchus mykiss* fingerlings fed with *Nelumbo nucifera* leaf extract was studied for 90 days. Two hundred and fifty fingerlings were randomly distributed into five treatment groups in triplicates. Each group was fed isonitrogenous and isoenergetic regimes containing 0% NNLE (control), 0.25% NNLE (T1), 0.75% NNLE (T2), 1.25% NNLE (T3), and 1.75% NNLE (T4) to satiation. Fortnightly, samples for enzyme assays, immune-gene expression and survival were recorded. The leaf extract was found to significantly ($p<0.05$) reduce malate dehydrogenase and aspartate aminotransferase activity in the liver tissue. Alanine aminotransferase activity in the muscle tissue of NNLE fed groups was significantly ($p<0.05$) higher than the control. The liver and gill superoxide dismutase activity were significantly ($p<0.05$) reduced in the NNLE fed groups compared to the control. *In-vitro* and *in-vivo* studies showed that NNLE significantly ($p<0.05$) reduces oxidative stress in fish. NNLE fed groups showed elevated TEC, TLC, respiratory burst activity, lysozyme activity and phagocytic activity as compared to control group. A similar pattern was observed in the post-challenge period. NNLE fed groups showed expression of defensin and hepcidin genes throughout the experimental period, confirming their role in fish's innate immune response. During pre-challenge phase, pro inflammatory cytokines were significantly ($p<0.05$) down-regulated as compared to control. In the post-challenge period, T4 (1.75% NNLE) caused substantial up-regulation of IL-1 and TNF-α expression. The regulatory cytokines were slightly up-regulated during pre-challenge and down-regulated after challenge. The treatment groups T3 and T4 showed significantly ($p<0.05$) higher survival rate after challenged with pathogenic bacteria *Aeromonas hydrophila*. The study reveals that supplementation of Indian lotus leaf extract at the rate of 1.75% in Rainbow trout diet enhanced the overall welfare.

Keywords: *Aeromonas hydrophila,* immunomodulation, leaf extract, *Nelumbo nucifera,* rainbow trout

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Effect of varying sources of arachidonic acid on the growth performance of whiteleg shrimp, *Penaeus vannamei* reared at three different water salinities

Sravanthi Oduru*, Syama Dayal, J., Gopinath, D. and Muralidhar, M.

ICAR- Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, Chennai – 600028, Tamil Nadu, India

*sravanthi.oduru@gmail.com

Climate change is estimated to affect the environment, escalating concern on all aspects of existence, especially the food-producing sectors like agriculture and aquaculture. Climate change -induced seasonal variations with heavy rainfall and high temperatures create salinity stress in the cultured environment. Mitigation approaches like dietary interventions emerge to be more adaptable to enhance stress resistance in aquaculture. During stressful conditions, there is an increase in the requirement of several nutrients, as there is a direct relationship between nutrition and immunity. Recent studies on Pacific white shrimp *Penaeus vannamei* suggest that Arachidonic acid (ARA) ameliorates the stress response. A 45-day feeding trial was conducted to elucidate the effect of ARA on salinity stress management in *P. vannamei* reared at three different salinities 5‰, 30‰ and 45‰. Three iso-nitrogenous (390 g/kg) and iso-lipidic (65g/kg) experimental diets containing varied sources of lipids (control diet, diet containing Porcine liver – an ingredient rich in ARA, diet containing pure ARA oil) were formulated. A total of 540 healthy acclimatized shrimps (7.5 g) were transferred into 27 experimental tanks with 20 shrimps per tank. Results showed a significantly ($p<0.05$) higher weight gain in shrimps fed with diet containing pure ARA oil in high salinity and no significant difference in the weight gain and growth performance at low salinity. At high salinity, shrimp fed with diet containing ARA oil improved in growth performance from 75.36 to 119.6% and those fed with diet containing porcine liver from 77.19 to 114.3%. It was concluded that shrimps fed with supplemented arachidonic acid had shown better growth rate and survival at high salinity but would not be beneficial while rearing at low salinity.

Keywords: Arachidonic acid, essential fatty acids, *Penaeus vannamei*, salinity

Effect of inulin on the growth and disease resistance status of Pacific white shrimp, *Penaeus vannamei*

Allie, N. U.*, Sudama Swain, Praveena, P. E., Bhuvaneswari, T., Panigrahi, A. and Subhendu Kumar Otta

ICAR- Central Institute of Brackishwater Aquaculture, 75, Santhome High road, R A Puram, Chennai–600 028, Tamil Nadu, India

*allienu96@gmail.com

Shrimp cultivation is one of the fastest growing sectors globally, and in most of the situations, the farmers face huge loss due to disease outbreak. Since shrimp lacks well developed immune system, enhancement of non-specific immune system of this organism through the use of immune-modulators has been found to be useful. The use of prebiotics has proven to show positive effect on beneficial gut bacteria, involved in gut metabolism and thereby enhancing the shrimp immune system. In this present study, inulin was used as a candidate prebiotic to study the effect on the growth and disease resistance of *Penaeus vannamei*. The experiment was designed with three different concentrations of inulin coated onto the normal basal feed (5 g kg^{-1}, 10 g kg^{-1} and 20 g kg^{-1}) along with the control group (without inulin) for a course of 30 days. Interestingly and as was expected, visible changes in growth were observed in experimental groups compared to the control. Significantly higher growth was observed with dosages of 10 and 20g kg^{-1} of feed than 5 g kg^{-1} of feed group. Evaluation of immune responses in *P. vannamei* was analyzed through expression of lysozyme, *SOD*, *crustin, peroxinectin*, *proPO*, actin, myosin and *HSP70*. Comprehensively, these studies revealed that experimental groups had higher level of immune gene expression compared to the control group. This was further proved through pathogen challenge study. Oral feeding of WSSV infected tissue and intramuscular injection of *Vibrio parahaemolyticus* showed extended period of protection in the animals of experimental group than the control groups. Through this study, inulin exhibited the characteristics of a prebiotic which showed significant growth performance and effect in defense against WSSV and *V. parahaemolyticus*.

Keywords: Growth, immune response, inulin, *Penaeus vannamei*, prebiotics, survival

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Prototype development of marine black pearl through biomineralization of *in-vitro* cultured mantle epithelial cells of black lip pearl oyster *Pinctada margaritifera*

Srinivasa Raghavan, V*. and Balaraman, T.

Madras Regional Station, ICAR-Central Marine Fisheries Research Institute, 75 Santhome High Road, Raja Annamalaipuram, Chennai 600028, Tamil Nadu, India.

*vetvsr@gmail.com

Nacre is a model of biomineralization process in mollusks comprising of aragonite platelets and organic material. Mantle epithelial cells control nacre formation. Epithelial cells from the mantle tissue of *Pinctada margaritifera* were cultured in-vitro using seawater as the culture medium. Periodic sub-culturing of mantle cells was carried out to establish primary cultures comprising of granulated epithelial cells. Nuclear beads were placed in culture wells containing semi-solid agar medium and incubated in vitro with cultured granulated epithelial cells in order to evaluate the nacre secretion. On visual observation, a brown coloration was observed on the surface of the bead after 7-10 days. Evaluation of the surface of the nuclear beads by scanning electron microscopy (SEM) after 60 days of incubation revealed a good brick and mortar pattern, characteristic of nacreous layer formation. A bright intense lustrous hue was also seen to develop on bead surfaces after this stage. SEM images of a cross section of the nacre-coated bead showed a pattern of arrangement of aragonite tablets similar to that seen in cross sections of the nacre layer of shell of molluscs. The refinement on the bright reflections of the lustrous nacre resulted in development of *in-vitro* marine black pearl prototype with increased intensity around the circumference of the nucleus owing to the thickness of nacre biomineralization. TEM analysis revealed 0.30 mm thickness of lustrous nacre, falling under good category gradation. The repeatability of the experiment to form lustrous nacre is 68% The functional ability of cultured granulated epithelial cells was further confirmed by detecting gene expression of matrix proteins, namely Nacrein, Lustrin, Molluscan Shell Framework Protein and Amorphous calcium carbonate binding proteins which play an important role in formation of the nacreous layer in both cultured cells and in native mantle tissue. There was a very high positive correlation between the expression patterns of the genes both in *in-vitro* cultured cells and native mantle tissue, signifying that the *in-vitro* cultured mantle epithelial cells retain their functional characteristics of biomineralization.

Keywords: Aragonite, biomineralization, epithelial cells, mantle, nacre, prototype

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Biomineralization of cryopreserved *in-vitro* cultured mantle epithelial cells of black lip pearl oyster, *Pinctada margaritifera*

Srinivasa Raghavan, V*. and Balaraman, T.

Madras Regional Station, ICAR-Central Marine Fisheries Research Institute, 75 Santhome High Road, Raja Annamalaipuram, Chennai 600028, Tamil Nadu, India.

*vetvsr@gmail.com

Nacre is composed of aragonite platelets and organic material formed by molluscs as inner shell layer through biomineralization process and mantle epithelial cells control nacre formation. Primary culture of granulated epithelial cells was established from mantle tissue of *Pinctada margaritifera*, through a process of continuous sub-culturing at 28°C in yeast supplemented sterile sea water culture medium. The cryoprotective effects of glycerol, dimethyl sulfoxide and a mixture of the two on long term preservation was studied. The mature granulated epithelial cells were mixed with 10% concentrations of the cryoprotective agent, initially stored overnight at -85°C and then subsequently transferred to -196°c. Viability and metabolic activity were equally better in both glycerol, dimethyl sulfoxide treated cells and comparable to that of unfrozen cells. The optimum post thaw cell viability after cryoprotection was 98% and 95% with glycerol and dimethyl sulfoxide in comparison to unfrozen cells (87%). The combination of the cryoprotectants and the control (frozen without cryoprotectants) were found to be significantly lower in terms of post thaw viability of cells. The cells were further used to induce nacre on nuclear beads in a semi-solid substrate. Nacreous layer composed of calcium carbonate in the form of aragonite platelets separated by sheets of elastic biopolymers in the form of organic matrix, sort of brickwork arrangement were noticed after 60 days of incubation. Cross section of the coated bead revealed a pattern of aragonite tablets arrangement similar to that seen in nacre layer of molluscan shell. Energy dispersive X-ray analysis revealed higher levels of calcium and found to be 89.30% and 63.72% on nuclear bead and its cross section. The major elements were found to be calcium, carbon and oxygen in all the stages. The study shows that mantle epithelial cells cultured *in-vitro* are amenable for cryopreservation and retain the original functional potential to secrete nacre representing the survival and recovery of activities even after freeze-thawing.

Keywords: Biomineralization, cryprotectant, epithelial cells, mantle, nacre

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

In-vitro analyses reveal Shewanella algae as a treasure for eicosapentaenoic acid: A prospective candidate for application in marine larviculture

Vishnu, R.[1,2]*., Sumithra, T. G.[1], Krupesha Sharma, S. R.[1], Anusree, V. N.[1], Chandrasekar, S.[1], Sayooj, P[1] and Tejpal C. S.[3]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Cochin University of Science and Technology, Kerala, India
[3]ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

*vishnuramachandran012@gmail.com

High-quality fish seeds and feeds are the most critical inputs in sustainable aquaculture practices. However, the success of larviculture is limited by the intricate dietary needs of larvae. Omega-3 long-chain polyunsaturated fatty acids (LC-PUFAs) including eicosapentaenoic acid (EPA), are vital for larval growth and development, making it a sought-after nutrient in larval diets. As the demand for sustainable sources of EPA has grown significantly in recent years, the search for a promising alternative to traditional EPA sources (microalgae and fish oil), which often face limitations in availability, scalability, and sustainability, becomes imperative. In this study, we identified the immense potential of Shewanella algae, a marine bacterium, as a prospective candidate for EPA production. In detail, 12 marine bacterial isolates were sub-cultured at below their optimal growth temperature (15^{o}C), and subjected to a series of in vitro analyses, including TTC-based assays, H2O2 plate assay, and spectroscopic assay (at 205 nM) after the modified Bligh and Dyer method of fatty acid extraction to identify the one EPA-producing bacteria. Finally, fatty acid profiling using gas chromatography-mass spectrometry (GC-MS) was performed to confirm and quantify the PUFA content in bacterial pellets. The results indicated that one bacterium, which was initially isolated from the gut of an aquatic mud crab (Scylla serrata), exhibited substantial EPA production. In detail, the EPA production was 5 µg per g bacterial dry weight and formed 0.43% of total fatty acids and 30.96% of total PUFA without any optimization. Furthermore, molecular screening for the functional genes involved in PUFA production confirmed the PUFA-producing genetic machinery in the bacterium, viz. pfaA and pfaC. Finally, bacterial identification using the polyphasic taxonomic approach identified the EPA-producing strain as S. algae. Overall, this study points out the untapped potential of S. algae as a treasure trove of EPA for the first time. Further research is warranted to evaluate the practical feasibility, scalability, and long-term effects of incorporating S. algae-derived EPA in larval diets, ultimately fostering sustainable, eco-friendlier, and efficient aquaculture practices.

Keywords: Fatty acids, GC-MS, larval diets, PUFA producing microbe, sustainable mariculture

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Pilot scale Solid State Fermentation: A key advancement in bioprocess development

Syama Dayal, J.*, Sujeet Kumar, Ambasankar, K., Joel Joseph Prasad, Aswath Rayarothan, Abhaya Robinson and Jagatheeswar, S. K.

ICAR–Central Institute of Brackishwater Aquaculture, No 75, Santhome High Road, R.A Puram, Chennai-600028, Tamil Nadu, India

* syamadayal@gmail.com

Solid state fermentation (SSF) has emerged as a prominent bioprocess technology for the production of various bioproducts, including enzymes, biofuels, organic acids, and specialty chemicals. While laboratory-scale SSF studies have yielded promising results, translating these findings into large-scale production has posed significant challenges. The pilot scale solid state fermentor, designed to bridge the gap between laboratory experiments and industrial-scale production, has become a crucial tool in optimizing SSF processes. Moreover, the flexibility of these systems allows for the exploration of novel substrates and microorganisms, leading to the development of innovative bioprocesses. The pilot-scale system offer precise control over critical parameters, such as temperature, humidity, aeration, and agitation, to ensure reproducibility and scalability. This also facilitated efficient monitoring and data collection, enabling process optimization and real-time adjustments. In the present study the substrate selected was soya bean meal, the micro-organisms that was used in inoculum fungi *Aspergillus niger*. Inoculum of 1% of the total weight of the substrate was added for this fermentation cycle. The quantification of microorganisms was done at 24h, 48h, 60h and 72h of the fermentation. The temperature was maintained between 29-32^{o}C during the cycle which was found to be the optimum condition for growth. The pressure was maintained at 0.5- 1 psi which was found to be optimum and the relative humidity was controlled at 75% which was the standard in the process. The results suggest that *A. niger* spores started germinating from 24h post incubation reflected by a lower value of 1 log population. By 48h and 72h *A. niger* count increased to 6 and 7 log, respectively which indicated the fermentation has taken place along with the strong fermented smell of ingredients. The changes in nutritional quality over the course of fermentation have indicated that best essential amino acid quality was observed at 72 hours after initiation of fermentation. Furthermore, SSF led to a reduction in anti-nutritional factors improving the overall nutrient bioavailability. In conclusion, pilot scale solid state fermentor plays a pivotal role in advancing SSF technology from the laboratory to industrial scales. Further research and development in pilot scale SSF systems are expected to contribute significantly to the sustainable production of bio-based products for sustainable aquaculture.

Keywords: *Aspergillus niger*, Solid state fermentation (SSF), Soya bean meal (SBM)

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Antagonistic properties and biocompatibility of host-gut-derived marine bacteria for the development of potential probiotic consortia in Indian pompano mariculture

Jayasree Loka*[1], Ritesh Ranjan[1], Biji Xavier[1], Sekar Megarajan[1], Narasimhulu Sadhu[1], Krupesha Sharma[1], Boby Ignatius[1], Joe K Kizhakudan[1], Subhadeep Ghosh[2], and Gopalakrishnan, A.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2] Indian Council of Agricultural Research, Division of Fisheries Science, Krishi Anusandhan Bhawan – II, New Delhi–110 012 India
*lokasree@gmail.com

An investigation was carried out to study the probiotic properties of marine bacterial species isolated from the gut of the Indian pompano, *Trachinotus mookalee*, for the development of an effective and potential marine probiotic consortia. For the present study, the guts of farmed Indian pompano were screened for the presence of beneficial bacteria by using standard methods, and the isolated species were identified based on morphological, biochemical and 16s rRNA gene sequence analysis. All the bacterial isolates were tested for their antagonistic activity and other probiotic properties. Out of all the bacterial isolates, 62% of isolates exhibited antagonistic activity belonging to the genera *Shewanella*, *Pseudoalteromonas, Bacillus* and *Halomonas.* Pure strains of isolates exhibiting high antimicrobial activity and other probiotic properties were selected for the preparation of Marine Probiotic Consortia (MPC). Three different consortia were prepared with different combinations of antagonistic bacteria, isolated from the gut of Indian pompano (MPC1 : with a combination of seven species belonging to four different genera, *Shewanella*, *Pseudoalteromonas, Bacillus* and *Halomonas*; MPC2: with a combination of three species belonging to two genera, *Bacillus and Shewanella* and, and MPC3 : a combination of three different species belonging to single genera). Study revealed that all three consortia exhibited high antimicrobial activity against the fish pathogens (*Vibrio* spp. and *Aeromonas* spp.), but the activity was significantly higher when tested with MPC1 ($p<0.05$), with a maximum zone of inhibition of 25 mm. Other probiotic properties, such as acid and bile salt tolerance, antibiotic susceptibility test, antioxidant activity, and haemolytic activity, indicated MPC1 as the most potential Marine Probiotic Consortia, with high antimicrobial activity towards the decolonization of pathogenic bacteria. A significant variation was observed between the probiotic consortia against various probiotic properties and also the biocompatibility between the strains ($p<0.05$). A probiotic bacterial concentration of $1x10^{12}$cfu ml^{-1} is ideal for the development of a potential Marine Probiotic Consortia with multiple bacterial strains belonging to different genera, isolated from the gut of Indian pompano. In conclusion, the study revealed multiple probiotic consortia, with remarkable probiotic properties, can play a significant role in the development of a successful probiotic consortium for the mariculture of Indian pompano.

Keywords: Biocompatibility, fish gut, Indian pompano, Marine probiotic consortia, probiotic properties

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

The impact of dietary microalgal oil on fatty acid composition and the expression of genes associated with fatty acid metabolism in silver pompano (*Trachinotus blochii*)

Chandrasekar Selvam*, Sanal Ebeneezar, Dani Shaji, Sajina, K., Sayooj, B. and Linga Prabu, D.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*fishochand@gmail.com

The present study aimed to explore the potential application of microbial oil (MO) obtained from A*urantiochytrium* spp., a type of microalgae recognized for its abundant docosahexaenoic acid (DHA) content. The focus was on assessing the feasibility of incorporating this MO in the diets of cultured silver pompano *(Trachinotus blochii*). A 45-day feeding trial was conducted with juvenile silver pompano (initial weight of 4 g) in saline water to assess the effects of incorporating *Aurantiochytrium*-derived MO in their diets. Three experimental groups were fed with three different experimental diets: diet 1 contained no microalgal oil, diet 2 contained 2% dry mass *Aurantiochytrium*, and diet 3 contained 4% wet mass *Aurantiochytrium*. Fish that were fed Diet 3, which included 4% wet mass of *Aurantiochytrium,* demonstrated a significant ($p \leq 0.05$) increase in weight gain and specific growth rate compared to those fed diet 1 and diet 2. The analysis of fatty acid composition in the muscle tissue indicated a decrease in EPA and DHA contents among fish that consumed microalgal oil (MO) compared to son to those on diet 1 without Microalgal oil. This trend corresponded with a reduction in the expression of FADS2 (Fatty acid desaturase 2) and ELOVL5 (fatty acid elongase 5) in the entire gut of silver pompano that were fed diet 2 and diet 3, as opposed to diet 1. In conclusion, addition of *Aurantiochytrium* in the diet of silver pompano positively influenced growth performance, while concurrently exerting a negative impact on the EPA (Eicosapentaenoic acid) and DHA contents in muscle. However, negative impact of dietary *Aurantiochytrium* on muscle EPA and DHA needs further investigation.

Keywords: *Aurantiochytrium*, DHA, EPA, microalgal oil, silver pompano

Protective mechanisms of *Schizochytrium* oil against hyperlipidemia: evidence from a zebrafish model

Gora, A. H.*[1], Rehman, S.[1], Dias, J.[2], Fernandes, J. M. O.[3], Olsvik P. A.[3], Sørensen, M.[3] and Kiron, V.[3]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]SPAROS LDa., Olhão, Portugal
[3]Faculty of Bioscience and Aquaculture, Nord University, Bodø, Norway

*adnan.gora@icar.gov.in

Long-term consumption of a Western-style diet rich in saturated fats and cholesterol elevates blood lipid levels, a major risk factor in the development of cardiovascular diseases (CVDs) in humans. However, the consumption of long-chain n-3 polyunsaturated fatty acids (n-3 PUFAs) can stall the CVD progression. Although n-3 PUFAs can significantly impact the blood lipid profile under a hyperlipidemic condition, the associated changes in the intestinal transcriptomic and plasma lipidomic landscapes have not been studied in detail. Therefore, we investigated the alterations in the intestinal transcriptome along and the changes in the plasma lipidome and liver histomorphology of zebrafish offered dietary *Schizochytrium* oil, under a hyperlipidemic condition. Fish were allocated to 4 dietary treatments: a control group, a high-cholesterol group and *Schizochytrium* oil groups with low (3.1%) and high (6.6%) inclusion levels of *Schizochytrium* oil. We quantified the circulating total cholesterol, lipoprotein cholesterol and triglyceride levels in the zebrafish fed the experimental diets. The results suggested that higher levels of dietary *Schizochytrium* oil could prevent the increase in total cholesterol, low-density lipoprotein cholesterol and triglycerides in the zebrafish plasma. Furthermore, *Schizochytrium* oil-fed fish had reduced hepatic vacuolization and higher hepatic mRNA expression of genes involved in β-oxidation and high-density lipoprotein maturation. Intestinal transcriptomic analysis revealed that *Schizochytrium* oil supplementation can restore the expression of genes altered by a hypercholesterolemic diet. The plasma lipidomic profiles revealed that the higher dietary level of microbial oil could elevate the long-chain PUFA content of triglyceride species and lower the concentration of several lysophosphatidylcholine and diacylglycerol molecules. Our study reveals the effectiveness of *Schizochytrium* oil against hyperlipidemia in zebrafish.

Keywords: Bioactive compounds, cardiovascular disease, plasma lipidomics, RNA seq

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Soybean meal-induced intestinal inflammation is associated with developmental defects and behavioral aberrations in zebrafish

Rehman, S.*[1], Gora, A. H.[1], Varshney, S.[2], Dias, J.[3], Olsvik P. A.[2], Fernandes, J. M. O.[2], Brugman, S.[4] and Kiron, V.[2]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Faculty of Bioscience and Aquaculture, Nord University, Bodo, Norway
[3]SPAROS LDa., Olhão, Portugal
[4]Department of Animal Sciences, Host Microbe Interactomics, Wageningen University, Wageningen, Netherlands

*saima.rehman@icar.gov.in

Dietary soybean meal induces intestinal inflammation in certain fishes. Although the molecular aspects of soybean meal-induced intestinal inflammation in zebrafish are known, the impact of the inflammatory diet on fish development and behaviour remains largely unknown. We fed zebrafish larvae with three diets–control, soybean meal and soybean meal with β-glucan to gain deeper insight into the behavioural and developmental changes associated with the soybean meal-induced inflammation model. We investigated the effects of dietary treatments on the locomotor behaviour, morphological development, oxygen consumption and larval transcriptome in zebrafish. Our study revealed that dietary soybean meal can hamper locomotor activity, cause developmental aberrations and increase the oxygen demand in zebrafish larvae. Transcriptomic analysis of soybean meal-fed fish indicated reduced expression of genes linked to visual perception, organ development, phototransduction pathway and upregulation of genes connected to steroid biosynthesis pathway. On the contrary, β-glucan, an anti-inflammatory feed additive, counteracted the behavioural and phenotypic changes and restored the expression of genes that were altered by dietary soybean meal. Furthermore, we found that feeding the inflammatory diet at the larval stage can lead to long-lasting developmental defects. In conclusion, our study reveals the extra-intestinal manifestations associated with soybean meal-induced inflammation in zebrafish.

Keywords: β-glucan, behavior, inflammation, RNA-Seq, zebrafish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Bioconversion of poultry feather waste for the formulation of keratin derivatives supplemented feed: measures towards sustainable marine ornamental aquaculture

Dhayanithi, N. B., Divya, P. R., Ajith Kumar, T. T.* and Uttam K. Sarkar

ICAR -National Bureau of Fish Genetic Resources, Lucknow–226 002, Uttar Pradesh, India

*ttajith87@gmail.com

Poultry feather waste has been discarded enormously in the environment with an annual accumulation of billion tonnes. There is a need to process the waste without polluting the environment. Since chicken feathers contain more than 90% keratin, designing a bioremediation method using keratinolytic microbes would be advantageous. The objective of the current study was to isolate and determine a suitable bacterial strain that can hydrolyse chicken feather waste into a value-added product. Keratinase-producing bacterium was isolated from the soil samples of the poultry waste dumping zone. Further, it was confirmed as *Stenotrophomonas pavanii* (Genbank accession No. KM588828.1) by 16S rRNA gene sequencing. The culture conditions and composition of the medium (NaCl 0.5 g l^{-1}, KH_2PO_4 0.3 g l^{-1}, K_2HPO_4 0.4 g l^{-1}, feather powder 10.0 g l^{-1}, pH 8.0) were optimized to improve keratinase production through shake flask culture. The maximum yield (79 ± 0.3 U ml^{-1}) of keratinase activity was recorded after 36 h of incubation at 40°C with an optimum pH of 8.0. Following this, the experimental clownfish feed was supplemented with a keratin-degraded end product. Fishes were fed with keratin derivatives, which enhanced the innate immune responses, and it was indicated with total white blood cell (WBC), serum lysozyme activity, respiratory burst assay, alternative complement (ACH_{50}) assay, phagocytic activity assay and increased resistance against the predominant bacterial pathogen, *Vibrio alginolyticus* compared to the control group. The study highlighted the usage of keratin derivatives in enriched feed, which can be utilised in promoting ornamental aquaculture through the production of healthy and immune-resistant marine ornamental fishes.

Keywords: Clownfish, disease resistance, immune response, keratinolytic bacteria, keratin derivatives, poultry feather waste

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Fishmeal replacement using a sustainable, low carbon footprint algal meal in the diet of snubnose pompano, *Trachinotus blochii*

Linga Prabu, D.*, Sanal Ebeneezar, Chandrasekar, S., Kalidas, C., Anikuttan, K. K., Kavitha, M., Ranjith, L., Asha, P. S. and Krupesha Sharma, S. R.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*prabufnbp@gmail.com

Marine microalgae have been considered as a low carbon footprint food/feed commodity with better carbon sequestration efficiency. It is a sustainable alternative source of protein and lipid for replacing the most depleting marine resource, fishmeal and fish oil, in aquafeeds. *Nannochloprosis* sp. is a unicellular green microalgae of marine origin rich in protein (50-52%), lipid (10-14%), eicosapentaenoic acid (EPA) (6%), and docosahexaenoic acid (DHA) (4%). A 90-day feeding experiment was conducted to replace fishmeal and fish oil in the diet of juveniles of snubnose pompano, *Trachinotus blochii,* to assess the growth performance, feed utilisation, nutritive profile and health of fish. Six iso-nitrogenous (40% CP) and iso-caloric (6% CL) experimental diets were prepared using Nannochloropsis meal (NM) by replacing varying levels of fishmeal protein such as 0, 20, 40, 60, 80 and 100% and named as 0NM, 20NM, 40NM, 60NM, 80NM and 100NM respectively. The actual fishmeal content in the 0NM diet is 24%, which was completely replaced by 31.25% of algal meal in the 100NM diet. The study revealed that there was a significant difference ($p<0.05$) in the growth performance in terms of weight gain percentage (WGP), specific growth rate (SGR), daily growth co-efficient (DGC), and feed utilization in terms of feed conversion ratio (FCR), protein efficiency ratio (FER) and protein efficiency ratio (PER) among the treatments. Among the treatments, higher SGR, WGP, and DGC were observed in 40NM followed by the 80NM group. Better FCR, PER, and FER were observed in 60NM and 80NM groups. The fatty acid profile of experimental fish showed higher eicosapentaenoic acid (EPA) and polyunsaturated fatty acid (PUFA) content in the order of 100NM>80NM>60NM>40NM>20NM>0NM. The liver histology showed no gross morphological difference among the treatments. The inclusion of *Nannochloropsis* meal increased in the diet resulted in increased length of intestinal microvilli. The study revealed that fishmeal can be effectively replaced with *Nannochloropsis* meal up to 40% (which accounts for 125 g kg^{-1} algal meal) without any adverse effect on the growth, health, and meat quality of *T. blochii*.

Keywords: Algal meal, daily growth co-efficient, feed conversion ratio, intestinal health, polyunsaturated fatty acid

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Mixed insect meal as a sustainable fishmeal replacer in the diet of juvenile snubnose pompano, *Trachinotus blochii*

Linga Prabu, D.*, Chandrasekar, S., Sanal Ebeneezar, Kalidas, C., Tamilmani, G., Rameshkumar, P. and Kajal Chakraborty

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*prabufnbp@gmail.com

Insects are capable of consuming animal manure, food wastes, and reducing pollution and providing protein (larvae), and fertilizer (frass). Insect meal production requires very little water as insects are more water-efficient creatures than any other source of protein. A 90-day experiment was conducted in indigenous re-circulatory aquaculture systems (iRAS) to replace fishmeal using mixed insect meal in the diet of juveniles of *T. blochii* to assess the growth performance and feed utilization. Five treatments to replace fishmeal protein using two different combinations of insect meal [silkworm pupae meal-black soldier fly meal (SWP-BSF) & krill meal-green bottle fly (KM-GBF)] in two different replacement levels (50 and 100%) were designed. Five iso-nitrogenous (40% CP) and iso-caloric (6% CL) experimental diets were prepared using mixed insect meals (KM-GBF & SWP-BSF) to replace two different levels of fishmeal protein (50% and 100%) along with a control diet without insect meal. The diets were named as follows: K:G50, 50% replacement of FM protein using KM-GBF; K:G100, 100% replacement of FM protein using KM-GBF; S:B50, 50% replacement of FM protein using SWP-BSF; S:B100, 100% replacement of FM protein using SWP-BSF and one control diet (FM). The growth performance of *T. blochii* in terms of weight gain percentage, specific growth rate, and average daily growth showed significant differences ($p<0.05$) among the treatments. Similarly, the feed utilization in terms of feed conversion ratio, feed efficiency, and protein efficiency ratio showed significant differences ($p<0.05$) among the treatment group fish fed using varying levels of mixed insect meal combination. The digestive enzymes such as amylase, protease, and lipase showed significant differences ($p<0.05$) among the treatments. The protease activity was found higher in the K:G50 group, whereas the amylase and lipase activity were higher in the S:B100 group. The liver section revealed normal hepatocytes in the treated groups. The study revealed that FM protein can be replaced using KM and GBF (75:25) up to 50% without negatively affecting growth, gut health and feed utilization.

Keywords: Black soldier fly meal, feed conversion ratio, gut health, insect meal, krill meal, waste valorization

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Dietary selenium influences the growth, antioxidant enzyme activity and gene expression of Pacific white leg shrimp *Penaeus vannamei*

Prasanna, U.[1]*, Judith Betsy, C.[1], Shalini, R.[1], Stephen Sampath Kumar, J.[2], Shahanwaz Ali[3] and Siva, C[3]

[1]Fisheries College & Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Tuticorin-628 008, Tamil Nadu, India
[2]Directorate of Sustainable Aquaculture, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam-611 002, Tamil Nadu, India
[3]Molecular Biology Laboratory, Directorate of Coldwater Fisheries Research, Bhimtal- 263 136, Uttarakhand, India

*prasannaudayakumar7@gmail.com

The present study investigated the effects of different levels of dietary selenium (Se) on the growth, antioxidant enzyme activity and relative mRNA expression of *Penaeus vannamei*. Sodium selenite was added to the commercial feed at 0 (C), 0.2, 0.4, and 0.6 mg kg^{-1}, with final Se concentrations of 0.38 (C), 0.59, 0.80, and 1.01 mg kg^{-1}, respectively. Shrimp were fed with the experimental diets for 56 days, after which the growth performance, antioxidant enzymes activity such as CAT, SOD and GPx and relative mRNA expression of antioxidant genes (SOD, CAT, GPx, TRx, Nrf2 and HO-1), immune genes (proPO, Lys, TGas, Bgp, Crus, Toll, MyD88 and IMD) and growth gene (IGF II) were recorded. The results showed that significantly higher final body weight (5.469±0.16 g), highest feed conversion efficiency (65.34±1.61 %) and lowest feed conversion (1.53±0.03) ratio was observed in shrimp fed with 0.59 mg/kg Se diet ($p<0.05$). Shrimp fed with 1.01 mg kg^{-1} Se diet had the lowest survival rate and highest hepatosomatic index ($p<0.05$). Antioxidant enzyme activity (SOD, CAT, and GPx) in HP and abdominal muscle was enhanced in 0.59 mg/kg of Se level ($p<0.05$). All the genes were upregulated in 0.59 mg kg^{-1} Se except the TGase gene ($p<0.05$). Our results suggested that Se supplementation with 0.59 mg kg^{-1} of diet improved the growth, antioxidant capacity and gene expression of *P. vannamei*. Furthermore, extra levels of dietary Se decreased growth rate, reduction of antioxidant enzyme activities and down-regulation of genes, indicating that high levels of Se in diet can induce oxidative stress in *P. vannamei*.

Keywords: Antioxidant enzyme, gene expression, growth, *Penaeus vannamei*, sodium selenite

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Synthesis of *Padina tetrastromatica* capped copper nanoparticles and its effect on growth, blood biochemical profiles and immune response of the Cobia (*Rachycentron canadum*)

Tamilmani, G.*, Sakthivel, M., Anikuttan, K. K., Rameshkumar, P., Sankar, M., Johnson, B., Ravikumar, T. T., Krishnaveni, N., Ishwarya, R. and Imelda Joseph

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*drtamilmani@gmail.com

The use of copper nanoparticles has garnered much interest in numerous industries. In this study, for the first time, an extract of the brown seaweed *Padina tetrastromatica* was used as an eco-friendly reagent to synthesize copper nanoparticles (PtCuNPs) using copper sulphate as a starting material. The morphology and structure of synthesized PtCuNPs were characterized by UV-visible spectrophotometry, Fourier Transform Infrared (FTIR), Transmission Electron Microscopy (TEM), and X-ray diffraction (XRD). The UV-Vis spectrophotometry measurement showed the surface plasmon resonance (SPR) peak at 255 nm, whereas FTIR measurements showed all functional groups had control over the reduction and stabilization of the nanoparticles. The X-ray diffraction pattern revealed that the particles were crystalline with a face-centred cubic (FCC) geometry. The TEM micrograph showed that the particle size distribution had a high uniformity with a size of 20–40 nm under the optimum condition. A 60-day feeding trial was conducted to evaluate the effect of the inclusion of Pt-CuNPs in the diet on the growth, blood biochemical profiles, antioxidant status and immune response of Cobia (initial body weight: 2.50±0.02 g). Basal diets (control) were supplemented with PtCuNPs at 2, 4, 6 and 8 mg/kg (dry feed weight) for the trial. The results showed that 4 and 6 mg/kg supplementations showed the maximum efficiency in final body weight, weight gain, specific growth rate, feed intake, protein gain and tolerance against low-salinity stress. Of these two supplementations, the 4mg/kg inclusion showed significantly ($p<0.05$) higher feed efficiency ratio, protein efficiency ratio, protein retention, whole body copper content, protease activity, lysozyme activity and total serum protein. Therefore, the results of the current study suggest that adding PtCuNPs in the diet @ 4mg/kg would improve the Cobia's growth rate and immune response.

Keywords: Cobia, copper nanoparticles, dietary supplements, immune response, *Padina tetrastromatica*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Aqueous leaf extract of *Psidium guajava* improves growth and health parameters in the Pearl Spot, *Etroplus suratensis*

Lakshmi, S. R., Bharath Jayaram, Rahul Krishnan, Devika Pillai and Gijo Ittoop*

Kerala University of fisheries and Ocean studies, Panangad, Kochi-682 506, Kerala, India

*gijoittoop@gmail.com

The present study evaluated the effect of aqueous leaf extract of *Psidium guajava* (ALG) on growth performance, haematological parameters, serum parameters, antioxidant enzyme activity and tissue morphology of the liver and intestine of *Etroplus suratensis*. The toxicity of the extract was tested as per OECD guidelines. The antibacterial property of ALG against *Aeromonas hydrophila* was estimated. The fingerlings (4.5±2.3g) were fed with four experimental diets containing 0.5%, 1%, 1.5%, 2% ALG and one control diet having 0% ALG for 60 days in triplicates with 10 fish in each replicate. At the end of the experiment, growth and survival were recorded. Blood parameters like RBC, WBC, HGB, HCT, MCH, MCV, MCHC and PLT were assessed. The serum parameters like total protein, albumin, A/G ratio, alkaline phosphatase and glucose were estimated. Liver tissue was used for assessing antioxidant enzyme activities. Histology of the liver and intestines was also done. The result showed that there is a significant increase ($p<0.05$) in growth parameters like weight gain, weight gain percentage, specific growth rate, and a decrease in FCR in fish fed ALG incorporated diets. All the haematological parameters showed a significant increase among treatment groups ($p<0.05$). The serum glucose showed a significant decrease when compared to control and parameters like ALT and AST showed no significant difference among treatment and control. The activity of SOD and catalase was significantly higher in treatment groups. Histological analysis of liver and intestine showed changes like an increase in hepatocyte diameter and villi length in treatment groups compared to the control fish. Minimum inhibitory concentration of ALG against *A. hydrophila* was 150µg ml^{-1}. The results of this study confirm the positive effect of ALG on the growth and health parameters of *E. suratensis*.

Keywords: Antibacterial properties, diet, *Etroplus suratensis*, histopathology, *Psidium guajava*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Growth, reproductive performance, body composition and egg quality of orange chromide, *Etroplus maculatus* (Bloch, 1795) fed with broodstock diets containing different levels of protein and lipid

Sayooj, P.[1]*, Vijayagopal, P.[1], Anusree, V. N.[1], Shihab Ismail.[1], Vijayan, K. K. [2], Sanal Ebenezar[1] and Chandrasekar, S.[1]

[1]ICAR–Central Marine Fisheries Research Institute, Kerala, India 682018
[2]ICAR–Central Institute of Brackish Water Aquaculture, Chennai, India 600028.

*sayoojba@gmail.com

The study aims to determine the effect of dietary protein and lipid levels on the growth, reproduction and egg quality of orange chromide, *Etroplus maculatus*. Nine diets representing a combination of three protein levels (40, 45 and 50%) and three lipid levels (09, 12 and 15%) were tested. Each replicate with 10 fish (8.25 ± 1.42 g) were fed with test diets to apparent satiation twice daily for pair formation and brood stock development. The weight gain of *E. maculatus* broodstock was not significantly ($p< 0.05$) different among fish fed diets with the various protein and lipid concentrations. The body protein content of broodstock was not significantly affected by dietary protein and lipid concentrations. However, increasing dietary lipid resulted in increasing body lipid content regardless of the dietary protein concentration in broodstock diets. Survival rate of three day post hatch (3DPH) larvae of *E.maculatus* was not significantly affected by different combinations of protein and lipid levels. Relative fecundity was found to be significantly elevated by dietary lipid at 12%. The survival rate of 3 DPH larvae was the highest among broodstock fed diets with 45% protein and 12% lipid. Because of the ease of conditioning, adaptability to formulated diets and continuous sustained reproductive output suggested that orange chromide is a model for examining the factors affecting egg and larval quality in edible cichlids like pearl spot and tilapia. The present study revealed that the best reproductive performance of *E. maculatus* broodstock was achieved at 45% dietary protein and 12% dietary lipid concentrations based on relative fecundity, fertilization rate, hatchability and survival of 3 DPH larvae.

Keywords: Egg quality, *Etroplus maculatus*, growth, lipid, protein, reproductive performance

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Aurantiochytrium: a potential replacer of fish oil in Shrimp

Ankit Kumar*, Manabjyoti Barman and Tincy Varghese

ICAR–Central Institute of Fisheries Education, Mumbai-400061, Maharashtra, India

*ankitbarnwal47@gmail.com

With the continuously increasing demand for fish oil rising from aquafeed industry, pharmaceutical industry and human consumption, there has been a rapid decline in the finite pelagic stocks as well as global fish oil production. Omega 3 fatty acid plays an important role in brain development and heart health. Aurantiochytrium is an oleaginous protist containing three times higher EPA and DHA than the conventional fish oil which can be cultured under controlled fermentation conditions. Thus an attempt was made to evaluate the significance of *Aurantiochytrium* in aquafeed for which three feeds with three different inclusion levels (33, 67 and 100%) to replace fish oil were fed to shrimp juveniles distributed randomly to four treatment groups. One- way-ANOVA was performed to test the significance of *Aurantiochytrium* among the four treatments. The treatment fed with 67% or 2/3rd replacement of FO with *Aurantiochytrium*-based meal exhibited significantly ($p<0.05$) higher growth performance in terms of weight gain (WG) (g), WG (%), specific growth rate, lower FCR, compared to other groups. Hence, the findings of the study suggest that *Aurantiochytrium* can be a partial replacer for fish oil, up to 67%. However, further investigations are required to validate the health benefits of *Aurantiochytrium* in comparison to fish oil.

Keywords: Aquafeed, *Aurantiochytrium*, fish oil, Omega 3 fatty acid

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Future-proofing rainbow trout aquaculture with functional feeds

Biju Sam Kamalam*, Anupam Pandey, Manchi Rajesh, Prakash Sharma, Nahida Rasheed, Nityanand Pandey and Pramod Kumar Pandey

ICAR-Directorate of Coldwater Fisheries Research, Bhimtal-263136, Uttarakhand, India

*bs.kamalam@icar.gov.in

The Indian Himalayan region is considered as the window of global climate change, as the fragile mountain ecosystems experience a higher degree of environmental impact. Particularly, with respect to coldwater aquaculture, climate change associated thermal regime changes are limiting the expansion and intensificationof rainbow trout (*Oncorhynchus mykiss*) production in the Indian uplands. To mitigate this adverse impact, nutritional solutions-interventions are globally considered as the most practically feasible strategies. In this milieu, we prepared different rainbow trout feed formulations with varying antioxidative nutrient supplementation levels (0, 0.06, 0.18 and 0.3%). Following that, we carried out an eight-week feeding trial to evaluate the functional potential of this antioxidant supplementation to enhance the thermal safety margins and acclimation capacity of rainbow trout juveniles (initial weight 3-4 g), when reared at temperatures above the physiological optimum (20±2°C). At the end of the trial, there were no significant differences in feed intake, feed utilisation and growth performance between the dietary treatments. Likewise, there were no biometric differences related to body condition factor, liver, heart and intestine. However, confirming the improved antioxidative status with the test diets, the total antioxidant activity levels in liver and plasma were found to increase linearly with the antioxidant supplementation levels and there was areciprocal decrease in TBARS levels in the liver. Corresponding to this, a substantial increase was observed in thermal safety margins with dietary supplementation of antioxidants. At both end of the temperature spectrum, the critical temperature tolerance limits (CT_{max} and CT_{min}) of rainbow trout were augmented by 1.5 and 3°C, respectively, i.e., the critical thermal scope was enhanced by 4.5°C in the 0.3% group. Underlying this, there was a potential improvement in the blood oxygen carrying capacity, concomitant decrease in routine metabolic rate and physiological stress with dietary antioxidant supplementation levels. Corroborating this, in the liver, we observed a significant downregulation of the mRNA expression of hepatic antioxidative enzymes (*gst* and *sod*) and cellular stress response markers, such as *gr1*, *hyou1*, *hif1a*, *junb*, *cct8* and *tlr5* at the transcriptional level, with higher levels of antioxidant supplementation (0.18 and 0.3%). Overall, we conclude that antioxidative nutrient supplementation can substantially augment the thermal safety margins of juvenile rainbow trout by improving organismal antioxidative status and oxygen carrying capacity, and minimizing metabolic energy demand. Functional feeds can thus future proof trout farming without compromising fish performance and welfare.

Keywords: Antioxidants, climate change, fish ecophysiology, metabolic adaptation, thermal safety margins

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Effect of partial replacement of fish meal with guar meal (*Cyamopsis tetragonoloba*) in the diet of pearl spot, *Etroplus suratensis* juveniles

Sarath Varghese[1*], Dinesh Kaippilly[1], Sanal Ebeneezar[2] and Neethu Zacharia[1]

[1]Kerala University of Fisheries and Ocean Studies, Panangad, Kochi-682 506, Kerala, India
[2]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sarathvarghesemndy@gmail.com

An eight-week experiment was conducted to evaluate the effects of partial replacement of fish meal using guar meal on the growth performance, whole body composition, anti-oxidant and digestive enzyme activities in *Etroplus suratensis* juveniles (initial body weight, 2.44±0.69 g). Five isonitrogenous (35% crude protein) diets containing 0%, 5%, 10%, 15% and 20% (C, T1, T2, T3 and T4 respectively) guar meal were formulated. The final weight, PRE and weight gain of the fingerlings that received the T2 diet were significantly higher ($p<0.05$) among the treatments. A significantly higher nutrient utilization efficiency in terms of FCR, PER and FER was obtained in the T1 diet. However, replacing the higher guar meal levels (15 or 20%) significantly reduced them. Analysis of whole-body composition showed significant differences ($p<0.05$) in moisture, protein, lipid, and ash contents among the dietary treatments. Protease activity decreased as the level of dietary guar meal increased. Amylase and lipase activity also showed significant differences among the treatments. The inclusion of guar meal in the diet led to evident changes in the fish's antioxidant status with significant changes in catalase, superoxide dismutase and glutathione peroxidase activity. The histological study demonstrated that all groups displayed normal morphology of intestine and liver tissue. In summary, this study demonstrates that dietary supplementation of guar meal up to 10% enhances the growth performance of pearlspot fingerlings without compromising overall growth, antioxidant responses, or digestive function. These findings offer valuable insights into the potential use of guar meal as a partial replacement for fish meal in the diet of *E. suratensis* juveniles, with implications for sustainable aquaculture practices.

Keywords: *Etroplus suratensis*, fish meal, guar meal, growth rate, histology

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Deciphering the dietary influence on the fatty acid profile of fishes of varying feeding guilds of the Vembanad Lake, southwest coast of India

Vineetha, G.[1]*, Jeyabaskaran, R[1], Parvathy, R.[1], Kezia James[1], Karati, K. K.[2] and Grinson George[1]

[1] ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2] Centre for Marine Living Resources & Ecology, Kochi-682 016, Kerala, India

*vineetha.varada@gmail.com

Fishes constitute a major nutritional source for the coastal population, besides providing them with livelihood opportunities and economic security. They form a dietary source of high quality protein, vitamins and minerals, and protect humans from many life threatening diseases due to their high polyunsaturated fatty acid contents, specifically the ω3 and ω6. Hence, it is essential to evaluate their nutritional quality with respect to their essential fatty acid content. Fourteen fishes having high market value among the inland population of the Vembanad Lake were evaluated for their nutritional quality with respect to their essential fatty acid contents. Fishes collected during the pre-monsoon (April) and monsoon (September) were categorised into varied feeding guilds, as Zooplanktivores, Zoobenthivores, Omnivores and Carnivores based on their dietary preferences. The fishes belonging to varied feeding guilds were evaluated for their seasonal variation in total fat, saturated fatty acid (SAFA), monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), ω3, ω6, eicosapentaenoic acid (EPA), docasahexaenoic acid (DHA) and lipid health quality indices such as Atherogenicity Index (AI), Thrombogenicity Index (TI), and flesh lipid quality Index. Among the feeding guilds, zooplanktivores exhibited marked seasonal variation in the lipid quality with relatively high fat, MUFA, SAFA, PUFA, EPA and DHA contents during monsoon compared to pre-monsoon. AI and TI also showed conspicuous seasonal variation with higher values during monsoon then pre-monsoon. The AI values of fishes collected during pre-monsoon were relatable to the FAO recommended values. TI value of fishes of feeding guilds, zooplanktivore, zoobenthivore, and carnivore satisfied the FAO recommended criteria during pre-monsoon while in monsoon except the zooplanktivores, the TI value of fishes of all other feeding guilds was above the recommended health values. FLQ of the fishes collected during pre-monsoon was significantly high compared to monsoon. Among the feeding guilds, FLQ was high in zooplanktivores followed by carnivores and zoobenthivores during both the periods. To conclude, nutritional quality was high in fishes collected during pre-monsoon and consumption of zooplanktivores were more health-promoting to humans than fishes of other feeding guilds.

Keywords: Fatty acids, fishes, guilds, health, nutrition

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Study on the co-infection of *Vibrio alginolyticus* with parasites in Indian Mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) from Karwar, West Coast, Uttara Kannada, Karnataka

Kurva Raghu, R.* and Rathod, J. L.

Karwar Regional Station of ICAR-Central Marine Fisheries Research Institute, Karwar, North Kanara-581301, Karnataka

*raghu.kurva@icar.gov.in

Rastrelliger kanagurta, Indian Mackerel, is an important marine food fish available throughout the year on the west coast of Uttara Kannada. Parasites in *R. kanagurta*, are not studied well, especially in the Uttara Kannada district of Karnataka. Accordingly, exploring the different parasites, their prevalence, abundance, mean intensity, and severity of the infestation in *R. kanagurta* of this region is essential. The present study revealed the morphological identification, prevalence, severity of the infestation, and seasonal study of parasites in *R. kanagurta* from the Karwar coast from January to December 2022. Water quality analysis was also done during this period as per standard protocols. The present study also revealed the co-infection with *Vibrio alginolyticus* without any external symptoms in July 2022. The current study found *Norileca indica* and *Nerocila phaiopleura*, *Trichodina* spp., and developmental stages of helminths in *R. kanagurta* during this period. A total of 746 fish were examined, and the prevalence in seasons had no significant ($p>0.05$, $df=2$) effect on trichodinids and developmental stages of helminths. However, parasitic cymothoids (*N. indica* and *N. phaiopleura*) varied significantly ($p<0.05$) according to the season. They showed greater prevalence during the pre-monsoon and least in monsoon due to fluctuations in environmental parameters like salinity (28.75±2.37) and temperature (28.5±0.9). Rainfall and flood water releases into the sea also play a key role during monsoons, during which the water temperature and salinity come down. Finally, *Trichodina* spp., Isopods, and developmental stages of helminth parasites were causing significant histological changes in the infected tissues.

Keywords: Co-infection, histopathology, parasitic study, prevalence, severity

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Pathological anomalies in vital organs of Indian mackerel, *Rastrelliger kanagurta* in relation to water quality and parasitic infestation

Kurva Raghu, R.* and Rathod, J. L.

Karwar Regional Station of ICAR-Central Marine Fisheries Research Institute, Karwar, North Kanara-581301, Karnataka

*raghu.kurva@icar.gov.in

Fish pathology deals with the diseases caused by parasites, bacteria, fungi, and other pathogens that affect fish's ordinary lifestyle. In the present study, we observed the significant pathological changes due to the parasitic infestation and their relation with the water quality. This is helpful for further research on the defensive mechanism against diseases and their treatment. Most fish in the wild or cultivated inhabitants (fishes) are infected with parasites in their lives, which are very common. Many reports are available on parasites causing mortality or severe damage to fish populations, but this is most common in aquaculture systems; however, it may be unnoticed in wild fish. In this regard, the target was isolating and identifying the parasites from the wild *R. kanagurta*. The results showed adult isopods (*Norileca indica* and *Nerocila phaiopleura*), developmental stages of isopods, *Caligus* spp., *Trichodina* spp., *Dactylogyrus* spp., and developmental stages of helminths during this work period. A total of 750 fish were examined. There was a relationship between water quality and parasitic infestation. Salinity (28.70±2.30) and temperature (28.50±0.9) favoured the proliferation of the parasites. The salinity and temperature were crucial in causing the parasitic infestation in *R. kanagurta*. The seasons had no significant ($p>0.05$, $df=2$) effect on the prevalence of the parasites, except in the case of parasitic isopods. The isopods showed maximum prevalence in the pre-monsoon (January to April). Weather conditions, rainfall, and flood water releases into the sea also played a key role during monsoons for parasitic infestations. Finally, we observed that *N. indica*, *N. phaiopleura*, *Caligus* spp., *Trichodina* spp., *Dactylogyrus* spp., and developmental stages of helminth parasites were causing several histological changes in the infected tissues.

Keywords: Indian mackerel, parasitic infestations, pathological anomalies, water quality

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Silencing shrimp STAT gene by administering dsRNA *in vitro* and *in vivo* to control of white spot syndrome virus infection

Joseph Jeswin*, Valsamma Joseph and I. S Bright Singh

National Centre for Aquatic Animal Health, Cochin University of Science and Technology, Fine Arts Avenue, Kochi, Kerala 682016, India

*jeswin4u@gmail.com

White spot syndrome virus (WSSV), the deadliest pathogen of crustaceans, particularly of shrimp causes rapid and total mortality with in ten days. No successful commercial drug has ever been made available to protect shrimp from WSSV. In this context, a molecular approach to arrest the multiplication of the virus in shrimp tissue is thought of based on RNAi and gene silencing. RNAi by dsRNA results in sequence-specific post-transcriptional degradation of target mRNA. Shrimp signal transducer and activator of transcription (STAT) gene is known to transactivate the expression of the WSSV immediate early gene (ie1) in infected shrimps. The current study investigates the efficacy of silencing STAT gene in *Penaeus monodon* to arrest the viral multiplication cycle. The dsRNA of STAT gene was prepared by *invitro* transcription having T7 RNA polymerase binding sites. Primary hemocyte shrimp cells were treated with STAT dsRNA at a concentration of 25 µg of dsRNA/ml of medium. The samples were collected in Trizol for RNA isolation at 24, 48 and 72 hour post treatment. Simultaneously, juvenile shrimp were fed with pellet feed coated with STAT dsRNA, and administered to deliver 5 µg dsRNA/gram of shrimp body weight. Animals were fed twice daily for five days at 5% of the body weight. The samples were collected for RNA isolation at 0, 24, 48, 72, 96, and 120 hour post-treatment. The silencing of STAT gene expression was evaluated by quantitative real time PCR of mRNA transcripts. In the primary hemocyte cell culture the mRNA level of STAT gene was reduced by 50% at 48 hrs post dsRNA treatment and at 72 hrs it got reduced by only 10%. In the case of juvenile shrimp, STAT mRNA level was reduced by 23% at 48 h, at 72 hr by 71.8%. The successful silencing effect found in both cell culture and juvenile shrimp provides valuable insights in to the possibilities of developing a novel strategy of RNAi-based therapeutics in shrimp against WSSV.

Keywords: double-stranded RNA, *Penaeus monodon*, RNAi, STAT, WSSV

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

TMT- based proteome analysis of rohu gut infected with *Edwardsiella tarda*

Nevil Pinto[1*], Yashwanth B. S.[1], Mehar Un Nissa[2], Sathiyanarayanan, A.[1], Sanjeeva Srivastava[2] and Mukunda Goswami[1]

[1]ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri (West), Mumbai-400061, Maharashtra, India
[2]Indian Institute of Technology Bombay, Powai, Mumbai 400076, India

*nevilpinto1@gmail.com

In fish, the gut recognized as a multifunctional organ, lined up with a single layer of epithelial cells plays a major role in nutrient absorption, osmotic regulation and protection against invading microbes. *Labeo rohita* (rohu) is a highly cultivable species in India and culture in other Southeast Asian countries. *Edwardsiella tarda* is a gram-negative pathogen, that infects the host by using gut mucosa. To better understand the molecular mechanisms after infection with *E. tarda*, a tandem mass tag (TMT) based quantitative proteomic analysis was performed to detect the protein expression profile of rohu gut. A total of 1,630 proteins having ≥ 2 unique peptides were identified. After quantitative analysis, 29 proteins were found to be differentially expressed proteins in the gut. Among these DEPs, 15 proteins were upregulated and 14 were downregulated for *E. tarda* infection. By integrating the results of metascape, genes were involved in protein transport (sec22bb, arf4a, xpo1b), SRP-dependent co-translational protein targeting to the membrane and metabolic process (rpl13, rps2, rpl35a, pipox, eif5b, erap1a). The top dysregulated proteins were involved in cellular energy homeostasis (gaa), metabolism of fatty acid (ehhadh, pipox), complement activation (protectin), and protein synthesis (rpl13). This work was reported for the first time in the rohu gut to study the response against the *E. tarda* infection. The findings of the present gut proteome help to understand the infection mechanism and disease resilience in aquaculture.

Keywords: Complement activation, *E. tarda,* gut, metabolic process, protein transport, rohu, TMT

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Assessment of antibiotic use and antimicrobial resistance pattern in freshwater aquaculture in Odisha and Andhra Pradesh: A preliminary report

Mishra, S. S.* Sahoo, S. N., Seshagiri, B., Rathod, R., Patel, S., Behera, D., Praveen K. N. and Swain, P.

ICAR-Central Institute of Freshwater Aquaculture (CIFA), Kausalyaganga, Bhubaneswar-751002, Odisha, India

*ssmishra60@gmai.com

Antibiotic resistance is one of the biggest threats to global health and food security. With continuous economic development in recent years, the aquaculture industry has greatly developed in India as in other Asian countries. Infectious diseases are always a hazard and may cause significant stock losses and problems with animal welfare. Intensive aquaculture has led to growing problems with bacterial diseases, which now require intensive antimicrobials. Almost every aquaculture industry sector, from fish to crustaceans and shellfish, uses chemotherapeutic agents, including antibiotics and many other chemicals. Although drugs such as Fluoroquinolones, Nitrofurans, and Chloramphenicol are prohibited in many countries, using these drugs is still common in some countries. The aquaculture drugs available in the market have been collected at different stages of aquatic animal health management like pond preparation, growth promotion, increasing oxygen concentration, disinfectant, probiotics and fish and prawn disease treatment. The antibiotics typically used are also important in treating human disease and infection. Use of antibiotics results in the emergence of drug-resistant bacteria, some of which are human pathogens. This has been a tremendous issue for public health and the environment. A questionnaire-based survey was undertaken in Odisha and Andhra Pradesh. Information on culture practices and drug use patterns at different stages of fish culture and in hatcheries and application of other inputs in the farm was collected. Fish samples were collected from 4 districts in Odisha and four districts in Andhra Pradesh. A total of 239 freshwater fish farms were surveyed and sampled; 158 fish samples, 239 pond water, 49 canal water, and bore well water samples as inlet water sources were processed to isolate *E. coli, Aeromonas* sp. and *Staphylococcus* sp. A total of 1,272 bacterial isolates were isolated, from which 1,272 isolates were analysed comprising 417 isolates of *E. coli,* 437 isolates of *Staphylococcus* sp., 418 isolates of *Aeromonas* sp. The samples were processed for AST, and the zone of inhibition obtained was analysed using WHONET software according to CLSI guidelines. The details of disease prevalence, variable drug use, AMR profile pattern and related issues have been elaborated in the present paper.

Keywords: Antibiotics, AMR, Antimicrobial Resistance, aquaculture drugs

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Present status of disease occurrence and economic loss in freshwater aquaculture in Odisha and Andhra Pradesh

Mishra, S. S.*, Sahoo, S. N., Giri, B. S., Rathod, R., Chaudhari, A. K., Patel, S., Behera, D. and Swain, P.
ICAR-Central Institute of Freshwater Aquaculture (CIFA), Kausalyaganga, Bhubaneswar-751002, Odisha, India
*ssmishra62@ gmail.com

The fishing sector in India, with about 7.7% of the global fish production, is the third-largest fish-producing country and the second-largest aquaculture fish producer in the world. With increased demand for fish production and intensive fish farming, aquatic animals come across various health menaces due to environmental stress, infectious diseases and disturbed aquatic environments. Different bacterial, viral, fungal and parasitic infections have been reported in farmed fish in freshwater aquaculture. It is estimated that 10-15% of production loss occurs due to disease-related problems. This has led to the use of a wide range of drugs and chemicals, including probiotics and bioremediation products in aquaculture, to control production loss. A questionnaire-based survey was undertaken to get information on disease occurrence, culture patterns and economic loss due to disease in Odisha and Andhra Pradesh. Surveys were conducted on different fish farms located in Krishna, East Godavari, West Godavari and Nellore districts of Andhra Pradesh and Baleswar, Bhadrak, Kendrapara and Jagatsingpur districts in Odisha to identify fish disease problems and economic losses. It was observed that very few farmers (around 15-20%) were able to understand the disease problems and quantify disease-related losses, while the majority (~ 80%) were dependent on friends, consultants, marketing personnel and dealers for advice on disease diagnosis and treatment needed. Among fish diseases, parasitic infestations were a major cause of concern because of high morbidity and production loss. Among the parasitic infestations, Argulosis was a significant problem. Besides this, the occurrence of Gill fluke (*Dactylogyrous*), Skin fluke (*Gyrodactylus*), *Lernaea*, *Trichodina* and *Myxobolus* infestations were also reported in some fish farms. Ectoparasitic diseases accounted for 37% of the problems, while bacterial, fungal infections and environmental factors accounted for 20-23%, 5-7%, and 30-32% of cases, respectively. During the survey, most of the farmers revealed that they faced significant problems with labour, feed availability and marketing of fish. The farm sale price was Rs. 90 to 100 per Kg, much lower than the farm price in Odisha (Rs.130 to 140 per kg). The details of disease prevalence, variable culture patterns, use of various drugs and chemicals in fish culture ponds, and related issues have been elaborated in the present paper.

Keywords: Disease management, economic loss, fish disease, freshwater aquaculture

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Investigations on the phenotypic and genetic patterns of oxolinic acid resistance among marine aquaculture pathogens

Krupesha Sharma, S. R*, Surya Gayathri, S, Sumithra, T. G, Anusree, V. N. and Suja, G.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* krupeshsharma@gmail.com

Vibrio vulnificus, Vibrio harveyi, Vibrio parahaemolyticus, Photobacterium damselae, Streptococcus agalactiae, Vibrio alginolyticus, and *Aeromonas veronii* are the major marine fish bacterial pathogens that cause significant economic losses to marine or estuarine aquaculture practices. The present investigation unravels the antimicrobial resistance (AMR) phenotypes and AMR genes of these pathogens against oxolinic acid, a commonly used quinolone antimicrobial agent in aquaculture, due to its low cost, low fish toxicity, and acceptable performance. Five isolates from each of these pathogen species, each representing five unique natural disease outbreaks of marine/estuarine fishes of India, were used in the study. Initially, species confirmations of all the isolates (35 in number) were done using specific PCR. Antibiotic susceptibility using disc diffusion test and MIC demonstrated that 100% of isolates belonging to *V. parahaemolyticus*, *V. vulnificus*, *V. harveyi*, *V. alginolyticus*, and *P. damselae* were sensitive to oxolinic acid. Conversely, 100% of isolates belonging to *S. agalactiae* were resistant to oxolinic acid. A variable susceptible pattern to oxolinic acid was observed among *A. veronii* isolates, with 40% and 80% isolates as resistant through the disc diffusion and MIC tests, respectively. Molecular screening for quinolone resistance encoding genes (*qnrS*, *qnrA*, and *qnrB*) revealed that three of five *A. veronii* isolates had *the qnrS* gene. Accordingly, the prevalence of *the qnrS* gene was found as 60% and 8.3%, respectively, among *A. veronii* isolates and the total aquatic pathogens. More importantly, all these three isolates were phenotypically resistant to oxolinic acid. The absence of the screened quinolone resistance encoding genes in the presence of resistance phenotype among *S. agalactiae* isolates warrants future research targeting more diverse AMR genes in this species. Altogether, the paper serves as the baseline for epizootic tracking of quinolone resistance among bacterial pathogens from diseased fishes, to devise practical guidelines for oxolinic acid use and to formulate efficient control measures against these pathogens in aquaculture, targeting final applications in the implementation of national green and healthy aquaculture practices.

Keywords: *Aeromonas veronii*, Antimicrobial resistance, *Photobacterium damselae, Streptococcus agalactiae, Vibrios*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Prevalence of shrimp microsporidian, *Enterocytozoon hepatopenaei* (EHP) in farmed tiger shrimp, *Penaeus monodon* in India

Naveen Rajeshwar, B.[1*], Sathish Kumar, T.[2], Jithendran, K. P.[2], Megha K. Bedekar[1], Jeena, K.[1], Sanath Kumar, H.[1] and Rajendran, K. V.[1#]

[1]ICAR-Central Institute of Fisheries Education, Panch Marg, Off. Yari Road, Versova, Andheri West, Mumbai-400 061, Maharashtra, India
[2]ICAR-Central Institute of Brackishwater Aquaculture, 75 Santhome High Road, R A Puram, Chennai-600 028, Tamil Nadu, India
#Present address: Department of Zoology, School of Biological Sciences, Central University of Kerala, Tejaswini Hills, Periye, Kasaragod-671 316, Kerala, India

*naveen.aahpb006@cife.edu.in

Hepatopancreatic microsporidiosis caused by the microsporidian parasite *Enterocytozoon hepatopenaei* (EHP) is one of the impactful diseases causing a substantial economic loss in the shrimp industry. Despite the wide range of hosts infected by EHP, most reports and research are focused on *P. vannamei* due to its wide-spread farming and severe growth retardation globally. However, there is a gap in the available information on EHP infection in farmed *P. monodon*, especially in the background of its re-introduction and use of specific pathogen-free seeds (SPF) in India. Against this backdrop, a PCR-based survey was conducted to understand the prevalence of EHP in *P. monodon* farms across five states of India. The present study reports the prevalence of hepatopancreatic microsporidiosis in sixty two *P. monodon* shrimp farms, which included 18 farms from Andhra Pradesh, 13 farms from Gujarat, 13 farms from West Bengal, 9 farms from Kerala and 9 farms from Tamil Nadu. The samples were screened for EHP by nested PCR targeting the spore-wall protein gene. State-wise, farms from West Bengal had the highest prevalence of EHP (53.58%; 7/13 farms), followed by Kerala (33.3%; 3/9 farms), Andhra Pradesh (27.7%; 5/18 farms), Tamil Nadu (22.2%; 2/9 farms) and Gujarat (15.3%; 2/13 farms). Farms from West Bengal and Kerala, which recorded a higher prevalence of EHP, were characterised by the extensive farming practice using wild seeds. However, the majority of the samples tested had a low level of infection, as only 3.22% (2/62 farms) farms tested positive in the first step PCR. Histology and quantitative PCR were carried out for all the positive samples. A large number of farms where EHP was detected (47.36%) had a history of EHP infection *P. vannamei* culture. Of the EHP-positive farms, 36.84% of farms had used seeds either collected from the wild or originated from wild brooders. In contrast, 80% of farms (32/40) that used SPF seeds were free from EHP infection. Notably, no prominent growth retardation could be observed in any farms surveyed. The present study revealed low prevalence (30.6%) and low level of infection in farmed *P. monodon* and this indicates that though *P. monodon* is susceptible to EHP infection, the impact on the species is significantly lower than that reported in *P. vannamei*. This forms the current report of the prevalence of EHP in *P. monodon* farms in India.

Keywords: *Enterocytozoon hepatopenaei,* India, microsporidian, *Penaeus monodon*, prevalence

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comprehensive sequence analysis of interleukin-10 in snubnose pompano (*Trachinotus blochii*) (Lacepede, 1801)

Chakkalakkal George J.*, Sumithra, T. G., Krupesha Sharma, S. R., Dhanutha, N. R., Anusree, V. N., Reynold, P., Amritha, J., Gayathri, S. and Lailaja, V. P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*georgeof35@gmail.com

Interleukin 10 (IL-10) is the central anti-inflammatory cytokine with a fundamental and multifunctional role in regulating the host immune response. IL-10 is uniquely positioned in the highly complex and interwoven teleost immune system. *Trachinotus blochii,* a crucial mariculture finfish species, belongs to the Carangidae family. Nevertheless, the intensified aquaculture practices make the species vulnerable to several infectious diseases, demanding detailed studies on different immune characteristics and disease management programs. But so far, no information is available on any immune genes, including IL-10. The present study identified and molecularly characterized the complete IL-10 gene of *T. blochii* (TbIL10) for the first time. Initially, gene-specific primers designed based on the available teleost IL-10 sequences in the NCBI site were applied in total gill RNA, amplifying the targeted 494 bp fragment. Sequence analysis revealed 99% identity to the IL-10 gene sequence of *Trachinotus ovatus*. Rapid amplification of cDNA ends-PCR was followed to create the complete cDNA sequence. The complete cDNA was 949 bp, containing an open reading frame (ORF) of 564 bp, 5' untranslated region (UTR) of 166 bp, and 3' UTR of 207 bp. Analysis of the genomic DNA showed that the gene was composed of five exons and four introns in the structure. The ORF encoded 187 amino acid protein with a calculated molecular mass of 21.5 kDa and an isoelectric point of 6.29. The Tb-IL10 mRNA contained a signal peptide with 22 amino acids in the N-terminal and a potential N-glycosylation site. TbIL10 was found to carry the conserved domains of the IL10 superfamily (cl02501). It also contained all the six essential cysteine residues. During phylogenetic analysis, Tb-IL10 was clustered with other fish IL-10s, apart from mammalian and avian IL-10s. The highest similarity was shown to that of *T. ovatus*, followed by *Siniperca chautsi* and *Oreochromis niloticus*. The study also generated the template-based 3-D homology model for *Tb-IL-10* for the first time using homodimeric human IL-10 with a Global Model Quality Estimation value of 0.54. The Ramachandran plot analysis showed that 92.7% of the amino acid residues were in the allowed region, illustrating its compatibility for downstream research. Altogether, the study represents the first comprehensive identification of a critical immune gene in *T. blochii*, and would contribute to evolving an immunomodulation protocol for intensive marine aquaculture practices.

Keywords: 3-D homology model, anti-inflammatory-cytokine, immune gene, *marine fish, RACE-PCR*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

In-vitro characterizations and *in-silico* analyses revealed an antineoplastic drug with clinically compatible features from a marine crab haemolymph-associated bacterial symbiont *Comamonas testosteroni*

Lailaja, V. P.*, Sumithra, T. G., Vishnu Hari, Anusree, V. N. and Sanil, N. K.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* lailaja@gmail.com

The bacterial enzyme L-asparaginase is the preferred antineoplastic drug approved by the FDA and WHO for the treatment of different haematological malignancies. Available medicinal preparations are based on *Escherichia coli* and *Dickeya chrysanthemi* L-asparaginase. However, these two enzymes' adverse side effects and toxicity make it indispensable to search for new microbiological sources of L-asparaginase. The established cause of the adverse side effects is the co-affinity of these enzymes towards L-glutamine and urea. In the continuous search for novel asparaginase with clinically compatible features, we identified the ability *of a bacterial symbiont from the haemolymph of marine crab Portunus sanguinolentus to* produce extracellular L-asparaginase with medically relevant features. The polyphasic taxonomic approach identified the bacterium as *Commamonas testosteroni. In-vitro characterization demonstrated the absence of* concurrent L-glutaminase and urease activities, the most desirable property for clinical application. The isolate showcased 117 ± 0.5 U ml^{-1} asparaginase within 24 h without any optimization. The production nature, type-determining assay, and screening for the functional gene (*ansB*) confirmed the type-II nature of the enzyme, a type targeted for medical applications. The enzyme exhibited promising activity and stability at human physiological pH (7.4) and temperature (37°C), predicting functions inside the human body. The study modelled the 2-D and 3-D structure of *C. testosteroni type* II-asparaginase for the first time. Detailed *in-silico* analyses and molecular docking studies based on the functional gene verified the results of *in-vitro* characterization on stability, type II nature, substrate specificity, and extracellular production of *C.testosteroni* type II-asparaginase. I*n-silico* results also revealed *C. testosteroni* type-II asparaginase as a non-allergenic protein contrasting the asparaginases from *E. coli* and *D. chrysanthemi.* Additionally, the analysis predicted the absence of immunogenic IgE epitopes and toxic motifs in the enzyme. In brief, the present investigation through a stepwise strategic approach incorporating both *in- vitro* characterization and *in-silico* modelling emphasized *C. testosteroni* type-II asparaginase as a competent candidate for clinically safe asparaginase production.

Keywords: *ansB gene, Glutaminase,* L-asparaginase, *Poutunus sanguinolentus, Urease*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Microbiome profiling of *Trachinotus blochii* unveiled the transient microbiome in the early life stages to become stable during ontogenetic progression

Sumithra, T. G.*, Krupesha Sharma, S. R., Gayathri Suresh, Ambarish P. Gop, Gomathi, P., Anil, M. K. and Gopalakrishnan Achamveetil

ICAR-Central Marine Fisheries Research Institute, Post Box No. 1603, Ernakulam North P.O., Kochi, 682 018, India

*sumithravet@gmail.com

Trachinotus blochii is a high-value marine fish for aquaculture. However, poor larval survival remains a critical bottleneck in culture practices, where sustainable microbial management approaches promise to enhance larval survival and quality. However, no data is available on the larval microbiome profiles of *T. blochii*. Notably, the information on microbiome transition during the ontogeny and the stage where the climax microbial communities are established is necessary to identify the best window to influence the larval microbiome. In this context, the present study explored the microbial community composition of the whole fish (*T. blochii*) during different ontogenetic stages [from 1-day post-hatching (dph) to 25 dph (completion of metamorphosis)] through 16srRNA amplicon-based metagenomics. Principal coordinate analysis and dissimilarity-based permutation analyses of the β-diversity measures showed the presence of two well-differentiated statistically significant clusters, with one cluster comprising all the samples belonging to ≤10 dph and another comprising samples belonging to >10 dph. The ≤10 dph samples also showed significantly lower α-diversity measures. Particularly, the larvae at 1 and 3 dph had significantly lower α-diversity measures than all other samples. In other words, the bacterial richness and the diversity measures were increased considerably along with ontogenetic progression till 12 dph and remained stable from 12 to 25 dph. As a greater microbial diversity confers a beneficial effect on the host, the decreased bacterial diversity measures in the lower life stages of the fish may reflect increased stress during initial days and can be a novel explanation for the increased mortality rates reported in ≤10 dph. Interestingly, the core whole microbiome considering all the stages (1 to 25 dph), was found to occupy 59% relative abundance. Specifically, the core microbiome occupied ~50% and ~80% relative abundance in ≤10 and >10 dph, respectively. Further, diversity measures of functional metagenomics were significantly higher in larvae of >10 dph than that of ≤10 dph. The lower abundance of core microbes and lower α -diversity measures of taxonomic and functional metagenomics suggest that the whole fish larval microbiome is highly transient during the early life stages and become stable as it reaches its climax community. Accordingly, the results hypothesize that the best window to influence the larval microbiome in *T. blochii* is ≤10 dph, after which their microbial communities got stabilized. In other words, the results open up better opportunities for the microbiome manipulation of *T. blochii* larvae at ≤10 dph.

Keywords: Core microbes, larval survival, metagenomics, silver pompano, whole larvae

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Unravelling the whole microbiome profiles of cobia (*Rachycentron canadum*) before and after metamorphosis by PacBio Single-Molecule Real-Time Sequencing

Gayathri Suresha*, Sumithra, T. G., Krupesha Sharma, S. R, Ebeneezar Sanal, Anikuttan, K. K, Sajina, K. A., Tamilmani, G. and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No. 1603, Ernakulam North P.O., Kochi, 682 018, India

*gayathrisureshmenon@gmail.com

Microbial dynamics during standard culturing practices represent one of the most confounding features in teleost microbiome research. Despite an increased focus on fish microbiome research, data on early life stages are limited, restricting the adoption of appropriate microbiome management strategies in hatcheries. The current work compared the microbiome profiles of a high-value marine aquaculture species, cobia (*Rachycentron canadum*), before and after metamorphosis (BM and AM) during routine culturing practices. It's worth mentioning that the present research serves as the first report on using the PacBio system for understanding fish microbiomes. The long-read sequences acquired with this sequencing platform partially eliminated the taxonomic uncertainty in the reads. The dissimilarity-based permutation analyses indicated a significant well differentiation (F value>10) in the microbiome composition of AM and BM samples. The cladogram analysis also revealed two well-differentiated groups based on ontogeny/metamorphosis. However, there was no significant difference between the α-diversity of taxonomic and functional metagenomic profile measures between these two stages due to higher inter-individual variations. A comparison of the taxonomic data revealed that the abundance of *Cyanobacteria* significantly decreased with a corresponding increase in *Plactomycetacea* and *Bacteriodata* in the AM stage compared to the BM stage. It was also noteworthy that the *Firmicutes* to *Bacteroidetes* ratio, an essential indicator of stress, was much lower in the post-metamorphosis samples. The linear discriminant analysis showed 36 genus-level taxa as high-dimensional microbial biomarkers for differentiating the AM and BM stages. The abundance of *Kordimonas* and *Endozoicomonas* belonging to α-*Proteobacteria* and γ-*Proteobacteria* was increased maximum, and the abundance of *Limimaricola, Pseudobacteriovorax*, *Marinomonas*, and *Pseudophaeobacter* was decreased maximum in the AM stage. Among the 36 discriminative microbial biomarkers, *Endozoicomonas* and *Shewanella* were present only in the AM stage. Concisely, the present study showed a definite temporal shift in the whole microbiome composition following the metamorphosis. The study also identified the critical discriminative microbial indicators of the AM and BM stages. The changes in the community profile observed in these studies should be further explored to understand if such alterations make the fish susceptible/resistant to diseases. The findings of the study provide a critical starting point for further investigation into the connection between the health of *R. canadum* and the early-stage microbiome.

Keywords: Biomarkers, long-read, metagenomics, stress, teleost microbiome

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Dynamics of antioxidant biomarkers during ontogenetic progression in *Trachinotus blochii* larvae

Amritha Jagannivasan*, Sumithra, T. G., Krupesha Sharma, S. R., Gayathri Suresh, Dhanutha, N. R., Reynold, P., Ambarish P. Gop and Gopalakrishnan, A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*amrithajagannivasan04@gmail.com

The silver pompano, *Trachinotus blochii*, is a euryhaline pelagic fish preferred for marine aquaculture. Research on the antioxidant biomarkers can generate profound insights into the defense mechanisms of the fish larvae against different stressors and can reveal manipulation strategies for improved larval growth and survival. Catalase activity, superoxide dismutase activity, and reduced glutathione (GSH) content are prominent antioxidant biomarkers to assess the stage-specific oxidative damage in developing fish larvae. Accordingly, the present study aimed to profile these three crucial antioxidant biomarkers in the selected stages of *T. blochii* larvae (0, 4-, 10-, 14-, 21-, and 25-day post-hatching, dph) to identify their dynamics in routine culture conditions. Larvae of *T. blochii* belonging to different ontogenetic stages were procured from the national brood bank facility at the Vizhinjam Regional Centre of ICAR-CMFRI, India, and the profiling was done in larval homogenates using the standard protocols through the microplate-based spectrophotometry. Catalase and SOD activities ranged from 2.99 ± 0.25 to 35.64 ± 2.18 µM of H_2O_2 consumed per min and from negligible initial values to 0.51 ± 0.02 units, respectively, per mg larval homogenate. Interestingly, both these activities showed a steady increase along with ontogenetic progression. At the same time, GSH levels maintained a constant value of 13.30 ± 0.30 µg throughout the ontogenetic progression. The significantly similar values of GSH throughout the ontogeny, which is the substrate for various antioxidant enzymes, and the steady increase in the antioxidant enzyme activities showed the potential of the complex network of antioxidants present in silver pompano larvae throughout the ontogeny to maintain a constant oxidative state in the larvae. Overall, the research serves as a foundation for a more accurate and thorough understanding of the antioxidant biomarkers in fish larvae, which can help with the best management strategies to reduce stress during sustainable larval production practices.

Keywords: Catalase, GSH, oxidative stress, silver pompano, superoxide dismutase

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Prevalence and characterization of *Vibrio parahaemolyticus* isolated from the black clam, *Villorita cyprinoides* from the southwest coast of India

Remya, B.*, Sree Reshma Raju, Krupesha Sharma, S. R. and Reynold Peter

ICAR-Central Marine Fisheries Research Institute (CMFRI), Ernakulam North P.O, Post Box No. 1603, Kochi, 682 018, India

*remyabhaskaran1@gmail.com

Vibrio parahaemolyticus are gram-negative, halophilic, human pathogenic bacteria of the Vibrionaceae family that are the most significant species responsible for worldwide seafood infection. Shellfishes especially bivalves have been recognized as a major reservoir of this pathogenic bacterium due to its filter-feeding nature and bioaccumulation potential. The study aimed to address the prevalence and characterization of *V. parahaemolyticus* isolated from *Villorita cyprinoides* from their natural habitats along two sites in Ernakulam district, Panangad (61) and Moothakunnam (97). Thirty *V. parahaemolyticus* isolates were identified with a prevalence of 19.6% from Panangad (12) and 18.5% from Moothakunnam (18). The virulent characteristics of *V. parahaemolyticus* were known to be linked with the synthesis of thermostable direct haemolysin (tdh), thermostable-related haemolysin (trh), and type III secretion systems (T3SS). The molecular screening identified all isolates positive for T3SS1 and two isolates from Moothakunnam displaying the presence of the trh gene, which is responsible for the generation of TRH toxins, indicating potential pathogenicity. Antimicrobial resistance study *via* disc-diffusion method with 12 antibiotics revealed the highest resistance towards cefotaxime (86%), whereas chloramphenicol and tetracycline were effective against all isolates. The isolates were further screened for the *in-vitro* enzymatic activity with selective media and identified the highest activity for gelatinase (100%), cellulase (100%), amylase (100%), caseinase (100%) followed by phospholipase (93.3%), DNase (90%), and lipase (70%). All the isolates were analyzed by ERIC-PCR and PFGE for Molecular Subtyping which differentiated *V. parahaemolyticus* with clonal relationships. The study provided insights into the prevalence of virulent strains, exoenzyme synthesis, and genetic relationships in *V. parahaemolyticus* isolated from wild samples.

Keywords: Antimicrobial Resistance, bivalves, enzymatic activity, genotyping, *Vibrio*

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Antibacterial, cytotoxicity and anti-inflammatory evaluation of N-Chlorotaurine (NCT) for possible application in aquaculture

Abhiram Ajayakumar[1], Rahul Krishnan*[1] and Rahul Rajendran[2]

[1]Department of Aquatic Animal Health Management, Faculty of Fisheries Science, Kerala University of Fisheries and Ocean Studies, Kochi-682506, Kerala India
[2]Department of Aqualife Medicine, Chonnam National University, Republic of Korea

*rahul.krishnan@kufos.ac.in

Taurine chloramine or N-Chlorotaurine is a major chloroamine generated in activated PMN at a site of inflammation, as a result of the reaction between HOCl and taurine, an abundant free amino acid in their cytosol. Studies on the mechanism of its action have revealed that NCT inhibits the activation of NF-κB which is a potent signal transducer for pro-inflammatory cytokine production, by oxidation of IkBα. Here we have in-vitro synthesized N-chlorotaurine (NCT). The bactericidal activity of NCT was tested in quantitative killing assays against a panel of multi-resistant Gram-positive and Gram-negative isolates. N-chlorotaurine (1%, 55 mmol l^{-1}) demonstrated a bactericidal effect i.e., a 2 to 4 $\log_{10}$ reduction in viable counts of *Streptococcus agalactiae, S. iniae, Aeromonas hydrophila* and *Edwardsiella tarda*, after incubation at 28°C for 6 to 9 h at pH 7.0. The cytotoxicity of NCT was evaluated by 3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium (MTS) assay to obtain 50% cytotoxic concentration. CC_{50} of NCT ranged from 450 to 500 µg/mL on SSN-1, FHM and EPC cells. NCT reduced the LPS induced inflammation in the cell culture models revealed by significant reduction in the levels of proinflammatory cytokines and decreased abundance of the NF-κB activation. Together, these results demonstrate the ability of NCT to kill above mentioned bacteria, hinting at its potential to be used as a promising new therapeutic agent having efficient bactericidal and anti-inflammatory properties. However, the findings suggest that NCT could be a valuable addition to the arsenal of therapeutic options for combating bacterial infections and inflammation-related diseases.

Keywords: Antibacterial, anti-inflammatory activity, cytotoxicity, N-Chlorotaurine.

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Computational aided identification of immune-epitopes and insilco development of multi-epitope-based peptide vaccine against Cyprinid herpesvirus-2

Amala Jiji[1*], Arun Sudhagar[1**], Thangaraj Raja Swaminathan[1,2], Arathi Dharmaratnam[1], Basheer Saidmuhammed Valaparambil[1] and Uttam Kumar Sarkar[3]

[1]Centre for Peninsular Aquatic Genetic Resource, ICAR–National Bureau of Fish Genetic Resources, CMFRI Campus, Kochi-682 018, Kerala, India
[2]ICAR-Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri P.O., Kochi-682 029, Kerala, India -
[3]ICAR–National Bureau of Fish Genetic Resources, Canal Ring Road, P.O, Dilkusha Marg, Lucknow-226 002, Uttar Pradesh, India

*Presenting author

** Corresponding author arunsaqua@gmail.com

Cyprinid Herpesvirus-2 (CyHV-2) is a linear double-stranded DNA virus categorized within the genus Cyprinivirus, part of the family Herpesviridae. This virus is responsible for causing herpesvirus hematopoietic necrosis disease, which is a highly contagious and fatal condition that has had a severe impact on goldfish (*Carassius auratus*) farming. Initially, it was believed to only affect goldfish; however, devastating outbreaks have been observed in other cyprinid fish species such as Prussian carp (*Carassius gibelio*), crucian carp (*Carassius carassius*), and hybrids of carps and goldfish. Vaccination is an effective method for preventing disease outbreaks, but the challenge of producing an adequate supply of viruses using cell lines remains a notable drawback when creating cell culture-based vaccines. To address this issue, the current study investigates the viability of using synthetic peptides as potential vaccine candidates to prevent CyHV-2 infection. pORF115, previously identified as an immunogenic membrane protein of CyHV-2 is used in the present study for the development of an epitope vaccine. Using insilco tools, immunodominant epitopes of Cytotoxic T cells, helper T cells, and B cells within CyHV-2's structural protein were identified. These epitopes were selected based on their strong antigenic potential, non-allergic nature, immunogenicity, and conservation across the viral strain. After the final screening, a total of 11 CTL, 8 HTL, and 9 B cell epitopes were identified. Appropriate linkers were used for joining the epitopes and a final vaccine contract of 341 amino acids was developed. Upon further analysis of the ultimate vaccine formulation, promising results emerged, affirming its antigenic nature, non-allergenic properties, and notably improved solubility. The results from the molecular docking and dynamics simulation demonstrated substantial structural compactness and stable binding. Additionally, the computer-generated immunological simulation suggested that the vaccine shows great potential for electing an immune response after administration while minimizing the risk of allergic reactions. Taken together, these findings indicate that the designed multi-epitope vaccine could be a promising strategy for preventing Cyprinid herpesvirus 2 infection.

Keywords: Cyprinid herpesvirus-2, epitopes, insilco, molecular docking, molecular dynamic simulation

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Taxonomy of two new species of myxosporeans infecting the *Abudefduf vaigiensis* from the southwest coast of India

Sneha Surendran*, Vijayagopal, P., Antony Ambrose and Sanil, N. K.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*sneharugmini@gmail.com

Myxosporeans are endoparasitic cnidarians primarily infecting fishes, and many species are known to cause serious diseases in cultured and wild fishes. *Abudefduf vaigiensis*, also known as 'Sergeant major' is one of the most attractive marine ornamental fishes with high commercial value. However, its pathogen profile in Indian waters has been poorly documented. The present study describes the taxonomy and systematics of two new species of myxosporeans infecting the gallbladder of *A. vaigiensis*. The host fish were collected from Vizhinjam coast, Kerala, and screened for the presence of myxosporeans. Morphological characterization of the parasites was done using DIC optics. Molecular and phylogenetic analyses were carried out using partial SSU rDNA sequences. The study recovered two species of myxosporeans belonging to the genus *Ceratomyxa*. Myxospores of the first species were slightly crescentic with convex anterior and slightly concave posterior ends and measured 4.3 ± 0.5 µm X 14 ± 1.6 µm. Spore valves two, unequal, with a straight suture. Polar capsules two, equal, spherical, positioned anteriorly, adjoining the suture line, measured 2.0 ± 0.4 µm X 2.0 ± 0.1 µm, and enclosed three polar filament coils; posterior angle measured 175.8 ± 4.2^0. Early sporogonic stages, and monosporic and disporic plasmodium present. Molecular studies produced a 1433bp long partial SSU rDNA sequence which showed the highest identity (95.03%) with *C. milleri* in BLAST analysis. In ML analysis, it branched with *C. milleri* with high bootstrap value. Considering the morphology, morphometry, and molecular and phylogenetic analyses, the species is new and is named *Ceratomyxa abudefdufi* n. sp. Myxospores of the second species were crescentic with convex anterior and concave posterior ends and measured 3.6 ± 0.2 µm X 18.1 ± 1.1 µm. Spore valves two, equal, with a straight suture. Polar capsules two, equal, spherical, positioned anteriorly, adjoining the suture line, measured 1.9 ± 0.2 µm X 1.4 ± 0.2 µm; posterior angle measured 153.6 ± 5.2^0. Early sporogonic stages, and disporic plasmodium present. The partial SSU rDNA sequence was 1456 bp long and showed the highest identity (98.68%) with *C. falcatus* in BLAST analysis. In ML analysis it branched with *C. falcatus* with a high bootstrap value. Morphology, morphometry, and molecular and phylogenetic analyses indicate that the species is new and is named *Ceratomyxa vaigiensis* n. sp. The study reveals the diversity of myxosporeans parasitizing marine ornamentals in Indian waters and forms the first report of a myxosporean infecting *A. vaigiensis*.

Keywords: *Abudefduf vaigiensis*, *Ceratomyxa*, gallbladder, myxosporean

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative analysis of proinflammatory and humoral immune gene expression in Cyprinid herpesvirus 2 infected and vaccinated goldfish (*Carassius auratus*)

Arathi Dharmaratnam[1*], Arun Sudhagar[1], Thangaraj Raja Swaminathan[1,2**], Amala Jiji[1], Basheer Saidmuhammed Valaparambil[1], and Uttam Kumar Sarkar[3]

[1]Centre for Peninsular Aquatic Genetic Resource, ICAR–National Bureau of Fish Genetic Resources, CMFRI Campus, Kochi-682 018, Kerala, India
[2]ICAR-Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri P.O., Kochi-682 029, Kerala, India -
[3]ICAR–National Bureau of Fish Genetic Resources, Canal Ring Road, P.O, Dilkusha Marg, Lucknow-226 002, Uttar Pradesh, India

*Presenting author

**Corresponding author t.swaminathan@icar.gov.in

Cyprinid herpesvirus 2 (CyHV-2), the etiological agent of goldfish haematopoietic necrosis virus (GFHNV) is drawing on to huge economic loss in goldfish (*Carassius auratus*) aquaculture. CyHV-2 is a large complex double stranded DNA included in the family Cyprinidae in the order Cypriniformes. This virus has caused serious threat not only in goldfish but also in many other cyprinids like prussian carp (*Carassius gibelio*), crucian carp (*Carassius carassius*), and hybrids. Owing to the global trade of goldfish, CyHV-2 was detected in European, Asian, Oceania and South American countries. In order to prevent the viral diseases, the modern aquaculture have focused in stimulating the immune system which have been attained by using vaccines and immunostimulants. The host immune response plays a vital role when infected with pathogen and the level at which the disease is cured depends on the immune response. Hence, a pilot study was done to compare the immune response developed in goldfish vaccinated with formalin inactivated whole cell CyHV-2 vaccine and CyHV-2 challenged goldfish. The formalin inactivated CyHV-2 vaccine was prepared by treating the CyHV-2 virus with 0.1% formalin for 2 days at room temperature. The genes expression of cytokines (IL-12, IL-10), interferon gamma (IFN-ϒ), adaptive markers like CD8 and CD4 were observed at various time intervals (6^{th} h, 2^{nd} day, 4^{th} day, 10^{th} day, 16^{th} day and 30^{th} day) from the kidney and spleen tissues of CyHV-2 infected and vaccinated goldfish. We have observed that the CD8 and IL-12 had a significant upregulation by 6^{th} h in the kidney of the vaccinated fish than the infected fish. The CD8 was significantly upregulated by 10^{th} day in the spleen of the vaccinated fish. IL-10 was significantly upregulated in the kidney of both vaccinated and CyHV-2 infected fish by 4^{th} day. IFN-ϒ was significantly upregulated by the 6^{th} h in the CyHV-2 infected kidney tissues. The results infer that the formalin inactivated vaccine was able to boost the immune gene as that in CyHV-2 infected goldfish. Furthermore, field-level research is needed to analyze the marketability and applicability of these vaccinations from an economic standpoint.

Keywords: CyHV-2, formalin inactivated CyHV-2 vaccine, goldfish, immune gene expression

A new species of myxosporean, *Myxobolus vembanadensis* n. sp (Myxosporea: Myxobolidae) infecting *Planiliza macrolepis* (Smith,1846) from Cochin backwaters, Kerala

Mary Soniya Correya*, Vijayagopal, P. and Sanil, N. K.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* ronysony29@gmail.com

Myxosporeans are microscopic, multicellular endoparasites predominantly infecting fishes. They have a complex life cycle with a vertebrate intermediate host and an invertebrate definitive host, usually annelids. Many myxosporeans are capable of causing serious mortalities in cultured and wild fishes. *Planiliza macrolepis* (largescale mullet) inhabits the brackishwater and coastal habitats and commands high value in domestic markets. The present study describes a new species of myxosporean infecting the gill filaments of *P. macrolepis*. The fish for the study were collected from Cochin backwaters, Kerala using Chinese dipnets. Samples were screened for the presence of myxosporeans using standard parasitological techniques. The morphometry and morphological analyses were carried out using DIC optics and molecular and phylogenetic analyses using the partial SSU rDNA. The present study recovered a species of myxosporean with a prevalence of 6.7%. The plasmodia were milky-white, elongate, and polysporic, found attached to the gill filaments, measured 1.2±0.1 (0.9-1.2) mm x 0.4±0.04 (0.3-0.5) mm. Mature myxospores ellipsoidal in frontal and biconvex in sutural views, with eight to ten sutural markings and an intercapsular appendix at its anterior end, and measured 9.4±0.2 (8.8-10.2) µm in length and 8.2±0.2 (7.7-8.7) µm in width. Polar capsules two, unequal, elongate-oval with pointed anterior ends located at the anterior region of the myxospore. The larger polar capsule extended into the posterior half of the spore and measured 5.6±0.2 (5.2-6.0) µm x 3.3±0.3 (2.6-3.8) µm, while the smaller polar capsule was limited to the anterior half and measured 5.0±0.1 (4.8-5.1) µm x 2.9±0.1 (2.5-3.1) µm. Polar filaments coiled, containing six to eight turns in small and large polar capsules. Sporoplasm filled the entire extracapsular space and contained a sporoplasmic nucleus and iodinophilous vacuole. Based on the morphology, the present myxosporean belongs to the genus *Myxobolus*. A comparison of the myxospores of the present species with similar species of *Myxobolus* revealed remarkable differences in morphology and morphometry. The partial SSU rDNA sequence obtained from the present isolate was 1976 bp long and displayed the highest identity of 88.53% with *M. muscularis* in BLAST analysis. In phylogenetic analysis, the present species was positioned within the *Myxobolus* clade infecting mullets and stands out with high bootstrap value. Based on morphology, morphometry, molecular and phylogenetic analyses, along with tissue/host specificities and geographic location, the present parasite is treated as new and is named *Myxobolus vembanadensis* n. sp.

Keywords: Myxobolus, *Planiliza macrolepis*, plasmodia, phylogeny, sporoplasm

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Pathogenic and genomic characterization of *Vibrio harveyi*

Sujeet Kumar*, Abhaya Robinson, Nishanthini, B., Sathish Kumar, T., Makesh, M. and Shekhar, M. S.

ICAR-Central Institute of Brackishwater Aquaculture, 75 Santhome High Road, R A Puram, Chennai-600 028, Tamil Nadu, India

*Sujeet.Kumar@icar.gov.in

Vibrio harveyi is a gram-negative, bioluminescent, marine bacterium causing serious infection in shrimp and fishes. A strain of *V. harveyi* named SB1 was isolated in 2020 from Asian seabass. During challenge study, the strain was found highly pathogenic to shrimp as well as Asian seabass. To further understand the virulence, the strain was sequenced with Illumina and PacBio platforms. The genome assembly was carried out using Flye assembler and further polished by Pilon using Illumina data. The assembly quality was assessed by Busco score which was found 100% representing high quality assembly. The genomic assembly of SB1 contained two chromosomes and a plasmid. The genome size was 5.87 Mbp with the largest chromosome of 3.46 Mbp and plasmid of 161.5kbp. The functional annotation suggested that the genome has 5391 protein coding genes and their rRNA genes are located at 3 regions. The analysis of plasmid suggests its conjugative nature with presence of many pathogenicity islands. A large pathogenicity island was also located on the chromosome 1. Analysis of proteases against MEROPS database revealed that almost 10% of genome is involved in protease production. Our study analysed several virulence factors and pathways which may be playing key role in the virulence of *V. harveyi*.

Keywords: Asian seabass, genome, pathogen, shrimp infection

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Antibacterial activity of alcoholic extract of *Decalepis hamiltonii* (DH) root against the fish pathogen (*Aeromonas* sp.)

Poonam Pal and Sanjeev Kumar*

Institute of Medical Sciences, Banaras, Hindu University (B.H.U.), Varanasi-221005, India

* zoo.s.p.9095@gmail.com

Aeromonas spp., which are prevalent in freshwater and tropical habitats and induce bacterial hemorrhaging in farmed fish, are among the most prevalent forms of pathogens in many fish species. Today, a sizable section of the global population, particularly in developing nations, relies on the traditional medical system to treat a wide range of illnesses. The medicinal plants can be used not only to treat illnesses but also to promote growth, increase stress resistance, and guard against infections. Additionally, compared to chemotherapeutic treatments, phytomedicines are more accurate and cost-effective as a treatment option. Almost all of the components of the unique climbing shrub *Decalepis hamiltonii* Wight & Arn., including the root, stem, and leaves, are utilized medicinally. In the southern region of India, its tuberous roots are frequently consumed as a health beverage and are renowned for their therapeutic benefits. The phytochemical components and antibacterial activity of the plant's root extracts are investigated in the current work. *Decalepis hamitonii* root fragments were extracted into an alcoholic extract, and their antibacterial and phytochemical content was examined. Alkaloids, flavonoids, phenols, steroids, tannins, terpenoids, saponins, and glycosides were found, according to the phytochemical analysis. *Aeromonas veronii* and *Aeromonas caviae*, two test organisms, were susceptible to the antibacterial activity. According to the study, some plant extracts from *Decalepis hamiltonii* may contain chemicals with antibacterial properties that can be exploited to create novel medications for the treatment of infectious disorders brought on by pathogens. This study also supports the plant's historic use in medicine.

Keywords: Antibacterial activity, *Decalepis hamiltonii*, extract, fish bacteria, phytochemicals

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Comparative evaluation of different chromatographic techniques for the purification of fish serum immunoglobulin

Sagar Gorakh Satkar[1*], Arun Sudhagar[1**], Thangaraj Raja Swaminathan[1,2], Sundar Raj Nithianantham[1], Neeraj Sood[3], and Uttam Kumar Sarkar[3]

[1]Centre for Peninsular Aquatic Genetic Resource, ICAR–National Bureau of Fish Genetic Resources, CMFRI Campus, Kochi-682 018, Kerala, India
[2]ICAR-Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri P.O., Kochi-682 029, Kerala, India
[3]ICAR–National Bureau of Fish Genetic Resources, Canal Ring Road, P.O, Dilkusha Marg, Lucknow-226 002, Uttar Pradesh, India

*Presenting author

**Corresponding author arun.sudhagar@icar.gov.in

Immunoglobulins (Ig) play a crucial role in the host defense against infections and diseases. The purification of these vital molecules is a fundamental step in immunology research. Though the purification of serum Ig in mammals are well standardized, it is often very challenging in the case of fish species. Hence, in this study, we made attempt to compare four different methods, (i) protein-A affinity chromatography, (ii) protein-L affinity chromatography, (iii) ammonium sulphate precipitate followed by ion-exchange chromatography, and (iv) BSA-affinity chromatography to find out an appropriate method for the purification of serum Ig from two fish species *Clarias dussumieri and Etroplus suratensis. Initially, sera were collected from 30 healthy C. dussumieri and E. suratensis fish, immunized with 200 µg of bovine serum albumin (BSA) and Freund's complete adjuvant. Subsequently, two booster doses, separated by 14-day intervals, were administered using the same antigen dose emulsified with Freund's incomplete adjuvant. The collected serum was subjected to all the above-mentioned chromatography for the purification of Ig. Subsequently, the purified samples were analyzed using sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE). In the* protein-A affinity chromatography, we could not purify the serum Ig for both the fish species. Conversely, protein-L affinity chromatography could effectively purify the serum Ig of *C. dussumieri, however, it was ineffective for E. suratensis. In the case of a*mmonium sulphate precipitate followed by ion-exchange chromatography we could purify the serum Ig form both the fishes, however, we observe a lot of non-specific proteins. BSA-affinity chromatography efficiently purified serum Ig from both fish species, while notably eliminating any non-specific protein presence. In the SDS PAGE analysis we could observe two heavy chains with molecular weight ~85 kDa and ~73 kDa and two light chains with molecular weight ~24 kDa and ~23 kDa for *C. dussumieri. In the case of E. suratensis one heavy chain and one light chain could be observed with a molecular weight of ~77 kDa and ~27 kDa respectively.* The native molecular weights of Ig obtained from *C. dussumieri* and *E. suratensis* were found to be ~ 870 kDa and ~ 840 kDa, respectively. Furthermore, the heavy chain of the Ig protein from the SDS-PAGE were validated using ESI-nano LC-MS/MS analysis. In conclusion, the comparative evaluation of various chromatographic techniques for the purification of fish serum immunoglobulin has shed light on the diverse capabilities and efficiencies of these methods.

Keywords: Aquaculture, immunoglobulin, immunology, serology, serum

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Investigations into disease outbreaks have revealed the endemic presence of infectious spleen and kidney necrosis virus in cultured Oscar fish (*Astronotus ocellatus*) in Kerala, India

Arun Sudhagar[1], Sundar Raj Nithianantham[1], Thangaraj Raja Swaminathan[1, 2], Sowmya Pazhur Mohandas[1], Neeraj Sood[3], Pravata Kumar Pradhan[3], and Uttam Kumar Sarkar[3]

[1]Centre for Peninsular Aquatic Genetic Resource, ICAR–National Bureau of Fish Genetic Resources, CMFRI Campus, Kochi, Kerala, India – 682 018
[2]ICAR-Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri P.O., Kochi, Kerala, India–682029
[3]ICAR–National Bureau of Fish Genetic Resources, Canal Ring Road, P.O, Dilkusha Marg, Lucknow, Uttar Pradesh, India – 226002

*arunsaqua@gmail.com

The Oscar fish (*Astronotus ocellatus*), prized for its vivid hues and size, is a popular exotic freshwater aquarium species in India. This study investigates a significant mortality event affecting juvenile and broodstock Oscars at two ornamental fish farms in Kerala, India, between June and August 2022. In both farms, cumulative mortality reached 100% within five days of the outbreak. The affected displayed abnormal behaviour, clustering, lethargy, mucous accumulation, fin damage, scale loss, and skin haemorrhaging. Moreover, oedema and petechial haemorrhages were also observed in the internal organs. Transmission electron microscopy revealed distinctive polygonal viral particles (121 ± 9.2 X 113 ± 11.1 nm) within spleen tissue, characterized by an electron-dense core enveloped by a translucent zone and an outer nucleocapsid layer. *When exposed to tissue homogenate from affected fish, A. ocellatus* fin cell line (AOF) exhibited observable cytopathic effects like cell rounding, vacuolation, and fusion, confirming viral involvement. PCR targeting the major capsid protein (MCP) gene (1362 bp) confirmed infectious spleen and kidney necrosis virus (ISKNV) as the causative agent. Furthermore, the amplified gene sequences displayed high similarity (<99%) to MCP gene sequences of ISKNV in the NCBI database. This research offers crucial insights into mass mortalities of cultivated Oscar fish, underscoring the need for robust measures to prevent and manage the dissemination of infectious viruses within aquaculture. Furthermore, it suggests a broader prevalence of ISKNV among ornamental fish farms in Kerala, warranting swift action to safeguard the local aquaculture industry.

Keywords: Aquaculture, aquatic animal health, ISKNV, surveillance, virology

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Genomic characterization of a novel lytic *Autographiviridae* bacteriophage PhPV1.2 specific to *Vibrio parahaemolyticus*

Keerthi R. Babu.[1,2*], Sobhana, K. S.[1], Aleena, Alex.[1,3], Neethu, K. P.[1,2], Jayasree, V. S.[1,2], Grinson, George[1]. and Gopalakrishnan, A[1].

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Cochin University of Science and Technology, Cochin University P.O., Kochi-682 022, Kerala, India
[3]Mangalore University, Mangalagangotri, Mangaluru–574 199, Karnataka, India

*keerthirbabu22@gmail.com

Vibrio parahaemolyticus is an opportunistic pathogen of fish and shellfish which causes severe diarrhoea and acute gastroenteritis in humans through uncooked or undercooked seafood. The rise of multidrug-resistant bacteria, including *V. parahaemolyticus*, has created significant challenges, and phage therapy to control bacterial infections has gained attention as a potential solution to address this issue, particularly in aquaculture. This study describes the isolation and characterisation of a novel bacteriophage PhPV1.2, lysing *V. parahaemolyticus* strain PV1.2 (GenBank accession No. MZ489224), isolated from a tidal pond in Puthuvype, Kochi, South India. Analysis of the host range demonstrated that the phage is specific to *V. parahaemolyticus*. The phage is stable within a temperature range of 0-60^{o}C and a pH range of 3-11. The phage displayed a burst size of 45 plaque-forming units per bacterium and a latent period of 40 min during one-step growth curve analysis. The draft genome of PhPV1.2 unveiled by research on the Illumina NovoSeq platform revealed the presence of a 38.5 Kbp dsDNA with 47.79 % G+C content, housing 50 predicted open reading frames (ORFs). These ORFs encode proteins related to phage biology, including structure, packing, host lysis and DNA metabolism. Using the prokaryotic gene prediction tool Prodigal, 3538 protein-coding genes were identified, and a blast search provided valuable insights into the functional annotations of these proteins. The blast annotation revealed a 79.44% similarity with the *Vibrio* phage PhiV141 complete genome. To understand its evolutionary context, a phylogenetic study was conducted using sequences of the terminase protein large subunit and DNA polymerase using the neighbour-joining method in MEGA XI. Based on transmission electron microscopy studies, genomic features, and phylogenetic analysis, PhPV1.2 has been identified as a novel phage belonging to the family *Autographiviridae*. Previously, PhPV1.2 was employed as part of a consortium alongside two other vibrio phages in an experiment to combat pathogenic vibrios that infect *Penaeus vannamei* larvae. This study underscores PhPV1.2 as a novel lytic phage with specificity for *V. parahaemolyticus*, which can be considered a promising candidate for phage therapy applications in aquaculture, offering a potential solution to combat multi-drug *V. parahaemolyticus* in seafood production.

Keywords: Aquaculture, burst size, host range, latent period, one-step growth curve, phage therapy

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Protective immune response against viral nervous necrosis (VNN) in silver pompano *(Trachinotus blochii)* against inactivated, recombinant and DNA vaccines by various delivery methods (intramuscular, intraperitoneal, and oral)

Rameshkumar, P[1]*, Abdul Nazar, A. K.[1], Anikuttan, K. K.[1], Thamizhvanan, S[1]., Sakthivel, M.[1], Tamilmani, G[1]., Ravikumar, T. T.[1], Abdul Majeed, S[2]., Sahul Hameed. A. S.[2] and Rajwade, J. M.[3]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India
[2]Aquatic Animal Health Laboratory, C. Abdul Hakeem College Melvisharam, India
[3]Agharkar Research Institute, Pune, India

*prkvet@gmail.com

The study aims to evaluate the Viral Nervous Necrosis (VNN) vaccine efficacy in silver pompano. The healthy silver pompano juveniles (1.5 to 2g body weight) were chosen for the vaccination trials. Five experimental groups were maintained, namely T1- Negative control, T2- Positive control, T3- Inactivated vaccine, T4- Recombinant vaccine, and T5- DNA vaccines (n=20 for each group in triplicates). All the vaccines were given at 0.05 ml I/m and I/p. After two boosters of 14-day intervals, the positive control and vaccinated groups were challenged with live betanodavirus (10^6 $TCID_{50}$) by intraperitoneal route on 30 DPV. After 11 days of DPC, the positive control fish displayed the clinical symptoms of viral infection like circling, surfacing, and acute death. The RPS observed in the whole virus-inactivated vaccine was 91.7% (I/m), 80% (I/p) and 68.42% (Oral). The RPS observed in the recombinant vaccine was 90% (I/m), 64.7% (I/p) and 64.7% (Oral). The RPS observed in the DNA vaccine was 52.6% (I/m), 45% (I/p) and 66.7% (Oral). Among the three types of vaccines, formalin inactivated vaccine and recombinant vaccine administered through I/m route were the most effective since they gave RPS of 91.7% and 90%, respectively. The DNA vaccine administered orally was more effective as it showed a maximum RPS of 66.7% compared to I/m and I/p. The RT-PCR of the brain and eye revealed that all three types of vaccines could neutralize the virus on 30 DPV. The mRNA expression of immune-related genes was analyzed in immune organs (spleen, and head kidney). The RT-PCR confirmed the viral neutralization in the vaccinated fish samples. Immunohistochemistry of the brain and eye revealed moderate to severe expression of inflammatory cytokines (IL1, IL3 and TNFα) in positive control compared to the vaccinated group. The vaccinated group showed significantly ($p<0.05$) higher growth metrics in all the experiments.

Keywords: Betanodavirus, cytokines, pompano, protection, vaccine

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Rapid detection of *Red Sea Bream Iridovirus* disease (RSIVD) by Recombinase Polymerase Amplification Assay (RPA)

Chovatia, R. M.*, Shahana, S., Rahul Krishnan and Muhammed P. Safeena.
Kerala University of Fisheries and Ocean Studies, Panangad, Kochi- 682 506, Kerala, India
safeena.mp@kufos.ac.in

Red Sea Bream Iridovirus (RSIV) is a causative agent of Red Sea Bream Iridovirus Disease (RSIVD) and significantly causes mass mortalities up to 60-90% among cage-cultured marine or brackish water fishes. Recently, the increasing cases of RSIVD outbreaks in cage-cultured fish in India have led to the need for its rapid detection and surveillance before the appearance of clinical signs. Rapid diagnostic techniques like PCR and, more recently, quantitative real-time PCR (qPCR) are routinely used for early detection of RSIV in fish. However, these techniques inherently require a thermocycler and a reliable power supply, thus restricting their use in laboratories. To address the requirements of amplification for use in low-resource settings or at the point of need, the present study aimed to develop a novel rapid, sensitive and specific Isothermal amplification technique, namely Recombinase Polymerase Amplification Assay (RPA) for the rapid detection of *Red Seabream Iridovirus* (RSIV) infection in fishes. RSIV-specific RPA primers were designed using the NCBI Primer-BLAST tool based on the major capsid protein (MCP) nucleotide sequence (GenBank: MT798582) of RSIV. The RPA assay was performed using the TwistAmp® Basic Kit (TwistDX, UK) at temperatures ranging between 37°C and 42°C and at time intervals between 10 and 20 min for optimisation. Amplified products were purified and visualised using agarose gel electrophoresis, and the band size of 124 bp was obtained at 39°C for 20 min. Furthermore, the specificity of the RPA assay developed was checked by performing an RPA assay using the DNA of RSIV and non-targeted pathogens like *Lymphocystis disease virus* (LCDV) and *Tilapia parvovirus* (TiPV) separately and using pooled DNA of both targeted and non-targeted viruses along with RSIV. The RPA assay produced a specific band of 124 bp for the pooled DNA sample and RSIV alone, whereas it didn't create any specific bands for LCDV and TiPV. Thus, the RPA assay developed in the study is 100% specific to RSIV detection and can be used as a point-of-care diagnostic tool for rapidly detecting RSIV before the onset of clinical signs.

Keywords: Isothermal amplification, Point of care diagnostic techniques, Recombinase Polymerase Amplification (RPA), RSIV

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Construction of a recombinant bacterial clone for assisting the PCR-based molecular surveillance of *Infectious hypodermal* and *hematopoietic necrosis* virus infections

Dhanutha N. R.*, Sumithra, T. G., Krupesha Sharma, S. R. and Anusree, V. N.

ICAR- Central Marine Fisheries Research Institute (ICAR-CMFRI), Post Box No. 1603, Ernakulam North P.O., Kochi 682018, India

*rdhanutha@gmail.com

Infectious hypodermal and hematopoietic necrosis (IHHNV) is a viral disease that has caused severe mortality and stunted growth in penaeid shrimps. It has been identified as a significant contributor to economic losses in the shrimp farming industry. IHHNV is transmitted horizontally through direct contact between infected and susceptible individuals. Accordingly, strict biosecurity measures are necessary to prevent and control IHHNV. PCR-based diagnosis can be applied to effectively monitor and detect IHHNV in shrimp farms. Prompt identification of infected shrimps can help prevent the virus's spread and reduce economic losses in the shrimp farming industry. Although PCR-based viral disease diagnosis is potentially a fast and reliable method, it has the possibility of false-negative results due to PCR inhibitors and suboptimal reaction conditions. Accordingly, to avoid false negative PCR results, establishing recombinant bacterial clones containing antigenic portions of IHHNV is necessary in diagnostic labs. Therefore, the establishment of recombinant bacterial clones containing the diagnostic fragment of the *Decapod penstylhamaparvovirus 1*, the aetiology of IHHNV, was done through the study. The diagnostic fragment was amplified from the infected Penaeus *monodon* post-larvae-3 stages using the OIE enlisted primers that amplify only the segment from IHHNV types 1 and 2 (the infectious forms of IHHNV), but not from types 3A and 3B (non-infectious and part of the host genome). The PCR product was then sequenced to confirm the specific amplification, and the obtained sequence was submitted to NCBI GenBank under the accession number OR372521. It showed a percentage identity of 99.27% with IHHNV strain IN-07 (GenBank: GQ411199.1). The confirmed PCR product was then purified and ligated into a pMD20-T vector plasmid. Finally, the ligated plasmid was transformed into competent *E. coli* DH5α cells, the *E. coli* strain lacking virulence properties. Confirmation of the prepared diagnostic clones was done by colony PCR, plasmid PCR, and DNA sequencing. Glycerol stocks of the confirmed clones were made and stored at -80°C. The clones can be used as the positive control in IHHNV diagnostic and molecular surveillance protocols of the national disease surveillance program to ensure 100% accurate results in the PCR protocol.

Keywords: Diagnostic clones, disease surveillance, IHHNV, penaeid shrimps

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Prevalence of White Spot Syndrome Virus in Wild & Farm Populations of Shrimps Post Covid-19 Lockdown

Paulton, M. P*, Gayathri, S. and Sajeela, K. A.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

* meleth_paulton@yahoo.co.in

The rise of aquaculture has been one of the most profound changes in global food production in the past 100 years. Driven by population growth, rising demand for seafood and a levelling of production from capture fisheries, farming aquatic animals has expanded rapidly to become a major global industry. Shrimp is a high-value commodity and one of the major aquaculture species in the world, including India. Viral diseases remain a constant threat and a significant concern in many shrimp-producing countries. This study examines the rise and characteristics of the major viral pathogen Called White Spot Syndrome Virus (WSSV) of shrimp and their impacts, and the particular aspects of disease emergence in both wild and farm populations. Once the clinical signs are developed, mortalities can reach 100% in 3–10 days. PCR has been extensively used to detect WSSV in a specific and sensitive manner. Nested PCR is even more sensitive than single-step PCR and has been used to detect WSSV. The simultaneous presence of WSSV in apparently healthy shrimps and post larvae from different wild and brackish water habitats was studied by nested polymerase chain reaction. In general, the overall results of the study indicate that there is a decline in the presence of WSSV in the environment and probably the reason can be attributed to the standstill state of all farming activities during the COVID-19 pandemic. This has readily influenced the wild population as well. Even the few positive samples from farms tested positive only in the second step of the Nested PCR assay, indicating less viral load. Hence, PCR-based farming practices are recommended to ensure the WSSV-free stocking of post larvae in our culture practices. This will protect the natural habitat and the farming ponds free from this deadly virus affecting shrimp mariculture.

Keywords: Post Covid-19, shrimp, WSSV

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Aquaculture Systems & Fisheries

Investigation of the characteristics of trained immunity in tilapia head kidney macrophages

David Waikhom*, Jeena Kezhedath, Megha Kadam Bedekar, Pani Prasad Kurcheti and Rajendran Kooloth Valappil
ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai, India
*davidwaikhom3@gmail.com

Trained immunity is a novel phenomenon depicting a heightened secondary response to homologous and heterologous pathogens; known to be providing cross-protection in individuals on pathogenic exposure. Major drivers of this response are the metabolic changes and epigenetic modifications in innate immune cells. The study focused on evaluating the metabolic alterations and expression profiling of molecular markers associated with trained immunity in head kidney macrophages (HKM) through an *in vitro* culture approach. For this, HKM were isolated and cultured using L-15 medium supplemented with inactivated 10% fetal bovine serum (FBS) and 2% antimicrobial solution. On attaining a confluency of 80%, cells were stimulated with β-glucan @100 µg ml^{-1}, followed by a 6-day rest period and were further restimulated with the same dosage. Post-restimulation macrophages were collected at seven different time points (0, 6, 12, 24, 48, 72, and 96 h) for analysis. Lactate and LDH assays were performed to assess viability and metabolic activity of the cells. The study profiled the expression patterns of the markers of trained immunity *viz*., *mTOR*, *HIF1α*, *HDAC*, and *IFN-γ*. The expression profiles depict the induction of trained immunity in β-glucan stimulated HKM. Upregulation of proinflammatory cytokines *viz*., *IFNγ*, *IL6*, and *TNFα* indicates the stimulation of immune responses. The elevation in lactate and LDH production suggests enhanced glycolysis and metabolic activity in trained macrophages. Findings of the study demonstrate the potential of immune training as well as the unravels the immune responses in trained head kidney macrophages of fish *in vitro*.

Keywords: Epigenetic modifications, LDH assays, Macrophages, mTOR, Proinflammatory cytokines

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Preparation of colorimetric spoilage indicators using plant anthocyanin extracts for intelligent packaging application in fish

Remya S.*, Mohan, C. O., Toms C. Joseph, Sreelakshmi K. R., and Bindu, J.
ICAR-Central Institute of Fisheries Technology, Kochi-682 029, Kerala, India
remya03cof@gmail.com

Intelligent packaging has emerged as a transformative technology in the realm of food preservation and safety. Among intelligent packaging techniques, freshness/spoilage indicators can provide direct product quality information resulting from microbial growth or chemical changes within a food product. The present study was focused on the development of colorimetric spoilage indicators using plant-derived anthocyanin extracts for innovative intelligent packaging solutions in the context of fish preservation. Anthocyanins, the natural pigments found in plants, were extracted from two distinct sources: blue pea flowers (*Clitoria ternatea*) and Mangosteen peel (*Garcinia mangostana*) and compared their effectiveness as colorimetric spoilage indicators. Additionally, Bromocresol purple (BP), a synthetic dye, was used as a reference indicator to evaluate the performance of the natural anthocyanin extracts. Anthocyanin was extracted using dried and powdered plant parts with 85% ethanol. Subsequently, the extracts were utilized to develop freshness-indicating papers. The colour of the freshness indicating paper with blue pea anthocyanin extract solution changed from pink to green in the pH range of 2.0–10.0. The colour of freshness indicating paper with Bromocresol purple changed from blue to purple. The colour of freshness indicating paper with Mangosteen peel anthocyanin extract changed from light pink to light yellow. To evaluate the practical application of these indicators, they were used for packaging applications of whole, gutted and steaked Indian mackerel (*Rastrelliger kanagurta*). Remarkably, BP, the anthocyanin derived from blue pea flowers demonstrated exceptional performance as a freshness indicator throughout the storage period, offering a clear and easily distinguishable visual cue for assessing the fish's quality. By harnessing the natural colour-changing properties of plant anthocyanin extracts, we can provide consumers and industry professionals with a reliable and intuitive tool to assess the freshness of fish products, thereby reducing food waste and ensuring a safer and more informed food supply chain.

Keywords: Blue pea flower, freshness indicator, seafood, smart packaging

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Appertization as a sustainable technology to preserve green mussel in traditional Ready-to-serve form and its commercialization

Mohan, C. O*., Remya, S., Sreelakshmi, K. R., Pankaj Kishore, Bindu, J., George Ninan

ICAR-Central Institute of Fisheries Technology, CIFT Jn., Willingdon Island, Matsyapuri P.O., Kochi-682029, Kerala, India

*comohan@gmail.com

Green mussel, (*Perna viridis*) belongs to family Mytilidae of phylum Mollusca, is abundantly available naturally in some parts of India and its culture is being promoted. India is one among the top 10 leading mussel producing nations and the contribution of genus Perna is very significant. Green mussels highly preferred due to its nutritional quality as an excellent source of long chain omega-3 fatty acids, minerals, vitamins and provides easily digestible protein with well-balanced essential amino acids. Malabar Coast of Kerala is commonly referred as '*Mussel fishery zone of India*' and the mussel products in many forms are relished due to their unique taste and flavour. Stuffed mussel with blend of rice and condiments in fried form ('*Kallumakkayi nirachath*' in Malayalam language) is one such product which has great demand from other parts of Kerala as well as from overseas due to its irreplaceable taste. The problem of perishability and availability throughout the year beyond season can be addressed only by adopting suitable processing methodologies. Scientifically established Appertization or heat processing in metal cans or flexible containers without added chemical preservative is the best method to enhance the shelf stability of the product stored at room temperature. Heat inactivation of the microorganisms is responsible for the long shelf life of the product. Initial moisture, protein, fat and ash content of the green mussel used for the development was 62.74, 15.11, 1.27 and 1.42%, respectively. F0 of 8.0 min in retortable pouch was found to make the product commercially sterile. pH of the product decreased from 6.61 to 6.48 and total volatile base nitrogen and trimethylamine nitrogen levels increased up on heat processing. Sodium, calcium and potassium content was 2.18, 0.312 and 0.961g% in heat processed product compared to 1.83, 0.048 and 0.185g%, respectively in fresh mussel. The traditional green mussel product, 'stuffed green mussel' in retortable pouch was stable up to 12 months at ambient storage temperature. The product has several advantages like long shelf life under normal room temperature without refrigeration, no chemical preservatives and additives to retain the food safe and wholesome, and is 100% natural. The product was commercialized through Agribusiness Incubation facility of ICAR-CIFT to M/s Food Foods Chaliyum, Kerala and the products are available in hypermarkets and supermarkets including in online platforms like Amazon, Foofood.in, *etc*.

Keywords: Agri-business incubation centre, appertization, commercial sterility, Fo Value, green mussel

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Mathematical modelling of the drying characteristics of marinated anchovy in infra-red dryer

Neethu, K. C. *, Aniesrani Delfiya, D. S. Remya, S., Murali, S. and George Ninan

ICAR-Central Institute of Fisheries Technology, CIFT Junction, Willingdon Island, Matsyapuri P. O., Cochin, Kerala -682 029

*neethu.c@icar.gov.in

A pilot-scale hot air assisted infrared (IR) dryer's drying capabilities and quality aspects of raw and marinated anchovies were studied. Anchovies were marinated using different combinations of Indian spices and dried in pilot-scale IR dryer at an intensity of 3,000 W m^{-2}, IR source to sample distance of 10 cm, hot air inlet temperature of 50°c and air velocity of 1.5 m s^{-1} for a period of 3 h. The moisture content of anchovy was reduced from 81.74 to 23.7, 23.35, 19.74, 13.10, and 22.39 (% w.b.) for raw, marination 1, marination 2, marination 3, and marination 4, respectively. Drying rate declined with time and followed the falling rate drying period. Drying rate of raw, marination 1, marination 2, marination 3, and marination 4 was found to be 1.389, 1.391, 1.410, 1.442 and 1.396 g g^{-1} DM h^{-1}, respectively. Marination was found to accelerate drying process. Drying characteristics curves were plotted and various drying models were fitted to describe drying kinetics of raw and marinated anchovies. Drying model's suitability was evaluated based on higher coefficient of determination value (R^2), lower root mean square error (RMSE) and reduced chi-square values (χ^2). While drying anchovies, the Page model performed best with raw, the Midilli model performed best with marination 1 and 2, and the diffusion approach model performed best with marination 3 and 4. The shrinkage of dried anchovy was estimated to be 24.70, 25.29, 26.21, 26.39, and 25.48% for raw, marination 1, marination 2, marination 3, and marination 4, respectively. The rehydration ratio of dried anchovies for raw, marination 1, marination 2, marination 3, and marination 4 was 1.34, 1.35, 1.35, 1.38, and 1.34, respectively. The colour values measured in terms of L*, a*, and b* was found to be differed after drying and also with the level of concentration of spice ingredients used for marination. The texture of the dried product in terms of shear force was tend to increase with the increase in concentration of spice ingredient and the level of moisture content in the dried anchovies. The hardness values for dried anchovies were reported to be 14.26, 24.73, 51.50, 23.05, and 37.29 N, respectively for raw, marination 1, marination 2, marination 3, and marination 4. Sensory evaluation using 9-point hedonic scale recorded highest score for anchovy dried after marination 3.

Keywords: Advanced drying technology, dry fish quality, drying kinetics, Indian spices, marinated and dried fish

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Unraveling the charisma of flavored 'muziris' oysters: an exploratory study

Jenni, B. * and Vipinkumar, V. P.

ICAR- Central Marine Fisheries Research Institute, Kochi -682018, Kerala, India

*jennihsharma@gmail.com

Kerala, the southern coastal state of India, is well recognized for its palatine sea foods. But the internationally accepted iconic food item, "Live Oyster" is not much familiar as a member in the privileged list. In the beginning of 21st century, ICAR-Central Marine Fisheries Research Institute (CMFRI), has taken an initiative to popularize oyster farming and its trade in India, especially in the states of Kerala and Karnataka. In 2002, CMFRI implemented a World Bank aided project in the pristine waters of Azhikode-Munambam estuarine area of Vembanad Lake ($10^0$10′46″ N and $76^0$10′4″E). The main objective of the project was the development of a value chain for the bivalves from the production to marketing. In India, the Indian backwater oyster *Magallana bilineata* is the candidate species in oyster farming. Initially more than 34 Women Self Help Groups were actively involved in the farming. The collective efforts of women SHGs and CMFRI's scientific interventions in the form of value addition as depuration increased the demand of 'LIVE' oysters. The success was reflected in India's bivalve aquaculture production of oysters from 2 tonnes in 1995, which peaked 4500 tonnes in 2017. In the product diversification process, Casino Group of Hotels (CGH-Earth) made history and started India's first live oyster bar at Casino Brunton Boatyard and included the depurated live oysters in their menu in 2014. In the consecutive years, the number of high-end restaurants was going up as Taj Mahal, Taj Malabar, ABAD, Grand Hyatt *etc*. To increase the popularity of live oyster consumption, CMFRI experimented live oysters with different natural extracts of cardamom, orange and ginger to add flavour. More than five trials were conducted for each extract with constant number of live oysters in different time intervals. This research effort attempted an explorative study on unraveling the charismata of flavored oysters. In the experimental trials, cleaning and depuration were done by standardized protocol developed by CMFRI. The study revealed that, the acceptance of live oysters was more for cardamom flavoured ones followed by orange flavored. Now the product is ready for commercialization under the brand name 'Muziris'. Oysters are popularly known as 'Milk of the Ocean' and are comparatively low cholesterol food. Oysters are rich in zinc, iron, vitamin B12, omega 3 fatty acids, minerals like copper, iodine and the rare mineral selenium. These are a couple of the highlighting glimpses on unravelling the delights of flavored oyster.

Keywords: Depuration, flavoured oyster, *Magallana bilineata,* Muziris, selenium

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Drying kinetics of clam in hot air-assisted continuous infrared dryer

Aniesrani Delfiya, D. S.*, Murali, S., Neethu, K. C. and George Ninan
[1]ICAR-Central Institute of Fisheries Technology, Cochin-682029, India
*delfy.lenin@gmail.com

The black clam (*Villorita cyprinoides*), is the most important clam species landed in India. Especially, Kerala has been the leading producer of this species in the past years. Clam is a rich source of bioactive components such as peptides, proteins, minerals, vitamins, and other amino acids which are essential for human health. On the other hand, clam meat is highly liable to the microbial spoilage and biochemical reactions because of the high moisture content in the fresh form. Drying is the most common and cost-effective method to reduce the moisture content of foods and retard the microbial and chemical changes in food to extend the shelf-life. Among the various drying methods, infrared radiation (IR) drying of foods ensure rapid heating, less drying time, and superior quality of the final dried product. Hence, in this study it was aimed to study the drying behaviour of clam in pilot-scale hot air-assisted continuous infrared dryer at the infrared intensity of 3,000 W m^{-2}, IR source to sample distance of 10 cm, drying air temperature of 55°C, and air velocity of 1.5 m s^{-1}. The total drying time of 3.5 h was recorded to reduce the moisture content of clam from 70.04±0.09 to 14.80±0.23% wb with the shrinkage and rehydration ratio of 17.1±0.69% and 1.55±0.15, respectively. The total colour change observed during drying was found as 21.05±0.42 and the specific energy consumption was 3.15 kWh kg^{-1} of water removed. Drying occurred in falling rate period with no constant rate period. Eight well-known thin layer drying models were fitted in drying data and Wang and Sing model was selected as the best fit with the χ^2, R^2, and standard error values of 7.58×10^{-4}, 0.993 and 0.004, respectively. Results revealed that the quick and hygienic drying of clam is possible using this dryer and the moisture content with respect to drying time can be predicted for the specified operating conditions using the selected drying kinetics model.

Keywords: Clam Drying, drying characteristics, drying kinetics, infrared dryer

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

ICAR-CIPHET Fish Steaking Technology for easy and hygienic fish dressing and waste management

Armaan Ullah Muzaddadi and Vikas Kumar*

ICAR-Central Institute of Post-Harvest Engineering and Technology (CIPHET), Ludhiana, Punjab-141004, Punjab, India

*vikas.kumar5@icar.gov.in

An essential post-harvest unit operation of finfish is its primary processing. However, it is cumbersome and mostly unhygienic in traditional practices by fish retailers, small scale fish processors, caterers and fish handlers commonly seen in the fish market. To ease this operation, handle fish hygienically, offer product display and collect disposed waste, ICAR-CIPHET developed a fish steaking-cum-waste collecting platform that can be easily operated by any non-technical personnel for a long time with less drudgery. A dressing table [100(H) × 48 (B) × 120 (L) mm] made of stainless steel (SS, 208) was provided with a sharp, round cutter (SS, 25.4 cm dia.), a water spraying system for cleaning, a motor (0.1 HP, 9400 rpm) pulley (polyvinylchloride, PVC, 20 cm dia.), a foot rotor pulley (PVC, 53 cm dia.) and proper waste disposal set up. The machine can steak fish @ 2-3 kg fish (carp) minute^{-1} and collect liquid and solid waste in covered containers separately. A fly protection, continuous rinsing, and filtration systems were added. The technology is to contribute immensely towards the Swachh Bharat Mission, facilitating the utilization of waste and thereby promoting waste to wealth.

Keywords: Fish Dressing, hygienic handling, steaking, waste management

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

The effect of high-pressure processing on the quality of seafood meat – A review

Patel Shivangi* and Shyni, K.

Department of Fish Processing Technology, Kerala University of Fisheries and Oceans Studies,Kochi

*shivangipatelfpt@gmail.com

High-pressure (HP) technology is useful for preserving food. When it applied to fish and shellfish, high-pressure (HP) treatment could result in several kinds of benefits since it would affect the extension of the shelf life of this extremely perishable seafood product. In contrast, under extreme conditions, changes in the meat's appearance, texture, and chemical composition can be observed in fish. The most significant modifications took place between 200 and 300 MPa, causing proteins to either partially or completely denature. These changes in turn affected the pH, hardness, whitening, water-holding capacity, the beginning of lipid and protein oxidation, and an increase in hardness. The brief overview of HP technology and its main impact on fish meat quality were reviewed in this paper by considering the targeted constituents and underlying mechanisms.

Keywords: High hydrostatic pressure technology, lipid oxidation, meat discoloration and hardness, meat quality, protein denaturation

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Industrial extraction as well as microscopic, biological, chemical and structural characterization of salt from commercial marine red seaweed *Kappaphycus alvarezii* (Doty) L.M. Liao and its comparison with other edible salts

Bhagirath Rakhasiya*, Shanmugam, M., Doniya Elze Mathew, Srinu Tothadi, Anshul Yadav and Vaibhav A. Mantri
CSIR-Central Salt and Marine Chemicals Research Institute, Gijubhai Badheka Marg, Bhavnagar – 364002, India
*bhagirathrakhasiya@gmail.com

The warm-water marine alga *Kappaphycus/Eucheuma* recorded the production of ~ 11.6 million tons (33.6 % of all seaweeds) in 2019. In the present study, the industrial processing of 1000 kg of fresh biomass by employing thrashing, coarse and fine filtration, followed by concentration through triple effect force circulation evaporator yielded 25 kg seaweed salt. The optical microscopic examination revealed absence of geometrical pattern, non-crystalline nature of seaweed salt. SEM micrograph indicated squircle shape of salt aggregated with distinct ruffled surface. The *in-vitro* anti-oxidant activity of 0.2±0.0 µg g^{-1} was recorded for seaweed salt. While *Caenorhabditis elegans* assay confirmed its non-toxicity. The complete absence of pathogenic *Salmonella* and Organochlorine and Organophosphorus pesticides make is safe for human consumption. Among macro minerals (K, Mg, Ca and Na) analyzed, K was found to be highest (3792.74±541.23 mg 100 g^{-1}) and Ca lowest (7.01±1.32 mg 100 g^{-1}). Among micro minerals (Fe, Mn, B and Ni) analyzed, Fe was found to be highest (6.52±1.40 mg 100 g^{-1}) and Ni lowest (0.14±0.01 mg 100 g^{-1}). Chromium (11.5 µg g^{-1}) was much lower than a permissible daily dose in seaweed salt. Other heavy metals (Mo, Cu, Co, Zn, As, Cd, Hg, and Pb) were below detectable level. The presence of KCl Form I in seaweed salt was inferred using PXRD pattern. Single crystal XRD revealed a face centered cubic unit cell with four cations and four anions. Seaweed augmentation with new immerging applications has recently witnessed a considerable shift in the utilization of biomass. The study unequivocally suggested potential economic utility of industrially unwanted constituents (seaweed salt) under the framework of waste to wealth. The use of renewable feedstock through bio-refinery process will help in contributing towards sustainable development goal of UN.

Keywords: Green protocol, *Kappaphycus alvarezii*, renewable feedstock, seaweed, sustainable development

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Environmentally friendly nanochitin preparation from shrimp shell chitin using organic acid hydrolysis enhanced by steam explosion

Soibam Ngasotter[1]*, Martin Xavier, K. A.[2], Porayil Layana[1], Balange, A. K.[1], Nayak, B. B.[1] and George Ninan[2]

[1]ICAR-Central Institute of Fisheries Education, Mumbai-400 061, Maharashtra, India
[2]ICAR-Central Institute of Fisheries Technology, Kochi-682 029, Kerala, India

*ngasotter@gmail.com

The shrimp processing industry annually generates a huge amount of shell waste, a significant portion of which is indiscriminately discarded, leading to severe environmental repercussions. These discarded shells are rich in chitin, a valuable biopolymer with versatile applications across multiple industries. Current methods for producing nanochitin involve the use of harsh chemicals, notably strong inorganic acids like HCl and H_2SO_4. However, these conventional methods exhibit several critical shortcomings, including environmental and health hazards, equipment corrosion, excessive degradation of the raw chitin material, and exorbitant production costs. To address these challenges, this study presents an innovative approach employing a weak organic acid, maleic acid, in conjunction with steam explosion for the eco-friendly production of nanochitin from shrimp shell chitin. Dynamic light scattering (DLS) analysis revealed that the resulting nanochitin exhibited an average particle size ranging from 300 to 400 nm. These nanochitin particles demonstrated good colloidal stability, primarily attributable to their highly negative average zeta potential values, falling within the range of -32 to -35 mV. It is important to emphasize that this research is still in its preliminary stages, necessitating further investigation to comprehensively characterize the nanochitin material produced. Nonetheless, this study holds immense promise as a potential pathway for preparing nanochitin from shrimp shell waste with superior colloidal stability, using an environmentally friendly and sustainable method. By circumventing the environmental and health risks posed by traditional chemical processes, this approach emerges as a sustainable solution to convert shrimp shell waste into high-quality nanochitin, opening new avenues for its application across diverse industries.

Keywords: Eco-friendly, green method, nanocrystals

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Protein hydrolysate from pink perch (*Nemipterus japonicus*) head waste during surimi processing: Optimization of extraction condition by response surface methodology and their characterization

Sathish Kumar, K.[1,2*], Elavarasan, K.[1], Joshy, C. G.[1], Bindu, J.[1], Amjad K. Balange[2] and Narasimhamurthy, L.[3]

[1]ICAR–Central Institute of Fisheries Technology, Cochin, Kerala, India
[2]ICAR- Central Institute of Fisheries Education, Mumbai, Maharashtra, India
[3]National Fisheries Development Board, Hyderabad, Telangana, India

*sathishcife@gmail.com

The present study aimed to optimize the enzymatic extraction conditions by adopting response surface methodology (RSM) to maximize the yield of fish protein hydrolysate (FPH) from pink perch head, generated as waste during surimi processing and characterised their properties. Central composite design was used to study the direct and combined effects of four input variables, namely enzyme concentration (0.25, 0.63, and 1%), extraction time (60, 90 and 120 min), temperature (45, 55 and 65°C) and pH (6, 7, and 8) on response to the yield (dry weight basis). Based on the fitted quadratic model and predicted values of response variable, the optimized condition for the maximum yield was at the enzyme concentration of 0.80%, extraction time of 110 min, temperature of 55°C, and pH of 6.11. Based on the optimized process conditions, the obtained protein hydrolysate yield was 8.02%, which was slightly higher than the predicted value (7.97%). Further, proximate composition, antioxidant and functional properties of FPH were determined. The proximate analysis indicated 80.18±0.41% protein, 2.24±0.02% fat, 4.85±0.08% ash and 4.98±0.72% moisture on dry weight basis. The amino acid profile showed that, lysine was major essential amino acids and glutamic acid was found to be major non-essential amino acid. The minerals analysis revealed Na (3,869.00±11.89 ppm) to be major mineral, followed by K (2,884.00±65.98 ppm) and P (2,132.00±41.2 ppm). In structural analysis, DSC, FT-IR, MALTI-TOF and SEM analysis were carried out. MALDI-TOF result displayed a few strong signals in a range of 7500-9000 m/z and the maximum signal was observed at 8563.37 m z^{-1} at 83% of intensity. The SEM image showed globular structures ranging between 6–14 µm, ruptured and shrunken in nature. The study revealed potential valorisation opportunities for hydrolysis of bio-waste and its application as protein source for supplements or functional ingredients for the development of high value products.

Keywords: Antioxidant activities, fish protein hydrolysate, functional properties, response surface methodology, structural characteristics

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

A demonstrative investigation on icing as an implementable solution to foul smell association with shrimp peeling waste

Elavarasan, K.*, Jeyakumari, A., Zynudheen, A. A., Pankaj, K., Joshy, C. G., Asha, K. K. and Bindu, J.

ICAR-Central Institute of Fisheries Technology, Kochi-682 029, Kerala, India

*elafishes@gmail.com

Management of fish processing waste holds a key to the transformation of aquatic food systems more sustainable. The majority of fish eaters in India carry only the dressed fish or peeled shrimp to the kitchen. The growth in retail practices and seafood export leaves behind a huge amount of highly perishable processing discards unattended. There is an urgent need to impart education, and practical knowledge on the utilization of waste to turn the fisheries sector sustainable. The present investigation is demonstrative and revisited in nature on the use of icing in the handling of shrimp peeling waste (SPW). Three independent lots of shrimp peeling waste from commercial peeling sheds were collected and stored at iced (chilled temperature-CT, 1:2 ice: waste; non-replenished) and non-iced conditions (room temperature -RT). The biochemical and microbiological changes under 12 hours of storage were evaluated using the methods of AOAC and ISO. Initially the TVB-N and TMA-N were 18-23 and 2-5 mg N 100 g^{-1} of sample and increased to 58-136 and 16-28 mg-N 100 g^{-1} sample within 4 hours, respectively whereas in iced samples TVB-N and TMA-N reached 28-59 and 5-7 mg-N 100g^{-1} of sample, respectively. The protein degradation and volatile amine formation were assessed by estimating the ratio of Non-Protein Nitrogen (NPN) to crude Protein Nitrogen (PN), α-amino nitrogen (AAN) to PN, AAN to NPN, and TVB-N to NPN. Results indicated that the spoilage in RT-SPW was mainly due to microbial assistance while that of in CT-SPW, was endogenous enzymes mediated. This fact was also correlated well with the aerobic plate count (APC) and ammonia formation. APC of initial samples were 6.85-8.72 log10CFU g^{-1} of samples which increased to 8-9.40 log10CFU g^{-1} within 4 h of storage in RT-SPW. A similar result was observed in CT-SPW after 12 hours of storage. SPW is used as a raw material for manufacturing valuable products like shrimp meal, chitin, and shrimp protein paste/soluble. In practice, the handling of SPW is not given importance and is transported after prolonged storage at RT. From the study, it is demonstrated that short-term ice storage in an insulated facility will largely alleviate the foul smell-related issues which are arising as a huge health concern for residents in and around the facilities, while transportation and during further processing into valuable products.

Keywords: Ammonia, foul smell, shrimp peeling waste, waste management

Supplementation of agri-wastes based hydrochar to augment microalgae biodiesel production for sustainable fisheries

Santhana Kumar V.*, Dhruba Jyoti Sarkar, Tanushree Banerjee, Soma Das Sarkar, Suvra Roy, Anjon Talukder and Basanta Kumar Das

Aquatic Environmental Biotechnology Nanotechnology Division, ICAR-Central Inland Fisheries Research Institute, Kolkata-700120, India

*sankumar1693@gmail.com

Fisheries sector is mostly dependent on the fossil fuels and the fossil fuel costs account about 40-50 % of the total expenditure required for fishing operations. The decrease in fossil fuel supply, price hike, high CO_2 emission and climate change warrants an alternative green and clean energy source for the sustainable fisheries. Microalgae-based biodiesel production has gained momentum due to its nascent advantages over petroleum-based fuels. However, issues like high cost of cultivation, usage of inorganic fertilizers, possess hindrance towards its commercial production and warrants new approaches which utilize waste resources for microalgae cultivation. Besides, agri-wastes like banana pseudo stem were plentily available (80 million tonnes $year^{-1}$) and remains unutilized. Hence the present study converted the banana pseudo stem into hydrochar via hydrothermal carbonization and utilized them as a supplement for augmenting growth and quality lipid production in microalgae *Graesiella emersonii* MN877773. The hydrochar was dispersed in deionized water at different concentrations (100, 250, 500 ppm) and supplemented into the initial and pre-grown (10 days old) algal culture solution. The experiment was carried out at a controlled temperature (27±2°C) and illuminated with a lamp (light intensity of 1300±400 lux) for 16 h light and 8 h dark conditions in triplicates in 250 mL conical flask contains 100 mL substrate for 20 days. The result revealed that the addition of hydrochar at 250 ppm concentration to the pre-grown microalgae improved ($p<0.05$) the cell growth and biomass productivity (2 times higher). There was a 27% increase ($p<0.05$) in lipid content and improved lipid productivity (i.e., 0.003 g l^{-1} day^{-1}) was also noticed. Addition of hydrochar also reduced the pH of the culture solution from highly alkaline to slightly alkaline, which is favourable for the growth and lipid accumulation in microalgae. Fatty acid profiling revealed the presence of more amount of methyl palmitate (56 % higher) upon hydrochar treatment. The vehicular properties of the biodiesel produced from the hydrochar treated microalgae was also found in compliance with the national and international standards. Besides, the produced biodiesel also showed few properties comparable with the fuel used for fishing vessels. Therefore, the present study concludes that addition of hydrochar at certain dosage during the exponential phase stimulates more production of quality biodiesel in the test microalgae. This strategy could pave the way to utilize agri-wastes for sustainable biodiesel production in order to attain FAO SDGs on "Affordable and clean energy" and "Climate action".

Keywords: Banana pseudostem, biodiesel, fisheries, hydrochar, microalgae

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Domestic Market Fish Waste to Green Innovation: recovering high value enzymes as a path to sustainable resource utilisation

Sahana, M. D.[1]*, Balange, A. K[1], Elavarasan, K.[2], Porayil Layana[1], Martin Xavier, K. A.[2], Nayak, B. B.[1], Amulya, S. G.[1] and Bejawada Chanikya Naidu[1]

[1]ICAR-Central Institute of Fisheries Education, Mumbai – 400061, Maharashtra, India
[2]ICAR-Central Institute of Fisheries Technology, Kochi-682 029, Kerala, India

*sahana.phtpb003@gmail.com

As global fish consumption has doubled, the problem of fishery waste on land has grown, particularly in domestic markets, where issues like insufficient infrastructure and improper food safety management measures are prevalent. It's crucial to underscore that fish waste management, particularly in domestic market, is a significant and pressing challenge. Fish processing discards usually account for 3/4th of the total weight of the raw material, with viscera alone accounting for 12-18% of fish body weight, creating hygiene and pollution concerns. However, this waste contains valuable proteolytic enzymes, that could find applications in detergents, food processing, tannery and pharma industries. Rapid degradation and compound richness make proper waste management crucial. Initiatives like India's PMMSY align with SDGs 12 and 14, emphasizing responsible consumption, effective waste management, and harnessing untapped potential for a sustainable future. This study aimed to explore the potential of fish processing wastes as a source for enzyme production, with a special focus on those of collagenolytic activity. Crude enzymes were extracted from domestic fish market visceral waste, evaluating collagenolytic activity. Using NaCl and TrisHCl (pH 8) buffers, extraction conditions were optimized by varying one variable while holding the others constant. Hydrolysis was measured by quantifying released leucine content at 570 nm. The SDS-PAGE analysis of the crude enzyme extracts, obtained using both the buffers, indicated molecular weights within the 20–60 kDa range. In the context of collagen hydrolysis, the ideal optimal temperature, pH and reaction time were found to be 60°C, 9, and 10 minutes respectively. It is noteworthy that the crude enzyme extracted with the NaCl buffer exhibited notably superior enzymatic activity compared to that extracted using the Tris buffer. These findings underscore the remarkable potential of these enzymes in the creation of specialized food protein hydrolysates distinguished by unique characteristics. Additionally, this investigation underscores the imperative for exhaustive examinations to elucidate enzyme activity across diverse substrates. Collectively, these discoveries illuminate a propitious path for repurposing visceral waste into valuable proteases using eco-conscious methodologies, offering an environmentally sustainable remedy for waste management challenges within the fisheries sector.

Keywords: Enzymes, eco-friendly, green method, sustainability, waste management

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Real-time authentication of shrimp species identity using ion mobility-rapid evaporative ionization mass spectrometry prevents seafood fraud

Niladri Sekhar Chatterjee*, Rajesh, R., Pranamya C. Haridas, Pankaj Kishore and Satyen Kumar Panda

ICAR-Central Institute of Fisheries Technology, Matsyapuri P.O., W. Island, Cochin-29, Kerala, India

*Niladri.Chatterjee@icar.gov.in

Globally shrimp is considered one of the most important seafood. However, given their phenotypic similarity, it can be difficult to distinguish various prawn species based solely on their morphology, rendering them susceptible to economically motivated mislabeling. Ambient mass spectrometry based untargeted lipidomics is an emerging approach for food authentication in real time and without any sample preparation. The present study aimed to investigate the lipidomic profile of three economically important shrimps namely *P. monodon*, *L. vannamei,* and *F. indicus*, to develop classification models and identify the potential markers for the discrimination of species identity using an ambient mass spectrometry-based untargeted lipidomics approach. The real-time lipidomics fingerprint of the shrimp species was acquired using ion mobility-rapid evaporative ionization-ToF- high-resolution mass spectrometer (ion mobility-REIMS) and conducted multivariate statistical analysis. The acquisition of data in ion mobility ToF mode resulted in the generation of 4D mass spectra with collisional cross section (CCS) values in addition to the RT, intensity, and m z^{-1}. The principal component analysis revealed formation of distinct clusters for each species group and showed R2X and Q2 values of 0.95 and 0.94 respectively. The optimized OPLS-DA and PLS-DA models showed classification accuracy of 99-100% with excellent fitness. Based on the VIP plot, S plot, and loadings plot of the developed OPLS-DA model, a total of 14 lipid biomarkers were tentatively identified for shrimp species discrimination, which includes phosphatidic acids, phosphatidyl choline, phosphatidyl inositol, phosphatidyl ethanolamine, glycerophospholipids, and phosphoglycerates. Furthermore, using the optimized classification models, the authenticity of the unknown shrimp samples can be analyzed in a real-time manner. In the future, such approaches will benefit the food industry to develop rapid and robust technologies for authentication analysis of various food matrices.

Keywords: Chemoinformatics, ion mobility, lipidomics, REIMS, seafood authentication

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Development of microbial hydrolysis as a green pretreatment technology for the tropical red seaweed, *Gracilaria corticata*, during 3-G bioethanol production

Ros Kooren[1,2]*, Sumithra, T. G.[1], Sreenath, K. R.[1], Krupesha Sharma, S. R.[1], Anusree, V. N.[1], Amala, P. V.[1], Vishnu, R. [1] and Jaseera, K. V.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No: 1603, Ernakulam North (PO), Kochi-682018, Kerala, India.
[2] Cochin University of Science and Technology, Kerala, India

*rostreasatimil@gmail.com

Bioethanol from marine algae (3G bioethanol) is an attractive form of sustainable and renewable energy. Finding an optimal pretreatment strategy that yields fermentable mono sugars from complex polysaccharides (saccharification) is crucial in 3-G bioethanol production. In this context, biological pretreatment using microbes can be a preferred strategy for producing bioethanol in an eco-friendly, energy-efficient, cheap, and technically viable platform. Accordingly, the present study explored the potentiality of 24 marine bacterial strains to improve the sugar yield from *Gracilaria corticata, a widely prevalent red seaweed species in tropical countries.* Prioritization of six microbes from a collection of 24 microbes was initially done considering different polysaccharides present in *G. corticata (*cellulose, starch, agar, and carrageenan). Final selection of three microbes was made based on the yield of reducing sugars from the seaweed in a minimal salt medium. Results showed that all three microbes significantly increased the release of reducing sugars, with significant differences (P<0.05) based on the medium, microbes, and days of hydrolysis. Factor analysis of mixed data indicated that microbes contributed to the maximum variability of the data. *Bacillus amyloliquefaciens* caused the maximum biomass conversion ratio for reducing sugars (24.8 ± 0.51%) with an increment of 6.39% from the control within 24 h. The maximum sugar release was obtained in nutrient broth. There was no significant difference in sugar release between washed and non-washed biomass, allowing skipping the washing process and reducing production costs. Even though different combinations of three prioritized microbes produced better saccharification than the control, individual use of prioritized microbes made a better release of reducing sugars. The long-term prospect of seaweed bioethanol production depends on the selection of processes in the hydrolysis stage, which was achieved through the present investigation, and the scaling up of this setup is the future perspective. In brief, the results of the present study emphasis on improved yield of fermentable sugars from *G. corticata* in a simple, cheap, efficient, and eco-friendly platform, foreseeing their potential future application in the 3G-bioethanol industries.

Keywords: Biofuel, hydrolysis, macroalgae, reducing sugar, screening plate assay

Formulating microbial degradation as an eco-friendly strategy for lobster shell waste management

Amala, P. V[1,2]*, Sumithra, T. G[1], Krupesha Sharma, S. R.[1] and Gopalakrishnan, A.[1]

[1]ICAR-Central Marine Fisheries Research Institute, Post Box No: 1603, Ernakulam North (PO), Kochi-682018, Kerala, India.
[2] Cochin University of Science and Technology, Kerala, India

* rosmiamala19@gmail.com

Formulating an eco-friendly strategy for efficient management of the vast amount of shell waste (SW) discarded from lobster processing facilities is an environmental obligation to control pollution and maintain the lobster industry's sustainability. In this scenario, microbial decomposition can be a low-cost, sustainable, eco-friendly technology for lobster SW management. The study outlines a strategy for lobster SW management through a single-stage co-fermentation using the prioritized proteolytic and chitinolytic bacteria for the first time. Three potential chitinolytic microbes (*Bacillus subtilis, Bacillus megaterium,* and *Bacillus amyloliquefaciens*) were initially prioritized by the screening process using colloidal chitin. The technique demonstrated the essentiality of 5% glucose supplementation for maximal chitinolytic activity. The final SW degradation experiments used the unprocessed shell waste from *Panulirus homarus*, a species representing a significant share of the marine lobster SW in tropical countries. Among the three prioritized chitinolytic bacteria, *Bacillus amyloliquefaciens* showed maximal activity in terms of degradation. Single-stage co-fermentation of either one of these chitinolytic strains in combination with one fish proteolytic strain (*Paenibacillus alvei*) was then tested in the unprocessed lobster SW. PCR confirmed the functional gene corresponding to their selected characteristic in these isolates before the SW degradation experiments. Remarkably, the single-stage co-fermentation efficiently degraded the lobster SW (86 ± 4.5% weight loss), with high deproteinization (94.03 ± 0.25%) and demineralization efficiency (91 ± 0.41%). The analysis through scanning electron microscopy revealed the cracked surface of the shells with several pores after the fermentation, demonstrating the degradation. More importantly, there was high NAG release (up to 648 mg g^{-1} of shell) which has great potential in the medical industry. In summary, the study depicts an efficient, eco-friendly bioprocessing strategy for lobster SW management with prospective bioremediation and valorization applications.

Keywords: Deproteinization, demineralization, Ggreen technology, N-acetyl glucosamine, SEM analysis

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

An investigation into the incidence of non-lactose fermenting *Enterobacterales* in fresh seafood

Santosh Kumar Panda, Binaya Bhusan Nayak, Sanath Kumar and Manjusha Lekshmi*
ICAR-Central Institute of Fisheries Education, Versova, Andheri (West), Mumbai-400061, Maharashtra, India
*manjusha@cife.edu.in

Non-lactose fermenting enterobacterales (NLFE) are potentially pathogenic bacteria that can contaminate seafood and pose health risks to consumers. Studies on the prevalence of NLFE in seafood and their virulence characteristics are sparse. The present study investigated the presence of NLFE in fresh seafood collected from fish landing centers and markets in Mumbai, India. A significant proportion (61%) of finfish and shellfish yielded NLFE on MacConkey agar. Of 156 NLEF isolates, 42 glucose-positive NLFE were subjected to further biochemical tests and PCR detection, followed by antimicrobial susceptibility testing. The results suggested that seafood-borne NLFE are predominantly *Proteus mirabilis, Proteus vulgaris, Enterobacter amnigenus* (Biogroup 1), *Enterobacter gergoviae, Citrobacter amalonaticus, Enterobacter cloacae, Serratia marcescens, Enterobacter agglomerans, Pragia fontium, Morganella morganii* and *Escherichia fergusonii*. The antibiotic susceptibility pattern of NLFE was tested against 14 commonly used antibiotics by the disc diffusion method. All (100%) isolates were resistant to ceftazidime, while 90.47% were resistant to tetracycline. All the isolates tested were sensitive to ertapenem, imipenem, and gentamicin, followed by ciprofloxacin (97.61%). Resistance to two or more antibiotics was detected in 32.5% of the isolates. Overall, the incidence of NLFE was higher in shellfish than finfish, which can be attributed to their filter-feeding habits. Multidrug resistance was also predominantly found in shellfish isolates of NLFE. This first report on the occurrence of potentially pathogenic NLFE emphasizes the need to understand their distribution in coastal-marine environments, pathogenic potentials, and survival characteristics under chilled and frozen storage conditions.

Keywords: Antibiotic resistance, *Enterobacterales*, non-lactose fermenting, prevalence, seafood

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Detection of *Cronobacter sakazakii* in seafood by colony hybridization using a biotin-labelled probe

Sanju Nehra*, Sanath Kumar, Binaya Bhusan Nayak and Manjusha Lekshmi

ICAR-Central Institute of Fisheries Education, Versova, Andheri (West), Mumbai-400061, Maharashtra, India

*sanju.phtmb109@cife.edu.in

Cronobacter sakazakii is one of the emerging opportunistic food borne pathogens, associated with seafood-borne human infections, originally isolated from powdered infant formula foods. It has also been reported from a variety of food sources including seafood, meat, plant and dairy products. Although published reports are available on PCR-based detection of *Cronobacter* spp., but these found not appropriate for the detection of *C. sakazakii* in seafood. Hence, in the present study, a molecular quantification method was developed and evaluated for its specific detection and enumeration in fresh seafood. Two reference strains of *C. sakazakii* (ATCC 29544 & MTCC 569) and 24 non-*Cronobacter sakazakii* strains were used, with focus on designing primers for the specific amplification of *C. sakazakii,* followed by the development of a biotin-labelled probe for its quantification by colony hybridisation technique in seafood. A total of 11 primers were designed targeting *omp*A, *rpo*B, *hly*, *glu*A, *wzz*B and *fhu*F genes using NCBI Primer-Blast tool. Of the 11 sets of primers designed, five (hly I, hly II, wzzz II, glu I and fhuF) were specific for the detection of *Cronobacter* spp. and three (wzz II, hly I and fhuF) for *C. sakazakii*, based on the PCR specificity exhibited against the related species *C. malonaticus* and other non-Cronobacter strains. PCR assays based on newly designed primers (hly I, hly II and wzz II) could detect as low as 1.45 cfu ml^{-1} in pure bacterial suspension of *C. sakazakii* ATCC 29544. The sensitivity of the assay was 2.9×10^4 cfu g^{-1} for hly I, hly II, glu I; 2.9×10^3 cfu g^{-1} for fhuF and 2.9×10^0 cfu g^{-1} for wzz II, in shrimp meat spiked with *C. sakazakii*. With 4 and 10 hrs selective enrichment of spiked shrimp in selective media, sensitivity of wzz II and fhuF primers increased to 0.29 cfu g^{-1} and 2.9 cfu g^{-1} sample respectively. Based on the sensitivity and specificity of primers, wzz II primer targeting the *wzzB* gene encoding desiccation tolerance in *C. sakazakii* was selected for designing a PCR product based biotin-labelled probe. The designed probe was found to be specific to *C. sakazakii* as it didn't show any cross-reactivity with other non-*Cronobacte*r strains used during colony hybridisation. The study reports for the first time the development of a simple and sensitive method using *wzzB* gene-based biotin-labelled probe for the detection and quantification of *C. sakazakii* in seafood by colony hybridization.

Keywords: Biotin-labelled probe, Ccolony hybridisation, *C. sakazakii,* primer designing, seafood safety

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Phylogenetic diversity of quinolone-resistant ESBL-producing *Escherichia coli* isolates from seafood

Dhanush, C. K.*, Manjusha, L., Nayak, B. B. and Sanath H. Kumar

[1]ICAR-Central Institute of Fisheries Education, Seven Bungalows, Andheri (W), Mumbai, 400061, India.

*dhanushck60@gmail.com

Escherichia coli in seafood could be derived from diverse anthropogenic sources due to the contamination of coastal-marine waters. Certain clonal types of *E. coli* are emerging as highly resistant to multiple antibiotics. Phylogenetic evaluation of *E. coli* can help to understand the distribution and origin of multidrug-resistant *E. coli* in seafood and the aquatic environment. The present study aimed to understand the quinolone resistance phenotypes and the genotypes in seafood isolates of ESBL-producing *E. coli*, and their phylogenetic diversity. Quinolone susceptibility patterns of 269 Extended Spectrum β-Lactamase (ESBL)-producing *E. coli* isolates from seafood were tested using first, second and third-generation quinolones. The isolates were further tested for the genetic factors conferring resistance to quinolones. The results showed that 73.60% of *E. coli* isolates were resistant to moxifloxacin, 57.99% to ciprofloxacin, 49.07% to nalidixic acid, 17.47% to norfloxacin, 14.49% to levofloxacin and 8.55% to ofloxacin. Further, 150 (55.76%) *E. coli* isolates carried at least one of the three (*qnrS, qnrB, qnrA*) plasmid-mediated quinolone resistance (PMQR) genes tested. The *qnrS* was the most prevalent gene (53.90%), followed by *qnrB* (7.43%), while *qnrA* was not found in any of the isolates tested. Based on the Clermont *Escherichia coli* phylo-typing of 150 quinolone-resistant isolates, 66 isolates (44%) belonged to the phylogroup B1, followed by 23 (15.33%) isolates to phylogroup A, 23 (15.33%) isolates to phylogroup UN, 18 (12%) to phylogroup D, 13 (8.66%) isolates to phylogroup C, 3 (2%) isolates each to phylogroup B2 and F, and 1 (0.66 %) isolate to phylogroup E. The results suggest that *E. coli* phylogroups B1 and A harbouring plasmid-mediated quinolone resistance genes were predominant in seafood in Mumbai. The current study underlines the need to develop measures to reduce antibiotic-resistant *E. coli* contamination of coastal-marine waters from human and animal sources, ensure the safety of fish and shellfish for human consumption, and prevent the spread of antibiotic-resistant *E. coli* in the population.

Keywords: *Escherichia coli,* ESBL, PMQR, phylogroup, quinolones

Marine fishing methods in India: An Economic Analysis

Narayana Kumar, R.*, Shyam S. Salim, Raju, S. S., Aswathy, N., Shinoj, P., Swathilekshmi, P. S., Johnson, B. and Swatipriyanka Sen

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*ramani65@gmail.com

In the present study, the economic performance of the various fishing methods in selected centres across India was assessed using major economic indicators namely net operating income, capital productivity (operating ratio), labour productivity, input-output ratio and gross value added (GVA). The analysis of the economic performance (2022) revealed that at macro level, the net operating income was estimated at Rs.31,160 crores with an average capital productivity of 0.47. The GVA was estimated at Rs.43,420 crores (74.54% of gross revenue). In the mechanized sector, capital productivity was highest in case of multi-day trawl (MDT) operating from Digha, with the lowest operating ratio of 0.45. The labour productivity was the highest in Thoothur MDT operation, worked out at 1992 kg per crew per trip. The gross value added (GVA) as a percentage of gross revenue was highest from multi- day trawls in Kolachel at 68.56%. Among the motorized fishing units, the capital productivity was highest in *Discovala* operation from Chinthapalli The labour productivity was maximum in the operation of gill net at Mangalore at 367kg per crew per trip. GVA as % of gross revenue was the highest for gill net operating from Thoothur (90.69%) followed by *discovala* at Chinthapalli (88.61%) and motorized gill net from Kolachel (88.18%). In the non-mechanized sector, capital productivity was the highest in the non-mechanized thermocol boats (operating ratio of 0.38), followed by hooks and line from Chinthapalli (0.50) and Naravalai at Bandarvanipeta (0.51) and Bagnet at Petnakota (0.51). The labour productivity was highest in the operation of Naravalai at Bandarvanipeta at 20 kg per crew per trip. The gross value added as a percentage of gross revenue was the highest in non-mechanized hooks and line from Chinthapalli at 99.94% This was attributed to the owner operation. The results indicated that the profitability of the fishing operation isn't scale neutral and varied with the craft gear combination, area and season of operation. However, these economic indicators continued to reflect in developing concerted policy measures for the sustainable marine fisheries development while ensuring fisher welfare.

Keywords: Capital productivity, economics, Gross Value Added, marine fishing, profitability

Vulnerability of fishery-based livelihoods to climate hazards: Insights from small-scale fisher households in Kerala state

Aswathy, N.*, Athira, N. R., P. V. Sunil and Vysakhan, P.

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*aswathy.icar@gmail.com

Climate-induced natural disasters such as cyclones, floods, droughts, and other related hazards have been frequently affecting the coastal states of India in recent decades. Coastal fisher communities are highly vulnerable to climate change in view of their dependence on fishery-based livelihoods, depletion of marine resources, low resource possession, lack of fishing rights, and environmental hazards. United Nations Framework Convention on Climate Change (UNFCC) identified the state of Kerala along the southwest coast of India as one of the climate-vulnerable hotspots threatened by extreme events including sea level rise. The catastrophic cyclone Okhi in 2017 and flash floods in 2018 caused extensive damage to the lives and livelihoods of people in the state. There was a substantial reduction in the fishing effort and catch of the resources targeted by the small-scale fishers in the state in the past decade affecting their livelihood sustainability. In this context, an assessment of the livelihood vulnerability of small-scale fisher households to climate hazards in Ernakulam district of Kerala state was done. A composite livelihood vulnerability index (LVI) was developed based on the data from small-scale fisher households in two selected fishing villages. The LVI was constructed based on eight major components consisting of socio-demographic, livelihood strategies, health, water, food, natural and physical capital, financial capital, and social capital. Fisher households in Chellanam fishing village had significantly higher vulnerability (LVI-0.42) compared to Elankunnappuzha fishing village (LVI- 0.35). The study suggests that there is a need for developing alternate livelihood strategies and institutional credit access for improving the adaptive capacity and livelihood sustainability of small-scale fisher households.

Keywords: Climate hazards, Kerala, livelihood vulnerability, small-scale fishers

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Dried fish powder from *Stolephorus* sp. Improves health status of children: A nutritional study in tribal district of Odisha

Akshay, P.*, Joshy, C. G., Suseela Mathew, Gopika, R., Sajeev, M. V. and George Ninan

ICAR-Central Institute of Fisheries Technology, CIFT Junction, CIFT Road Matsyapuri, Willingdon Island, Kochi, Kerala 682029

*akshay.cift@gmail.com

Malnutrition and hunger remain as significant global challenge, impacting around 11% of the world's population and approximately 14.5% of India's national population. Inadequate consumption of high-quality protein, especially among younger populations, has been associated with stunted growth and has evolved a renewed interest in animal-derived foods. ICAR- Central Institute of Fisheries Technology in collaboration with WorldFish, a CGIAR organisation chalked out an approach to formulate dried anchovy fish powder, in order to incorporate into the daily diets of undernourished communities so as to improve their health and nutritional status. Fish is considered as a valuable nutritional source due to the presence of high-quality protein, omega-3 fatty acids, and essential vitamins and minerals that are promoting the nutritional requirement for better human health. The proximate composition and fatty acid profile of the dried fish powder from *Stolephorus sp* were examined wherein moisture, protein, ash, and fat were found to be 10%, 75.52%, 9.27%, and 14.43%, respectively. The poly unsaturated fatty acid content was found to be high, making the fish powder a good nutritional supplement for improving the brain and heart health. Further, *in vivo* studies were conducted to evaluate the bioavailability and nutritional benefits of dried anchovy powder in male Wistar rats. Histopathology assessment were also done to evaluate the tissue regenerative responses. The results from animal trails indicated that the group fed with dried fish powder exhibited superior feed conversion efficiency (4.82) and specific growth rate (1.92) compared to the control and standard diet groups, showing improved growth, enhanced lipid profiles, and improved liver function. Notably, fish powder-fed rats displayed collagen deposition in their liver tissue, suggesting a potential reparative response. Human trials in 50 anganwadies over a period of six months involving children in Mayurbhanj district of Odisha proved that the incorporation of dried fish in meal improved their health status significantly. In conclusion, to support with the results of *in-vivo* studies, incorporating fish into the diets can improve nutritional status of children, which can be considered as a step forward for sustainable nutritional development globally.

Keywords: Anchovy, dried fish, fish consumption, growth study, nutrition

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Exploring the Consumer Perceptions of Novel Fish Skin Leather Developed Using Discarded Fish Skins

Shubham Soni[1*], Arpita Sharma[1] and Martin Xavier[2]

[1]ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra, India
[2]ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

*shubhamsoni29@gmail.com

Demand for aquatic foods is on the rise and is expected to grow more and it is directly linked to the increasing fish waste across the globe. Fish waste has the potential to be adopted in the circular economy (CE), especially by employing the 'use waste as a resource' strategy. Notably, fish skins, comprising 3-10% of fish body weight, are often discarded and contribute to fish waste. Aligning with the CE strategy, ICAR-CIFE has developed a technology of developing a Novel Fish Skin Leather (FSL) using discarded fish skin waste. The tensile strength, tear strength, elongation percentage, and thickness of this FSL are per the standards recommended by the Bureau of Indian Standards. The objective of this study was to evaluate consumer perceptions of this FSL among various stakeholder groups which included leather professionals, textile designers, leather craftspersons, leather consumers and fisheries professionals. Adopting the standard protocols, the sensory evaluation of this FSL was assessed on visual, olfactory, auditory and tactile attributes. The assessment encompassed willingness to buy, potential product applications, overall liking and market acceptability. Respondents reported that they were willing to buy FSL and also suggested that they can prepare accessories and use it on garments. All sensory attributes had high to very high acceptance score. The tactile attributes had very high acceptance score (0.92), followed by visual attributes (0.86). Overall liking also had a very high score (0.84), market acceptability (0.81), product acceptance (0.8) and consumer acceptance had a score of 0.88. It was concluded from this study that FSL holds significant promise as a sustainable alternative in the leather and textile industries. The positive consumer perceptions, including willingness to buy and versatility of FSL in various product applications, underscore its potential to contribute to CE, achieve the sustainable development goals and reduce fish waste. Collaboration between the fisheries sector and fashion design industries can further promote the adoption of FSL, driving positive environmental and economic impacts.

Keywords: Circular Economy, consumer perception, fish skin leather, sensory evaluation

Novel fish-based products for better health and nutrition: Interventions among vulnerable population in India

Gopika, R*., Sajeev, M. V., Joshy, C. G., Akshay, P., A. K. Mohanty and Suseela Mathew

ICAR-Central Institute of Fisheries Technology, CIFT Junction, Willingdon Island, Matsyapuri P.O., Cochin-682029, Kerala, India

*gopikaremadevi17@gmail.com

Fish-based food systems have gained significant attention as a sustainable and nutritious source of food, particularly in regions with limited agricultural resources. Indian population often face challenges related to food security and nutrition due to their geographical location and limited access to diverse food sources. The ICAR-CIFT and WorldFish Centre, Malaysia has initiated a program focused on educating vulnerable communities about the nutritional benefits of fish-based products. The project targeted communities showing high incidences of anaemia and malnutrition residing in Wayanad, Dakshina Kannada, Cuttack and Ri-Bhoi across the states of Kerala, Karnataka, Odisha and Meghalaya. The project aimed to enhance the nutritional well-being of these communities by encouraging the consumption of novel fish-based products developed by ICAR-CIFT. Fish being an excellent source of high-quality protein, essential fatty acids, and micronutrients critical for growth and overall health; the primary objective of this program was to improve the nutritional status of adolescent children and women through increased consumption of fish and fish-based products. Prior to introducing the products, an acceptability survey was conducted to assess the initial receptiveness and willingness of the target population towards the proposed fish-based products. The activities included awareness cum training and demonstrations to provide an insight into the nutritional benefits of fish-based products as food and its role in ensuring nutritional security particularly that of adolescent girls and women. A pilot intervention programme was initiated in Cuttack district, Odisha over a duration of two months involving 50 participants. During this period, each participant was provided with a pouch containing 15 g of specially formulated CIFT dry fish powder, which they consumed daily for the two-month period. The study closely monitored and recorded the changes in the participants' Haemoglobin (Hb) content at regular intervals. Following the intervention with CIFT dry fish powder, a notable enhancement in the Hb content was observed. Overall, the program showcased potential of fish-based products in addressing malnutrition. By empowering adolescent children and women through nutritional education and economic opportunities, the program contributed to improved well-being and resilience in communities. The lessons learned from this intervention are now utilised for conducting similar programmes in three other states. The project outputs can empower future initiatives seeking to leverage local resources for alleviating malnutrition.

Keywords: Fish-based products, intervention, malnutrition, vulnerable communities

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Stakeholder consultative process in participatory social impact analysis and beneficiary assessment in project evaluation

D. Rajasekar[1]* and J. Yogalakshmi[2]

[1]Forest Conservation Official and Expert Consultant, GRGS
[2]Tamilnadu Agricultural University, Coimbatore, Tamil Nadu, India

*rajasekar.ifs@gmail.com

Project formulation, midterm appraisal, post evaluation necessarily involves people's participation in terms of stakeholder's consultation, beneficiary analysis and recording their feedback through impact analysis. The recording of feedback in impact analysis in social development brings out the contingency or mitigation plans and also paves way to inclusive decision making process. Beneficiary analysis is an extension of Economic Rate of Return Analysis that seeks to disaggregate the total increase in income to determine specifically which segments of society will benefit from the proposed activities, sheds light on the merits of proposed investments in terms of promoting significant reductions in poverty and helps in identifying preferred alternatives. The Beneficiary Assessment (BA) approach focused on gaining insights into community perspectives through interviews and group discussions at community level, by working with members of similar communities to get qualitative and participatory assessments provided by the people who are directly affected. BA involves systematic consultation with project beneficiaries and other stakeholders to help them identify and design development activities, signal any potential constraints to their participation, and obtain feedback on reactions to an intervention during implementation. It is an investigation of the perceptions of a systematic sample of beneficiaries and other stakeholders to ensure that their concerns are heard and incorporated into project and policy formulation. BA undertake systematic listening, which "gives voice" to poor and other hard to reach beneficiaries, highlighting constraints to beneficiary participation, and obtain feedback on interventions. It involves in depth conversational interviewing around key themes or topics, focus group discussions and direct observation and participant observation. BAs are approaches in which the participatory process can begin with systematic and continuous tracking of action sponsor/beneficiary attitudes from identification through preparation to implementation of a project. Ordinarily, BAs are carried out by local people under the direction of a trained team leader or social scientist. The Steps in Beneficiary Assessment are familiarization, study design, selection and orientation of local interviewers, study, preparation of the BA report. In terms of shrimp farming in Andhra Pradesh, BA involved identification of Beneficiaries, Characterization, Needs Assessment, Economic Impacts, Environmental Considerations, Community Engagement, Regulatory Compliance, Health and Safety, Long-Term Viability and capacity building *etc.*

Keywords: Beneficiary Analysis, impact Analysis, participatory social impact analysis, steps in beneficiary assessment, stakeholder consultation

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Quantifying Women's Empowerment in Aquaculture: A Study in Jagatsinghpur, Odisha

Sarita Das[2], Biswajit Sahoo[1], Saha, G. S.[1] , Mahapatra, A. S.[1], Mohanty, U. L.[1], De, H. K.[1] and Rath, D. P.[1]

[1]ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha, India
[2]KrishiVigyan Kendra, Jagatsinghpur, OUAT, Bhubaneswar, Odisha, India

gssaha63@gmail.com

Women's empowerment involves establishing a supportive environment that enables women to independently make decisions that not only benefit themselves but also contribute positively to society. The study revealed the assessment of women's empowerment in aquaculture-related occupations in Jagatsinghpur, Odisha, using the Women Empowerment in Aquaculture Index (WEAI). A total of 98 women from nine randomly selected women self-help groups were interviewed using a structured questionnaire. The study examined the relationship between various socio-economic factors and empowerment levels, identifying significant correlations with participation in extension activities, training and innovativeness, at ($p<0.01$) level of significance. It indicated that women who were more innovative and actively engaged in extension activities and training programs tends to be more empowered. Additionally, "social participation" was found to be significantly associated with empowerment at ($p<0.05$) significance level. Regression analysis revealed that 53.9% of the variation in women's empowerment levels could be explained by factors such as annual income, utilization of information sources, social participation, participation in extension activities, training, and innovativeness. Furthermore, women empowerment level of 9 SHGs also measured using WEAI which has 30 items under 6 domains (access toand control over resources and services, ability to decide independently, attitude towardsaquaculture, control over use of income, knowledge on aquaculture, and participation in socialand economic activities). Women's empowerment levels varied widely among self-help groups (61% to 95%), with notable disparities in various domains. Among the constraints that limit women's involvement in aquaculture were non-availability of larger-sized fingerlings, insufficient financial support from government organizations, and a lack of knowledge regarding recommended practices.

Keywords: Aquaculture, empowerment, Self-Help Group, WEAI

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Risk sharing and informal credit transactions in marine fisheries: Implications for policy

Suresh, A.*
ICAR-Central Institute of Fisheries Technology, Cochin-682 029, Kerala, India
*sureshcswri@gmail.com

The developmental efforts to deepen the formal credits in marine capture fisheries is rooted primarily on the "exploitative" nature of the informal credit. The political state has tried to wean out the market power of the auctioneer-lenders through deepening formal credit through self-help groups, cooperatives, commercial banks etc., but without much success. The nature of credit transactions has implications on the welfare of fishers, and, therefore, has policy relevance. In this backdrop, the present paper investigated the nature of credit transactions in artisanal marine fishing, and the role of risk-sharing in the continued presence of informal credit by examining the case of Kerala state, on the south-west coast of India. The study used primary data collected from 100 traditional fishers from Ernakulam district. The results indicated that 81% of fishers avail credit. The multiple credit sources were auctioneers (67%), commercial banks (43%), relatives and private parties (59%), non-banking financial agents like chitties/curries (47%), Matsyafed (37), money lenders not engaged in fisheries (17%), regional rural banks (6%) and co-operative banks (2%). About 48% of fishers availed credit from more than two sources. The mean credit availed was Rs 0.71 million and the mean credit outstanding was Rs 0.25 million (based on those who availed credit). The role of auctioneer-lenders was encompassing as it affected output markets as well. The loanee fishers perpetually shared 5-10% of their revenue to these auctioneer-lenders. The study noted interlinked transactions between credit and output markets and between credit and labour markets, segmentation of the credit market, credit rationing, and interest rate variations. The continued existence of informal credit relations interlinked with output marketing was explained by the risk-sharing mechanism. Through the interlinked transactions, while the fishers shared the income risk with the auctioneer-lenders, the auctioneer-lenders shared the risk of the low volume of fish to be transacted through him/her. The relations were cemented by the "trust" element in society, which maked violations costly. The regression analysis indicated no systematic variation in the credit availed, except for the type of vessels- the larger the vessels, the bigger the credit availed. The study suggested policies to deepen the formal credit flow by incorporating the risk elements in the credit products and bundling credit and insurance to provide risk coverage.

Keywords: Fishery credit, fishery insurance trust, inter-locked transactions

Biodiversity – Environment impact and participatory social impact assessment for certification of shrimp farming in coastal region of Andhra Pradesh

Rajasekar, D[1]. and Yogalakshmi, J.[2]*

[1]Forest Conservation Official, Punjab and Expert Consultant, GRGS
[2]Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

*assessments@greenranks.com

Andhra Pradesh is the leading shrimp producer, accounting for more than 50% of the total output with economic interventions and major activity of aquaculture farms in the coastal areas. The state is endowed with suitable climatic conditions and ample water resources fed by evergreen Krishna and Godavari, besides a long coastline of 974 km for aquaculture and ably supported by Governmental interventions in terms of supply of water, electricity and others. Shrimp farming presents various opportunities for biodiversity conservation such as siting of farms not in natural mangrove occurring areas and away from its natural habitat without encroaching its territory, new habitat creation, better alternative livelihoods, technological innovation with few constraints such as occasional change in land use pattern from agriculture to aquaculture, pollution, disease transmission, overuse of resources, fluctuating market demand *etc*. The criteria for screening of the farm was done in consultation with local stakeholder's interaction in addition to verification from maps, records and also triangulation in the farm location. The siting of the farm was analyzed with respect to coastal, riverine, estuarine, drains and mangrove barriers and its distances from the farm in question. The criteria and indicators were analyzed during assessment of sites for its suitability to become eligible for certification in addition to impact assessments through interviews with stakeholders including the Government agencies such as Forest, Village Panchayat, MPEDA *etc*. The social impacts by the farm and its location were analyzed in terms of employment, wages, non-discrimination, equal opportunity to use natural and man-made resources by all and access to other facilities. The standard of living, education levels and the improvement in livelihood income were analyzed using the participatory tools of stakeholder's consultation methods in the farm. The results were also shared with them and discussions were held with respect to any kind of conflicts in terms of over exploitation of resources, denial of access of facilities or pollution or any kinds of discrimination in the farm. The conflict resolution mechanism and the facilities extended to the workers were recorded during interviews with all the stakeholders. The paper describes the methods of assessing the positive and negative impacts on biodiversity, environment, society and economy of the rural areas through livelihood analysis and the impacts were drawn and reported through matrix and mitigation plan in cases of contingencies and unforeseen circumstances. It gives recommendations for best management practices for long term sustainability.

Keywords: Biodiversity, coastal Aquaculture, Environment Impact Assessment, Participatory Social Impact Assessment, shrimp farming

Value added fish products: A potential alternative for livelihood improvement & entrepreneurship development in Northeastern region of India

Amjad K. Balange*[1], Martin Xavier[2], Layana, P[2]., Deepjyoti Baruah[1], Lohit K. Baishya[1] and Arpan Bhowmik[1]

[1]Animal, Poultry & Fisheries Sciences Division, ICAR-Indian Agricultural Research Institute (IARI), Gogamukh, Dhemaji district, Assam
[2]ICAR-Central Institute of Fisheries Education (CIFE), Panch marg, Off Yari Road, Mumbai, Maharashtra

*Amjad.Balange@icar.gov.in

"Value addition" is nowadays a buzz word which means converting a low-cost raw material into more convenient, safe, and appealing product with a better price. Fish is not an exception and many value-added products are prepared from the low-cost fish. Fish is known for its health benefits with high quality proteins, fats, minerals, and vitamins. Therefore, value added fish products are also rich in health beneficial nutrients. The standardized recipes, protocols and quality standards are now available for different types of value-added fish products. The North East hilly region has immense fisheries resource in the form of reservoirs, tanks and ponds, beels, oxbow lakes and other derelict waters covering 4.18 lakhs ha water-spread area in addition to rivers and streams which is about 20,875 km. The two major riverine systems i.e. Brahmaputra and the Barak with their tributaries make this region blessed with such vast and varied water resources for fisheries. Though many research works and initiatives are taken up for increasing the fish production from this area, works related to value added fish products are limited. Therefore, an attempt has been made to demonstrate value-added fish products preparation for promoting the entrepreneurship development in this area. Training programs were conducted in the seven sister states of North East Hilly region of India for imparting necessary skills in preparing value added fish products to fisherwomen, unemployed youths and women self-help groups. However, it was observed from the feedback of trainees that merely imparting training is not sufficient as they need initial capital and operational support to start their enterprise. Therefore, a pilot plant of 200 kg capacity of value-added fish product per day was established at Guijan Village, Tinsukia district of Assam. Now this has become a common facility for the local fisher folks, women self-help groups and unemployed youths in that locality who were imparted necessary skills in preparation of value-added fish products. They can bring their low-cost fish in the facility and prepare their value-added fish products for their livelihood. Similar kind of pilot plants can be replicated throughout North Eastern (NE) hilly region for increasing the production of value-added fish products and doubling the income of stake-holders in NE region. As the per capita consumption of fish is high in the NE region and its vast fisheries resources, explores the immense potential for value added fish products in the NE region for livelihood generation.

Keywords: Livelihood generation, North East India, skill development, value added fish products

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Import rejections of Indian seafood products in international markets – Trends and causes

Sachu Sara Sabu* and Suresh, A.

ICAR-Central Institute of Fisheries Technology, Cochin-682 029, Kerala, India

*sachuss15@gmail.com

As a major producer and exporter, India continues to record an impressive trade surplus in seafood products. Nevertheless, raising consumer concerns about seafood safety and quality, and increasingly stringent regulatory standards raised the unit cost of export through increased cost of compliance. Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT) are the major instruments by which countries regulate and restrict the fish trade. The present study was focused on import standards of fish and fish products in international markets, and status and determinants of import rejections of Indian fish products. Data on import standards and import rejections of Indian seafoods from 2010 to 2020 were collected from ITC market access tool and UNIDO trade compliance database. Unit Rejection Rate (URR), Relative Rejection Rate (RRR), and percentage analysis were carried out to find the magnitude and determinants of import rejection by major importers. Some of the significant import rejections Indian fisheries sector faced are veterinary drug residues, bacterial contamination, heavy metal, hygienic condition, labeling, packaging, pesticide residues, and additives. Among these reasons of import rejections, more than 80% of import rejection was due to veterinary drug residues, hygiene failures and bacterial contamination. Indian exporters suffered rejections in the regions averaging 150 consignments per year. The rejected consignments had averaged an annual value of about USD 2.5 million. The rate of rejections (per million dollars of trade) varied quite substantially from year to year (by a factor of 10 in some cases) but had averaged 0.3 rejections for every USD 1 million of exports. URR of Indian fish exports declined and were 0.06, 0.026, 0.01 and 0.02 for USA, EU, China and Japan, respectively with higher RRR for imports from Vietnam at EU and Japan. Indian fish rejections at the USA were higher than EU and Japan. Bacterial contamination causes dominated the rejections by USA. Chemical was the major cause for rejections at EU and Japan. Results suggested significant improvement in the quality compliance of Indian fish exports. The study analysed the initiatives undertaken by Indian sea food industry to comply with quality regulations and the institutional supports thereof. The study finds an affirmative role of the industry and the institutional supports by government and research organisations in enabling compliance with the regulations.

Keywords: Import standard, import rejection, rejection rate, seafood safety

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Impact of rising fuel prices on gillnet and longline fishing Vessels' operations at Thoppumpady Fishing Harbour, Kerala

Chandrasekar, V*., Suresh, A., Geethalakshmi, V. and Nikita Gopal
ICAR-Central Institute of Fisheries Technology, Kochi-682 029, Kerala, India
*vcsecon@gmail.com

Gillnet and longline fishing operations are prominent fishing gear methods utilized along the Indian coast. This study examines the influence of increasing fuel prices on the operations of gillnet and longline fishing vessels at Thoppumpady Fishing Harbour in Kerala. Detailed operational data and catch information were collected from 20 gillnet vessels and a longline fishing vessel, encompassing 200 fishing trips. The average fuel consumption pattern per fishing trip and the frequency of visits by fishing boats at Kochi fishing harbor in the same time period were also analyzed. Diesel prices during this period ranged from 66 to 72 Rs/liter. Fuel costs constitute a significant portion of fishing operations expenses, accounting for approximately 63% of the total operational expenditure. The study found a negative correlation between coefficients and diesel price variations, indicating that fluctuations in fuel prices can have a profound impact on the fishing industry's profitability and sustainability. Economic analysis revealed that a one-rupee increase in diesel prices resulted in a subsequent increase in the cost of approximately Rs. 4093 per trip in total operational expenditure for fishing vessels. This upward trend in fuel prices poses a substantial challenge to the profitability of fishing operations, placing an increased financial burden on fishermen and potentially leading to reduced profit margins or even financial losses. Furthermore, higher fuel costs may discourage fishermen from embarking on longer fishing trips or exploring new fishing grounds, ultimately causing a decline in catch volumes. This has been affecting the livelihoods of fishermen, their families, crew members, and input suppliers, as well as the overall economic stability of the fishing community. To mitigate the adverse effects of rising fuel prices, various strategies can be pursued, like adoption of fuel-efficient technologies, exploration of alternative energy sources.

Keywords: Fuel price impact, gillnet and longline fishing operation, profitability, sustainability

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Fish Consumption in India: Evidence from Indian households

Rajesh, I. D.* and Suresh, A.

ICAR – Central Institute of Fisheries Technology, Cochin-682029, Kerala, India.

*rajeshid312@gmail.com

Fish is one of the important sources of animal protein compared to most other options. Studies have shown a consistent increase in fish consumption among Indian households from 1987-88 to 2009-10. In light of this trend, this study primarily investigated the fish consumption behavior of Indian households using data from the 68th round of the consumer expenditure survey (2011-12) and its social and economic correlates. The analysis revealed that a higher percent of rural households consumed fish than their urban counterparts, exceeding the national average. The share of average monthly per-capita fish consumption in total food consumption was 10.5% at the national level, slightly higher in rural areas (10.52%) compared to urban areas (10.45 %). Further, a greater proportion of households in certain states in the North-East region and South India consumed fish. The empirical model indicated that a household's fish consumption increased with the age of the head of the household, higher income (captured by monthly consumption expenditure), and larger household size. Additionally, compared to general caste, other castes households exhibited higher odds of consuming fish. The household's religious background was also correlated with fish consumption decisions. Overall, the result suggested that social and economic backgrounds along with geographical locations had a significant correlation with the fish consumption decisions of the households.

Keywords: Fish consumption behavior, fish demand, income elasticity, nutritional security

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Occupational hazards faced by marine fish retailers in the coastal state of Odisha, India

Suchismita Prusty* and Arpita Sharma

ICAR- Central Institute of Fisheries Education, Versova, Mumbai-400 061, Maharashtra, India

*suchismita.fexpa903@cife.edu.in

Occupational hazards (OH) are the hazards which arise in or from the workplace that could impair the health and well-being of workers. In fisheries sector, women are mainly active in post-harvest activities. Women's participation as fish retailers and their work related injuries were reported in states like Gujarat, Maharashtra, Kerala, Karnataka and Tamil Nadu. However, this kind of study, in one of the leading maritime states of India *i.e.* in Odisha is lacking. To address issue, a study was undertaken with an objective to analyse the fisheries activities and occupational hazards faced by marine fish retailers. In the present study, information was collected from 120 marine fish retailers (60 fresh and 60 dry fish retailers) from coastal districts Puri and Ganjam. The information was collected by employing an interview schedule with each participant and to collect information on ergonomic related Musculoskeletal disorders (MSDs) a standardized Nordic Musculoskeletal Questionnaire (NMQ) was used. The study found that the average age of fresh fish retailers was 45 years and 43 years for dry fish retailers. Daily fisheries activity chart revealed that, the fresh fish retailers were involved in collection of fish from landing centres, sorting of fish, commuting to the fish market, cleaning of fish and selling. The activities of dry fish retailers were collection of fish from landing centres/wholesalers, sorting, commuting to fish market, cleaning, salting, drying and selling. The average time spent on retailing related activities found that marine fresh fish retailer spent 13 hours per day and dry fish retailer spent 14 hours/day. Maximum time *i.e.*, 8 hours per day was taken up in fish selling activity. Study on occupational hazards found that the retailers faced mainly two major occupational hazards *i.e.* Physical and ergonomic hazards. In physical hazard, they reported some of physical injuries such as cuts (83%), sunburns (53%), pricks from spines (66%), falls due to slippery surface (37%). Nordic assessment showed that MSDs prevalence in marine fish retailers were, in the neck (60%), back (66%), elbow (47%), upper back (56%), lower back (68%), knee (80%) and thighs (78%). This is because uncomfortable body postures, as well as repetitive movements, are adopted for long periods of time and becomes the cause of musculoskeletal disorders and body pains. Fish retailers can take the benefit of Government health schemes like Pradhan Mantri Jan Arogya Yojana (PM-JAY), Aam Admi Bima Yojana (AABY), Rashtriya Swasthya Bima Yogana for which awareness programmes are required.

Keywords: Ergonomic, fish retailer, musculoskeletal disorders, occupational hazards, physical hazard

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Eco-tourism Initiatives in the mangrove and coral reef areas of the Gulf of Mannar and Palk Bay- An outlook

Saravanan, R.*, S. Thirumalaiselvan, Rajkumar, M., Syed Sadiq, I. and Sikkander Batcha, S. M.

Mandapam Regional Centre of ICAR-CMFRI, Mandapam Camp-623 520, Tamil Nadu, India

*saravanan.r@icar.org.in

The Gulf of Mannar and Palk Bay, bordering the southeast coast of Tamil Nadu state in India, support a wide array of ecosystems, both marine and terrestrial. There are ecologically and biologically sensitive areas located along the coast starting from Point Calimere to Kanyakumari, *viz*., Muthupettai lagoon, Point Calimere Sanctuary, mangrove forest, seagrass ecosystem, coral reef ecosystem, and wetland ecosystem, etc. The Palk Bay region supports a wide range of seagrass meadows, and its dugong population makes it one of the most important areas for protection with scope for tourism potential like dugong watching, similar to whale shark watching. However, four places along Palk Bay and the Gulf of Mannar have been identified and promoted for ecotourism with stakeholder participation *viz*., Karangadu Mangrove, Kurusadai Island National Park Safari, Tharuvaikulam Coral Reefs, and Pichaimoopanvalasai Manal Thittu are some of them. These community-based ecotourism initiatives of the forest department attract considerable tourism, most prominently to Kurusadai Island, where the National Park Safari attracts more visitors due to its proximity to Rameswaram. These initiatives, which started in 2022, need to be monitored to understand how they help or hinder the ecosystem on which they depend and to formulate further guidelines for sustainable management in the long run.

Keywords: Ecotourism, Gulf of Mannar, Palk Bay

Theme: Aquaculture & Fisheries-based Transformation of Food Systems
Sub theme: Processing, Value Addition, Quality Control & Social Sciences

Fish demand paradigms and perspectives across Telangana, India

S. S. Raju*, Shyam S Salim, Charles J. Jeeva, Athira, N. R. and Akhil Reddy

ICAR-Central Marine Fisheries Research Institute, Post Box No.1603, Ernakulam North P.O., Kochi -682018, Kerala, India

*ss.raju@icar.gov.in

The fish supply in the country continues to show unprecedented growth over the last two decades. However, the fish demand exhibits wide variation across/ within the different states, seasons, and species. The present paper attempted to assess the pattern of fish consumption and its attributes in Telangana. The study was conducted across the different locales *viz*., inland urban (Hyderabad, Ranga Reddy, Warangal and Vikarabad) and inland rural (Mahbubnagar, Medak, Medchal and Gadwal) districts utilizing with a pre-tested schedule. A total of 720 consumption households were covered for the study. Purposive random sampling method was used for choosing the respondents. Different statistical and econometric tools were deployed for analyzing the data. The consumer profile revealed that 80 percent of the respondents were of middle age group (20-50 years) with primary education (40%). More than 90 per cent consume fish on a regular basis. Based on the conjoint analysis results, the outcome revealed that the fish consumption increased over the years on account of better fish availability (53%), accessibility (45%) and affordability (38%). The fish accessibility revolved around one to two km radius as opined by all the consumers. The preference index indicated that Rohu was the most preferred species followed by Murrel and Catla. The discriminant analysis results indicated that quality is the most significant discriminant factor describing the major driving force of the fish consumption followed by nutrition etc. The constraints in fish consumption as perceived by the consumer's indicated that irregular supply, high price, wide fluctuations in price, poor access to buying and lack of fresh preferred fish served as limiting factors in augmenting fish consumption. The study revealed that there exists a scope to improve the fish consumption in the state through concerted efforts in creating awareness, developing infrastructure, and imitating value addition.

Keywords: Conjoint Analysis, Discriminant Analysis, fish consumption, inland, Preference Assessment Index, Telangana

XVI AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 7

Nature-based Solutions for Sustainable Agri-food Systems

Water Harvesting and Enhancing Water Productivity

Soil Health and its Restoration

Ensuring Nutritional Security through Natural Resource Management

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Water Harvesting and Enhancing Water Productivity

Bio-drainage systems in the food industry: Concept and design for zero discharge production unit

Manoranjan Kumar*, Rao, K. V. and Vinod Kumar Singh

ICAR-Central Research Institute for Dryland Agriculture, Santosh Nagar, Hyderabad—500 059, Telangana, India

*Manoranjan.Kumar@icar.gov.in

Minimization of Water pollution from food processing plants is one of the major concerns in the era of climate literacy and sustainable development goals. The discharge of pollutants, waste, and by-products from the operations of food processing plants in the forms of suspended solids, chemical contaminants, non-biodegradable substances as well as pathogenic microorganisms are the major source of contamination of water bodies, such as rivers, lakes, and groundwater. Such pollution has significant economic, sociological, environmental, and ecological implications as it adversely affects several SDGs (sustainable development goals) such as SDGs 6, 9, 12, 13, 14, 15, and 17. SDG 6 aims to clean water and sanitation remain the most important aspect of minimization of water pollution. Zero-discharge food production unit refers to industrial facilities within the food and beverages sector that operate with the major objective of eliminating discharge into local water bodies by fulfilling the principle of sustainability. Such zero-discharge production units were conceptualized and designed for Frigerio Conserva Allana Pvt Limited (FCAPL), an export-oriented Food Processing unit spread over 112 acres of land in the Industrial Development Area (IDA), Algole Road, Zaheerabad, Telangana. The product profile includes Tropical Fruits pulps, Vegetables, Frozen Meat, and Marine foods. The plant mainly produces frozen buffalo meat with a production capacity of 700 TPD (tonnes per day). The existing water balance of the plant includes the daily water discharge combined from the processing plant and residential complex is about 700 Kilo-litre per day (KLD) which is received by ETP. This water is treated by the ETP out of which 300 KLD is recycled back for plant operations and the remaining 400 KLD stored in the existing reservoir/pond for further use as irrigation water to the various plantations. During, monsoon specifically, the runoff generated from the roof as well as surface flow is either collected in the different unlined pond or disposed-off from the FAPCL complex to the downstream through storm drain. The present system was unable to handle all the water generated by means of either runoff or affluence and thus became a major environmental concern, particularly with respect to groundwater in the downstream areas. The entire soil moisture conservation plan and plantation schemes were conceptualized and developed to achieve the Zero Discharge Concept at the FAPCL complex through two main interventions, (i) surface and roof-top runoff management and (ii) management of evaporation and transpiration systems. The surface and rood-top runoff management includes the development of a water storage tank to store 32,000 m^3 of runoff water. The Trench-cum-bunds (TCBs) are designed to conserve about 6000 m^3 of water *in situ* and facilitate the hybrid napier cultivation for internal consumption. The paired row Corymbia plantation scheme in 44.6 ha is designed to transpire about 350-700 KLD. Thus, the zero-discharge production unit was designed considering safe storage in ponds/reservoirs, releasing the excess water into the atmosphere through evaporation from ponds and transpiration by augmented vegetation.

Keywords: Augmented vegetation, Bio-drainage, Corymbia plantation, Zero discharge

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Water Harvesting and Enhancing Water Productivity

Need for ecosystem approach for water quality management in Mangaluru, south India

Bindu Sulochanan* and Veena Shettigar

ICAR–Central Marine Fisheries Research Institute, Mangalore Regional Centre, Hoige Bazar, Mangaluru-575 001, Karnataka, India

*bindu.sulochanan@icar.gov.in

Mangalore City urban agglomeration covers an area of 132.45 km^2. Equitable water sharing, could reduce competition among diverse stakeholders and thereby protecting the fragile coastal ecosystem. A baseline study was carried out from Nov 2017- Feb 2020 to assess the water quality of Netravati and Gurupura estuary in five stations on a monthly basis. In addition, two wells water quality was monitored one each at the tail end of the estuary. The indicators for assessing estuarine stations were dissolved oxygen (DO, mg l^{-1}), dissolved inorganic phosphorus(DIP, mg l^{-1}), dissolved inorganic nitrogen (DIN, mg l^{-1}), and chlorophyll a. These indicators were assessed, based on the estimation of water samples using standard analytical methods (APHA, 1981) for DO, dissolved orthophosphate, reactive silicate, NO_2-N, NO_3-N, total NH_3-N and chlorophyll a,b,c. The results obtained were compared with the corresponding baseline range concentrations of the National Coastal Assessment Report (USEPA, 2012). It was observed that in Netravati and Gurupura estuarine stations 78.55% and 71.8% of water quality was rated Fair respectively, taking into consideration all indicators. The water quality for the remaining was rated Poor as no Good rating was observed during the period. The well water quality acceptable for drinking in the tail end of Gurupura River based on the permissible limit for the parameters was pH (100%), TDS (10.7%), Chloride (75%), NO_2-N (85.7%) while NO_3-N and NH_3-N was100% respectively. In the Netravati River tail end it was pH (25%), and TDS (85%), while for Chloride, NO_2-N, NO_3-N, and NH_3-N the quality was 100% acceptable. ANOVA showed a significant difference ($p<0.001$) for parameters pH, TDS, Salinity, Chloride, dissolved orthophosphate, and Nitrate ($p<0.01$) between the two wells. The pH ranged between 5.48-8.43, Salinity 0-0.9 ppt, chloride 0-498.16 mg l^{-1} and TDS 225-1835 mg l^{-1} in the wells. Pearson's correlation showed a negative correlation ($p<0.001$) between rainfall and water temp, salinity, and TSS and was positively correlated with DO, NH_3-N, Si O_3-Si, and NO_3-N. Between estuarine stations significant difference ($p<0.001$) was observed in Atm temp, dissolved oxygen, pH, DIP, and reactive silicate. In well water, there was no significant correlation between rainfall and parameters indicating that the influence is mainly due to the groundwater inflow from the estuaries. The importance of effective water resources management is especially significant for public health benefits, especially in light of the anticipated impacts of climate change in the nearshore coastal ecosystem.

Keywords: Coastal ecosystem, estuary, Rainfall, Water quality

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Water Harvesting and Enhancing Water Productivity

Contextualizing nature-based solutions for sustainable sewage treatment in traditional urban water bodies to promote urban agriculture in Madurai, India

Lokesh, S*, Elamuhil, S. and Praveen Kumar, S.
DHAN Foundation,1A, Kennet Cross Road, Madurai – 625 016, Tamil Nadu, India
dhancure@dhan.org

Urban agriculture plays a pivotal role in addressing the pressing global challenges of food security and productivity, ensuring that underserved populations have direct access to fresh, nutritious produce. Nevertheless, urban agriculture faces significant challenges, including alterations in land use and land cover (LULC) patterns, heightened runoff, community ownership, and contamination of water bodies by sewage. These obstacles loom large in the realm of urban agriculture. Conversely, cities serve as reservoirs of sewage, and when appropriately treated, this wastewater resource becomes a substantial boon for urban agriculture. In this context, Nature-Based Solutions offer a cost-effective and environmentally friendly approach to sewage treatment. Natural forces, including chemical, physical, biological, and solar processes, are harnessed to achieve wastewater treatment. Madurai, the third-largest city in Tamil Nadu, boasts a rich heritage intertwined with water management. The agrarian community, reliant on their observations and wisdom, developed tank technology to conserve water during monsoon showers. However, water bodies in the region are contaminated by sewage from various sources. Madurai, generating approximately 97.93 million liters per day (MLD) of sewage, treats only 26 MLD, even though it possesses a combined Sewage Treatment Plant (STP) capacity of 172 MLD. Consequently, rivers, channels, and tanks like the Vaigai River, Sattiyar River, and chain of tanks are exposed to untreated sewage, with even irrigation channels carrying sewage instead of river water and stormwater. In response to these challenges, the DHAN Foundation contextualizes Nature-Based Solutions for Sewage Treatment in Kathiyanoor tank, Madurai, India, to promote Urban Agriculture. To ensure the successful implementation of NBS, contextualizing the technology is crucial. The project includes experimenting with different combinations of floating wetlands, free surface flow wetlands, submerged aquatic plants, and native and exotic species. This paper highlights the critical need for sustainable sewage treatment in urban water bodies, the Amount of harvested water utilised for urban agriculture, and the yield gained by the urban farmers with a particular focus on Madurai, India. It explores the potential of nature-based solutions, especially wetlands, in mitigating sewage pollution and improving water quality, emphasizing the importance of context-specific experimentation and integration with existing infrastructure.

Keywords: Nature-based solutions, Sewage treatment, Urban agriculture

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Community-level physiological profiling of soil microbial communities under varied salt loads

Madhu Choudhary[1*]., Hanuman S Jat[1,2]., Rakesh Kumar[3]., Sanjay Arora[4]., Yadav and R. K[1]

[1]ICAR- Central Soil Salinity Research Institute, Karnal -132 001, Haryana, India
[2]ICAR-Indian Institute of Maize Research, Ludhiana- 141 004, Punjab, India
[3]ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India
[4]ICAR-CSSRI Regional Research Station, Lucknow-226 002, Uttar Pradesh, India

*madhucssri@gmail.com

Salt affected soils (SASs) are distributed globally and leading to huge losses of agriculture production systems. Limited information is available on changes in microbial activities and their functional diversity under different types of SASs and their relation with soil physico-chemical properties. A micro plot study with five types of soils- highly saline, moderately saline, highly sodic, moderately sodic and normal was conducted to evaluate the impact of salt type and load on soil physical, chemical and biological properties. To understand the changes in soil biological properties in relation to salt concentration surface (0-15 cm) and subsurface (15-30 cm) soils samples were evaluated. Higher pHs, CEC, and ESP were observed in sodic soils (10.04, 10.19 cmol kg^{-1}, and 76.15) while higher EC_e was found saline soils (13.53 ds m^{-1}). In the surface layer significantly higher concentration of Na^+, Ca^{2+} and Mg^{2+} was observed under highly saline soils (151.71 me l^{-1}, 11 me L^{-1} and 47.83 me L^{-1}) whereas the concentration of CO_3^{2-} and HCO_3^- found significantly higher under highly sodic soils (2.17 me L^{-1} and 11.28 me l^{-1}). The OC content was found to be highest under normal soils (0.67% and 0.52%) followed by moderately sodic soils (0.34% and 0.38%). Highly saline soils showed highest BD (1.65 g cm^{-3}) in the surface layer followed by moderately saline soils (1.59 g cm^{-3}). Infiltration rate was highest in normal soil (0.21 cm h^{-1}) followed by moderately saline (0.19 cm h^{-1}) and highly saline soils (0.17 cm h^{-1}). Lower bulk density (1.40-1.55 g cm^{-3}) and higher infiltration (0.21 cm h^{-1}) rate in normal soils shown its good physical health over SASs. In surface layer average well color development (AWCD) was higher than subsurface and increased with incubation period. In surface layer diversity index H was found highest (3.19) in normal soils followed by moderately saline (2.82), moderately sodic (2.67), highly saline (2.49) and lowest in highly sodic soils (1.57). Enzymatic activities (DHA, ARLS and invertase, etc.) and bacterial and fungal populations were found to decrease with increasing in salt load. The study suggested that poor soil physio-chemical and biological conditions are correlated with salt load therefore studies on the soil physicochemical and biological properties must be carried out for recommendation on land use, reclamation strategies or nutrient management practices in a long run to fulfill the UN's Sustainable Development Goals.

Keywords: Enzyme activities, Saline soils, Salt affected soils, Sodic soils, Substrate utilization, Well colour development,

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Cut-soiler assisted subsurface sodicity reclamation increases rice-wheat yield in Indo-Gangetic plains

Manisha, Gajender Yadav*, Rajender Kumar Yadav, Arvind Kumar Rai, Virender Singh Hooda, Govind Prasad and Junya Onishi

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana, India

*Gajender@icar.gov.in

In the northwestern part of the Indo-Gangetic Plains (IGP), India, sodic soils occur due to clay illuviation, and deposition of pedogenic calcium carbonate under semiarid climate. This impairs the hydraulic conductivity of soils and eventually leads to high exchangeable sodium percentages in subsurface layers of soil. This anticipated reduction in crop productivity and the unappreciable crop management practices of burning straw, and injudicious use of sodic water also recur subsurface sodicity in the in IGP where rice-wheat cropping system is predominantly followed. To resolve the twin problem of subsurface sodicity and residue burning, the Cut-soiler assisted placement of soil amendment (gypsum) at sub surface along with surface rice residue is a potential technique is being tested under ICAR-Central Soil Salinity Research Institute (Karnal) and the Japan International Research Centre for Agricultural Sciences (JIRCAS) collaborative project. The Cut-soiler placement of gypsum and rice residue was simulated in a column study to evaluate its reclamation effect on sub surface sodicity and subsequently on rice wheat yield. The treatments consisted surface application of gypsum (SA), surface and sub-surface placement (50 cm below the surface) of rice straw residue and gypsum that is a simulation of sub-surface cut-soiler assisted drains in field condition. The columns were irrigated with water having RSC <2 mel^{-1} and >5 mel^{-1}. The results showed that surface application of amendment and subsurface placement of gypsum, rice straw residue at 50 cm depth reduces subsurface sodicity in terms of pH and subsequently increase in rice-wheat yield. There was a significant reduction in soil pH in treatment surface and subsurface placement of straw and gypsum with a magnitude of 1.3 unit and 0.6 units in the columns irrigated with <2 RSC and >5 RSC water as compared to initial soil pH, respectively. The decreased pH have propensity of increased rice yield up to 3.72 t ha^{-1} in the same treatment. The magnitude of increment in yield was 23.09 % with respect to RSC <2 over RSC >5. The succeeding wheat crop possess 9-38 % and 4-22% increase in yield in RSC<2 and >5 irrigation water, respectively, in all treatments as compared to control. Therefore, the Cut-soiler assisted sub-surface placement of these amendments found promising in reclamation of sub-surface sodicity and increase yield in rice-wheat cropping system under sodic soils.

Keywords: Cut-soiler, Reclamation, Residual sodium carbonate (RSC), Subsurface sodicity

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Impact of agri-food system integrated with eco-friendly nutrient management technologies on farm-based tribal livelihoods of Madhya Pradesh

Shinogi K. C.*, Srivastava, S., Meena, B. P., Sinha, N. K., A. Sahu, Bharati, K., Gurav, P. P., Thakur, J. K., Sarkar, A., Saha, M., Haokip, I. C., Devi, M. H., Salame, R., Tripathi, A. K., Singh R. K. and Wanjari R. H.

ICAR-Indian Institute of Soil Science, Berasia Road, Bhopal-462 038, Madhya Pradesh, India

*shinojikallely@gmail.com

Tribal agroecosystems in India are often deprived of resources and technologies necessary for generating optimum crop yield. This keeps farm-based livelihoods unsustainable in most of the tribal pockets in India. Agricultural development in these unprivileged areas is possible only through a participatory technology development approach. The study carried out during 2018-22 in some tribal villages of Betul and Balaghat districts of Madhya Pradesh assessed agro-ecosystem sustainability and technological backup of tribal agri-food systems. The study area had rainfed farming systems which were managed hitherto with the help of traditional technologies. Of late, chemical fertilizers and plant protection chemicals have entered into these systems along with the commercialization of agriculture. The major crops grown are soybean and maize in farmlands located inside the hilly tracts of open forest in Betul. The soils in this region are less fertile (average nutrient content of 0.4% Organic C, 116.4 kg ha^{-1} N, 9.6 kg ha^{-1} P, 224 kg ha^{-1} K) compared to the rice growing region of Balaghat located inside dense forest (average nutrient content of 0.92% OC, 205.7 kg ha^{-1} N, 19.6 kg ha^{-1} P, 223.1 kg ha^{-1} K). In an effort to improve yield and income in these tribal agriculture systems, ten liquid bio-formulations such as *Rhizobium*, phosphorus, potassium and zinc solubilizing bacteria, *acetobacter*, *azotobacter*, *Trichoderma*, *Pseudomonas*, *Metarhizium* and *Beauveria basiana* were integrated with the existing farm management practices so as to enhance soil nutrient availability as well as to lessen the incidences of biotic stress. Field trials carried out on cost-sharing basis, in 200 farmers' fields of six tribal villages in Betul district showed significant differences in crop yields between the intervention treatments and farmers' practice. A yield improvement of 48.8% in soybean, 22.9% in maize and 23.9% in rice crops were observed over farmers' practice with the integration of bio-formulations. The interventions have added an extra cost of 3200 Rs. ha^{-1}, which generated an additional net income of 13522 Rs. ha^{-1} from the soybean crop, 12751 Rs. ha^{-1} from maize crop and 12475 Rs. ha^{-1} from rice crop. Since tribal farmers are gradually stepping back from traditional practices and adopting new technologies unscientifically, leaving serious impacts on soil and water resources, integration of eco-friendly alternatives that can generate optimum yield and income from these resource-poor systems through restoring soil health and making it more resilient to changing climate effects is the need of the hour.

Keywords: Bio-formulation, Nutrient management, Soil health, Tribal agriculture,

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Enhancing sustainable agri-food systems through optimal spacing and phosphorus management through organic and inorganic sources

Kousalya, A. *, Sharmili, K., Gobikashri, N. and Jennifer Flora, G

Division of Agronomy, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore-641 114, Tamil Nadu, India

*Kausalyaa1999@gmail.com

In the pursuit of sustainable agriculture solutions to address global challenges, this study investigates the impact of spacing and phosphorus management through both organic and inorganic approaches. The experimental study was conducted during the *Rabi* season 2021-22 at the instructional farm of Karunya Institute of Technology and Science, Coimbatore, Tamil Nadu, in Randomized Block Design with ten treatments each replicated thrice. These treatments encompassed various spacing levels (20cm×20cm, 25cm×25cm, 30cm×30cm, 35cm×35cm, 30cm×10cm) and two phosphorus application sources (DAP and Vermicompost). The findings demonstrate a highly significant positive correlation between grain yield and various agronomic parameters, including stover yield, dry matter production (DMP) at harvest stage (r = 0.941**), nitrogen (N) uptake (r = 0.939**), potassium (K) uptake (r = 0.935**), dry matter production (DMP) at 60 DAS (r = 0.935**), phosphorus (P) uptake (r = 0.914**), seeds per pod (r = 0.913**), leaf area index (LAI) (r=0.894**), plant height (r = 0.880**), protein content (r=0.872**), test weight (r=0.863**), branches per plant (r=0.845), number of pods per cluster (r=0.802). Regression analysis further underscores the significant positive effects of plant height, leaf area index, dry matter production (DMP) at 60 DAS, dry matter production (DMP) at harvest, branches per plant, number of pods per cluster, number of pod clusters per plant, seeds per pod, test weight, protein content, and the uptake of nitrogen, phosphorus, and potassium. Notably, the application of 100% RDP through DAP + 20cm×20cm spacing resulted in the highest grain yield profoundly influenced by various parameters. These findings offer valuable insights into optimizing agricultural practices to enhance sustainability and productivity within agri-food systems, thereby contributing to the global endeavor of sustainable food production and resource management.

Keywords: DAP, Correlation, Regression, Vermicompost,

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Assessment of SOC stocks and SOC density on the cotton growing belt of South Gujarat as influenced by diversified crop condition

Bambhaneeya, S. M*. and Garaniya, N. H.

Department of Soil Science, College of Agriculture, Navsari Agricultural University, Campus Bharuch, Maktampur–392 012, Gujarat, India

*sureshsoilscience@nau.in

Cotton (*Gossypium spp*), is the queen of fibers or white gold and one of the most important cash crops of Gujarat state. Soil carbon stock, especially soil organic carbon (SOC) is a good indicator of soil productivity potential. It affects the physical, chemical, and biological properties of the soil and plays a crucial role in sustaining soil quality, agricultural production, and environmental quality (Zhang *et al.* 2003). Soil organic carbon is thus an extremely valuable natural resource and hence the SOC stock must be restored, enhanced, and improved. Therefore, proper management of SOM assumes importance in sustaining soil productivity in tropical soils and ensuring food security. Hence, the determination of SOC stock and SOC density from profile soils of South Gujarat from rainfed and irrigated cotton (hybrid/*Bt*/desi) is one of the main objectives of the present study. All the profiles were excavated up to 120 cm soil depth. The size of total SOC stock (t/ha) in each layer of soil profiles was computed by multiplying OC concentration (g kg^{-1}) in the layer with bulk density (Mg m^{-3}), thickness (m) and multiplying it with 10 (Batjes, 1996). However, in the profiles under study soil layers were as follows, 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil depth. The highest and the lowest SOC stock up to 30 cm soil depth for irrigated profiles P5 (31.6) and P9 (27.9), respectively and the same for rainfed soils were P6 (30.4) and P10 (18.4), respectively which indicated that P5 and P6, respectively in irrigated and rainfed situations exhibited the higher capacity to help in mitigating global warming and climate change and higher productivity potential coupled with available water capacity and nutrient dynamics as compared to other respective irrigated and rainfed profiles. Mean SOCD at 0-15, 15-30, 30-60, 60-90 and 90-120 (all irrigated profiles collectively), were 1.50, 1.26, 2.15, 1.93 and 1.53 t ha-1 respectively. Further, Mean SOCD at 0-15, 15-30, 30-60, 60-90 and 90-120, were 1.22, 1.00, 1.93, 1.56 and 1.27 respectively. Up to 30, 60 and 120 cm soil depth from surface, the mean SOCD of rainfed profiles were 2.22, 4.14 and 6.97 t ha^{-1}, respectively.

Keywords: Cotton, Density, Irrigated, Organic carbon stock, Rainfed, South Gujarat

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Simulated cut-soiler (PSSD) reduces soil salinity and improves mustard production in saline arid regions

Neha[1], Gajender Yadav[1*], Yadav[1], R. K., Govind Prasad[1], Satyender Kumar[1], Rai[1], A. K. and Junya Onishi[2]

[1] ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana, India
[2]Japan International Research Center for Agricultural Sciences, Japan

*gajender.icar@gmail.com

Salt accumulation in the soil is a major contributing factor to land degradation and decreases agricultural production, particularly in arid and semiarid regions. Out of the total geographical area of India about 2.95 Mha is under saline soils. The existing drainage techniques are applicable to a large area that requires a high cost and community approach. Cut-soiler is a tractor-mounted machine for constructing crop residue-filled preferential subsurface drainage (PSSD) on individual fields. Keeping in view the problem of salinity, this lysimeter study in controlled conditions is being conducted under ICAR-Central Soil Salinity Research Institute, Karnal, and the Japan International Research Center for Agricultural Sciences (JIRCAS) collaborative project. In this Cut-soiler constructed Preferential Shallow Sub-Surface Drains (PSSD) were simulated in the 12 lysimeters (2x2 m^2) as main plot treatments along with control (without Cut-soiler) in another 12 plots. The two soil types in subplots (6 plots in each Cut-soiler and control plots) i.e. sandy loam saline and heavy textured normal. Three saline water irrigation treatments *viz.,* 4, 8, and 12 dS m^{-1} were applied in sub-sub plots treatments. The reduction in soil salinity (ECe) recorded under Cut-soiler PSSD was up to ~60 % over without Cut-soiler. Consequently, the increase in the mustard yield was up to 31.5 % under Cut-soiler PSSD. This increment in mustard yield under Cut-soiler PSSD was mainly due to a reduction in soil salinity that provides better soil conditions for plant growth. That improves plant water relations and physiological mechanisms in terms of increase in RWC (relative water content) (8.6 %), photosynthetic rate (27.4 %) transpiration rate (15.1 %), and stomatal conductance (38.5 %) in mustard plants. There is a decrease in less negative water potential (-1.47 and -1.80 Mpa) and osmotic potential (-2.14 and -2.54 Mpa) and the lowest Na/K ratio (0.023 and 0.037), which were recorded under Cut-soiler drainage. Hence, Cut-soiler PSSD proved beneficial in mitigating the adverse effect of salt stress by effective salt removal and increasing the growth and seed yield of mustard crops.

Keywords: Cut-soiler preferential shallow sub-surface drainage (PSSD), Land degradation, Mustard, Salt stress

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Enhancing sustainable agri-food systems through optimal spacing and phosphorus management in irrigated blackgram

Kousalya, A.*, Sharmili, K., Gobikashri, N. and Jennifer Flora, G

Division of Agronomy, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore-641 114, Tamil Nadu, India

*Kausalyaa1999@gmail.com

In the pursuit of sustainable agriculture solutions to address global challenges, this study investigates the impact of spacing and phosphorus management through organic and inorganic sources in irrigated blackgram. The experimental study conducted during the *Rabi* season 2021-22 at the instructional farm of Karunya Institute of Technology and Science, Coimbatore, Tamil Nadu, in Randomized Block Design with ten treatments and each replicated thrice. These treatments encompassed various spacing levels (20cm×20cm, 25cm×25cm, 30cm×30cm, 35cm×35cm, 30cm×10cm) and two phosphorus application sources (DAP and Vermicompost). The findings demonstrate a highly significant positive correlation between grain yield and various agronomic parameters, including stover yield, dry matter production (DMP) at harvest stage (r = 0.941**), nitrogen (N) uptake (r = 0.939**), potassium (K) uptake (r = 0.935**), dry matter production (DMP) at 60 DAS (r = 0.935**), phosphorus (P) uptake (r = 0.914**), seeds per pod (r = 0.913**), leaf area index (LAI) (r=0.894**), plant height (r = 0.880**), protein content (r=0.872**), test weight (r=0.863**), branches per plant (r=0.845), number of pods per cluster (r=0.802). Regression analysis further underscores the significant positive effects of plant height, leaf area index, dry matter production (DMP) at 60 DAS, dry matter production (DMP) at harvest, branches per plant, number of pods per cluster, number of pod clusters per plant, seeds per pod, test weight, protein content, and the uptake of nitrogen, phosphorus, and potassium. Notably, the application of 100% RDP through DAP + 20cm×20cm spacing resulted in the highest grain yield profoundly influenced by various parameters. These findings offer valuable insights into optimizing agricultural practices to enhance sustainability and productivity within agri-food systems, thereby contributing to the global endeavor of sustainable food production and resource management.

Keywords: DAP, Correlation, Regression, Vermicompost

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Risk assessment and management of arsenic in rice soils: A case study in Nadia Bengal

Rahul Mishra*[1], Datta, S. P.[1], Meena, M. C[2]., Dwivedi[3], B. S[3]., Golui, D[2]., Sinha, N. K.[1] and Behra, S. K.[1]

[1]ICAR-Indian Institute of Soil Science, Bhopal-462 038, Madhya Pradesh, India
[2]ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India
[3]NRM-ASRB, New Delhi-110 012, India

*mishrarahul471@gmail.com

Arsenic (As) contamination of soil, water, and food has become a widespread global problem and affecting millions of people worldwide. Contamination of As in soil and water directly or indirectly imposed hurdles in achieving sustainable development goals. It is of utmost importance to assess the risk imposed by As and devise suitable management options that are green, easily adoptable at farmers' fields, and sustainable in nature. For this purpose, 201 soil, plant, and 22 water samples were collected from contaminated fields. Solubility and free ion activity model was used to predict As content in rice grain and prescribe the toxic limit of extractable arsenic in soils concerning human health hazards for its intake through rice. A ready reckoner was developed to predict HQ of As intake through rice grain based on soil extractable As, pH, and OC content using solubility-FIAM parameters. An attempt has been made to evaluate the effect of flooding (W1), alternate wet and drying (AWD; W2) water management in combination with phosphate (0.0, 30.0, 60.0 mg kg^{-1}: P1, P2, P3) and vermicompost (0.0, 2.5, 5.0 g kg^{-1}: C1, C2, C3) application on the accumulation of As in rice grain and soil solution As extracted with rhizon sampler. Results revealed that As content in collected groundwater varied from 12.7 to 91.9 µg l^{-1} with a mean value of 24.3 µg l^{-1}. Transfer of As from soil to rice grain was predicted based on solubility FIAM. The parameters C, β1, and β2 of solubility-FIAM were calculated as -2.31, -0.017, and 0.64, respectively. The solubility-FIAM model described 79% of the variability in As concentration in rice grain. Under AWD water management, As content in pore water extracted by the rhizon sampler was 260 and 93.0 µg l^{-1}, respectively. Arsenic content in soil solution was reduced under W2 due to its redistribution in relatively less labile fractions. The lowest value of As in rice grain was observed with a conjoint application of phosphate and vermicompost (C2 and P2) in AWD water management.

Keywords: Arsenic, FIAM, Risk assessment, Water management

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Salinity management through cut-soiler-constructed preferential shallow sub-surface drainage for higher crop production in salty ecologies

Gajender Yadav[1*], Yadav[1] R. K., Neha[1], Satyendra Kumar[1], Rai[1] A. K., Bhasker Narjary[1] and Junya Onishi[2]

[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana, India
[2]Japan International Research Center for Agricultural Sciences, Japan

*gajender@icar.gov.in

Salinity is a severe soil degradation problem and a major constraint in crop production, which covers a ~1 billion ha area of arid and semi-arid regions. Out of all the salt-affected areas worldwide, ~397 million hectares (M ha) is saline, constituting 20% of total cultivated land and 50% of the irrigated areas of Earth. In India, around 2.1% of the total geographical area, around 6.73 M ha, is salt-affected, of which 2.95 M ha is saline. The Cut-soiler constructed residue filled preferential shallow sub-surface drainage (PSSD) is a promising cost-effective salinity management technology for small-scale application and adoption in salty drylands. This evaluated the salt removal effect and standardized the optimum lateral spacing of Cut-soiler constructed PSSD at field scale. The Cut-soiler preferential sub-surface drainage was constructed at 2.5, 5.0, 7.5- and 10.0-meters lateral intervals at a depth of 60 cm using rice residue as a filling material @ 6 Mg ha^{-1} and control (without Cut-soiler). The Cut-soiler PSSD reduced ~52.4 % soil salinity after three years of construction at 2.5-meter lateral intervals. In April 2021(after 3 years of drains construction) the soil salinity (ECe) in 2.5, 5.0, 7.5 and 10.0 m lateral spacing were 5.89, 7.84, 8.22, 8.78 dS m^{-1} over control (12.44 dS m^{-1}). The Cut-soiler treatment significantly increased mustard seed yield in comparison to without Cut-soiler plots. In 2020-21 the mustard yield in 2.5, 5.0, 7.5, and 10.0 m lateral spacing were 1.49, 1.22, 1.15, and 1.01 t ha^{-1} which were higher than the control (0.63 t ha^{-1}). The narrowest lateral spacing of Cut-soiler constructed PSSD was found to reduce soil salinity over no Cut-soiler plots. Therefore, the closest lateral spacing was found promising for salinity management and sustainable crop production in highly salt-affected fields.

Keywords: Cut-soiler, Drainage, Lateral spacing, Reclamation, Salinity

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Carbon sequestration through composting of aquatic weeds in the Kuttanad region of Kerala, south India

Muralidharan, P. and Sajnanath, K.

ICAR-Krishi Vigyan Kendra-Alappuzha, ICAR-CPCRI, Regional Station, Kayamkulam – 690 533, Kerala, India

*muralidharan.p@icar.gov.in

Extensive accumulation and spread of aquatic weeds in the paddy fields and water bodies pose a major menace for paddy cultivation, inland navigation, fish culture, and availability of pure drinking water in the Kuttanad Wetland Ecosystem, which is bestowed with the status of Globally Important Agricultural Heritage System (GIAHS) by the FAO. An attempt was made to compost of these aquatic weeds through technology demonstrations using an Effective Microbial (EM) solution with the collaboration of the MGNREGS. The aquatic weeds collected from water bodies and paddy fields were heaped on the side bunds or nearby upland area, applied activated EM solution along with cow dung slurry (wherever available) in different layers of the heaps of 20m^3 (5 x 2 x 2 m) and covered by coconut fronds or waste cloths. The compost was ready in 45-60 days with the recovery of 10-15% of the original fresh volume, and contained on an average 9.51% Organic carbon, 0.71% N, 0.24% K, 34.8 ppm Ca, 11.0 ppm Mg and 2.05 ppm B which could be utilized for the cultivation of banana and vegetables by the partner farmers. Since these aquatic weeds are assumed to accumulate heavy metal ions in their biomass, the compost produced was analyzed to rule out the presence of any of these heavy metals. Analytical results showed the presence of Cadmium (Cd), Lead (Pb), Chromium (Cr), and Arsenic (As) in the compost but not Mercury (Hg). Further analysis of plant parts (leaves and stem) and fruits of Tomato, Brinjal, Chilly, Okra, Cowpea and flowers and seeds of Amaranthus revealed that the content of Cadmium, Lead and Chromium were lower than critical limits in both compost and vegetable samples. Though arsenic content in compost sample was higher than critical limit, its presence in the vegetable samples was not in the detectable range. During the nine years from 2014 to 2022, about 2560 t of fresh aquatic weeds removed from 382 ha of the paddy fields (*padashekharams)* were converted to about 346 t of compost involving about 2000 farmers in three villages of Kuttanad with the collaboration of MGNREGS. Thus sequestration of 32.9 t of organic carbon through this local action by farmers was facilitated in addition to the crops produced. If the activity could be expanded to the 30,000 ha paddy fields spread in three districts of the Kuttanad region by coordinated efforts of the local self Governments and Govt. Departments, the weed menace could be brought under control to an extent along with the sequestration of a considerable amount of carbon, which would be a measure for the mitigation of climate change.

Keywords: Aquatic weeds, Compost, Kuttanad, Paddy

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Biochar: A tool for mitigating climate change

Ambuj Kumar Singh* and Kajal Verma

Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi – 221 005, Uttar Pradesh, India

*ambujsingh67@bhu.ac.in

Biochar, a solid porous material obtained from the carbonization of biomass under partial or absence of oxygen conditions, has been proposed as a climate change mitigation tool because it is expected to sequester carbon (C) for centuries and to reduce greenhouse gas (GHG) emissions from soils. The use of biochar as a soil additive may offer an opportunity to tackle a number of these issues simultaneously (Lee et al., 2010). The conversion of biomass carbon to biochar leads to sequestration of carbon about 50% of the initial carbon compared to the low amounts retained after burning (3%) and biological decomposition (less than 10-20% after 5-10 years) (Lehmann et al. 2006). Biochar potential to contribute to the mitigation of climate change by increasing soil carbon (C) (Lehmann, 2007; Woolf et al., 2010). In addition, biochar can increase crop yields (Biederman et al.,2013) and reduce water stress, which helps to adapt to climate change. Biochar also controls nitrogen (N) cycling (Clough et al., 2013), especially N_2O emissions from soil are reduced on average by 54 % in lab studies and 28 % in field measurements (Cayuela et al., 2014). Biochars are often alkaline and therefore increase soil pH after application (Joseph et al., 2010). Denitrifying bacterial communities have the potential to increase their N2O-reducing activity with increasing pH, which may reduce N_2O emissions from soils. Rondon et al. (2005) reported a 50% reduction in N_2O emissions from soybean plots and almost complete suppression of CH_4 emissions from biochar-amended acidic soils in the Eastern Colombian Plains.

Keywords: Biochar, Carbon sequestration, Climatic change, Green house gases

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Build-up or depletion of soil phosphorus and potassium of alfisols after long-term manuring, fertilisation and continuous cropping?

Dhiraj Kumar*, RH Wanjari, NK Sinha, and Anil Nagwanshi

ICAR-Indian Institute of Soil Science, Berasia Road, Bhopal-462 038, Madhya Pradesh, India

*dhiraj.iari@gmail.com

The phosphorus and potassium nutrition of crops is quite important keeping in view of its imbalance use that leads to cascading effects on crops, soil, and the environment as a whole. The studies on long-term fertilizer experiments at different locations viz., Bangalore, Palampur, Pattambi, and Ranchi lying in Alfisols of our country revealed that the maximum yield of different crops was obtained with the treatment 100% NPK+ farmyard manure (FYM), followed by the treatment receiving 100% NPK over rest of the treatments and control. The recommended application of nutrients, as well as their simultaneous application through inorganic and organic sources in an integrated manner, resulted in higher stable yields, improved nutrient balance and its uptake over the years, as well as a positive impact on soil health. Continuous application of P to a crop resulted in an increase in the uptake of P in the crop. Further, the continuous absence of K in fertilizer schedule or application in quantities lower than that removed by crop made Alfisols responsive to K application due to slower release of K from the non-exchangeable pool and reduction in available K content. The conjoint use of fertilizers and organic manure was also significantly superior to other treatments in terms of soil health improvement.

Keywords: Alfisols, Crop productivity, Inorganic fertilizer, LTFEs, Nutrient balance, Organic manure,

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Soil Health and its Restoration

Engineered microbes for waste biomass-based pigment production

Harsh Saini*., Sakshi Paliwal., Akshat Lakhesar

Agriculture Research Station, College of Agriculture, Sumerpur, Pali, Rajasthan, India

*harshsaini777888@gmail.com

Biomass from agri-food waste is the most prevalent organic waste and has a high potential for valorization in the creation of sustainable bioproducts. These wastes are abundant in bioactive carbohydrates, peptides, pigments, polyphenols, vitamins, natural antioxidants, and other compounds as well as being recyclable in nature. The circular economy and zero waste concepts depend heavily on the bioconversion of agri-food waste into value-added goods. Food researchers are looking for ways to use this waste for the synthesis of microbial pigments and further biotechnological exploitation in functional foods or value-added goods in order to lessen the environmental load. Microbes are important sources for a variety of bioactive compounds, such as the creation of microbial pigments through fermentation and/or the use of waste. This letter evaluated several recent developments in significant bioengineering fields in order to create engineered microbial systems for increased pigment synthesis using biomass/byproducts from agri-food wastes in a sustainable manner.

Keywords: Agri-food waste, Bioengineering, Engineered microorganisms, Fermentation, Microbial pigments, Sustainable development, Waste biomass

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Sustainable intensification and diversification options for enhancing productivity and farm income in tobacco-based systems of Andhra Pradesh

Kiran Kumar, T.*, Kasturi Krishna, S., Poorna Bindu, J., Viswanath Reddy, K. and Sheshu Madhav, M.

ICAR-Central Tobacco Research Institute, Rajahmundry-533 105, Andhra Pradesh, India*

*kiran.tirumala@icar.gov.in

Tobacco is one of the most important high-value commercial crops in India and plays a pivotal role as the second largest tobacco producer (761 M Kg) in global production, with its cultivation in an area of 0.45M ha. Although tobacco makes a significant contribution to the Indian economy and livelihood security for millions of farmers, emerging issues such as climate change, resource degradation, biotic and abiotic stresses, and escalating production costs are becoming increasingly complex. To overcome these challenges, sustainable intensification and diversification are important approaches for enhancing productivity and farm income in tobacco-growing regions of Andhra Pradesh. A field experiment was conducted at the ICAR-CTRI Black Soil Research Farm, Katheru, Rajahmundry to evaluate the performance of different crops and cropping systems (sorghum, maize, foxtail millet, finger millet, chickpea, mustard, chilli, and turmeric) during the Kharif and Rabi seasons during 2017-2022. The experiment was conducted in a randomized block design with four replications. The grain/dry rhizomes/dry chilli yields of sorghum, maize, foxtail millet, finger millet, mustard, Bengal gram, chilli, and turmeric were converted into tobacco leaf equivalent yield (TLEY) based on prevailing market prices. Among the different cropping systems studied, the maize-tobacco system is highly remunerative in terms of tobacco leaf equivalent yield TLEY(2367 kg/ha) and net returns (Rs. 142410/ha), followed by the sorghum-tobacco system with 2114 kg/ha TLEY and Rs. 115036/has as net returns. During 2019-21, other commercial crops such as chilli and turmeric were also studied along with other tobacco-based systems. Chilli and turmeric performed well in terms of tobacco leaf equivalent yield (TLEY) and net returns compared with other tobacco-based systems. However, Foxtail millet (korra)-Tobacco and Finger millet (ragi)-tobacco registered higher tobacco leaf equivalent yield and net returns compared to existing fallow-tobacco. The highest system productivity based on TLEY was recorded in chilli and turmeric crops, which is due to high productivity levels of chilli and turmeric coupled with more price prevailing in the market for chilli and turmeric. Based on this study, it could be concluded that intensification of tobacco with maize and sorghum (kharif) is highly remunerative compared to the fallow-tobacco system and sole chilli; sole turmeric crops are highly productive and profitable and enhance farm income in tobacco growing regions of Andhra Pradesh.

Keywords: Crop intensification, Diversification, Maize-tobacco, System productivity, Tobacco

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Pond liming: A nature-based solution for invasive aquatic plant species management and ecosystem restoration

Prameela, P.*, Savitha Antony and Gowtham, S. G.

All India Coordinated Research Project on Weed Management, Kerala Agricultural University, Thrissur-680 656, Kerala, India

*prameela.p@kau.in

Management of freshwater aquatic weeds especially submerged species is a major concern in agriculture and fisheries. They take over water bodies and pose threats such as interruption of water flow, blockage of canals and irrigation systems, and detrimental to fish production apart from leading to biodiversity degradation. Physical removal is the only management option available which in most cases is economically not feasible. Chemical management techniques pose risks to non-target species and humans. Biological options are available only for a few floating species like salvinia and eichhornia. In India, no safe herbicides are registered for use in aquatic weed management. Recently weed infestations in freshwater systems are increasing and there is an urgent need to develop an ecofriendly management strategy. Lime application is a customary practice in aquaculture for water purification, clarification, and for pH buffering. A detailed study on the effectiveness of various doses of burnt lime or CaO (2, 4, 6, 8, 10, and 15g/L of water) was conducted at AICRP on Weed Management, Thrissur. The mesocosm study was conducted in cement tanks of 40L capacity filled with fresh water (pH-7; EC-0.3dS/m) and the submerged aquatic weed hydrilla was established and the treatments were applied after two weeks. The effectiveness of treatments was assessed based on chlorophyll degradation and the extent of decay. In the tank study, there was a drastic reduction in chlorophyll content even at the lowest dose. The chlorophyll degradation progressed with time and complete degradation was observed by three weeks of liming even at lower doses. The degradation rate was fast with increasing doses of lime. There were significant changes in water quality parameters like pH, EC, acidity, alkalinity, carbonate, bicarbonate, nitrate, hardiness, and mineral constituents. The field testing of the technology was carried out in ponds infested with submerged flora of hydrilla, najas, cabomba, utricularia, limnophylla, and algae. The lower doses of 2 and 4g/L were less effective and the higher doses of 6g/L and above resulted in complete chlorophyll degradation and death of weeds and algae by three weeks. No adverse effects on aquatic fauna such as fishes and snails were observed. The study indicates the possibility of CaO application as an eco-friendly means for managing submerged freshwater aquatic weeds and algae.

Keywords: Burnt lime, Calcium oxide, Hydrilla, Submerged weeds, Water quality

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Traditional farming system as a nature-based solution to enhance ecosystem services: Role of species richness and management intensity

Parameshа, V.*, Parveen Kumar and Manohara, K. K
ICAR-Central Coastal Agricultural Research Institute, Old Goa-403 402, Goa, India
*parameshagron@gmail.com

Enhancing land productivity through effective land-use management systems is crucial for achieving a harmonious blend of agricultural output and diverse ecosystem benefits, particularly in the context of climate change adaptation and mitigation. To address this challenge, the global proposition of farming systems has emerged as a promising avenue, aiming to optimize land usage for heightened agricultural yield, while concurrently mitigating climate-related impacts and minimizing economic vulnerabilities for farmers. Within this framework, Arecanut (*Areca catechu* L.), a significant cash crop in the west coast India, holds prominence as it is cultivated within agroforestry systems. Although previous research has often contrasted tree-crop combinations with single-crop setups, a comprehensive evaluation of these Arecanut-based traditional farming systems in terms of provisioning ecosystem services (PES) remains noticeably limited. Particularly, the influence of factors like species diversity and management strategies on PES in traditional farming systems has remained a gap. This study thus endeavours to investigate precisely this aspect, scrutinizing the repercussions of species richness and management practices on PES within traditional farming system, utilizing the case of Goa in West coast India as a focal point. It was found that several indicators exhibited no meaningful correlation between ecosystem services, biodiversity, and management intensity. The decline in available soil nutrients was attributed to the competitive nature of intercropping, leading to exhaustion. Furthermore, our analyses indicated that intercrop selection did not consistently align with the ecological preferences of the chosen species. Applying analytical techniques like Canonical Correspondence Analysis and Analytical Hierarchy Process, our findings highlighted that farmers prioritized biodiversity, yet often overlooked critical management practices such as intercrop planting densities, resulting in diminished ecosystem services. Notably, moderate to high levels of intercrop diversification, coupled with medium management intensity, demonstrated the potential to yield a spectrum of ecosystem services. In conclusion, this study underscores the necessity for farmers to strike a careful equilibrium between the selection of intercrop species and their management strategies. By catering to the needs of both farmers and crops, a symbiotic relationship between agricultural productivity and ecosystem services can be cultivated.

Keywords: Analytical hierarchy process, Biodiversity, Canonical correspondence analysis, Soil fertility

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Development of chitosan-based packaging films impregnated with clove oil for aflatoxin management in chilli and nutmeg

Anees, K[1]., Aswini, P. P[2]., Jayashree, E.[1]., Sarathambal, C.[1] and Sruthy, P. B[1].

[1]Division of Crop Production and Post Harvest Technology, ICAR-Indian Institute of Spices Research, Kozhikode- 673 571, Kerala, India
[2]Kerala University of Fisheries and Ocean Studies, Panangad, Kochi-682 506, Kerala, India

*aneeskaprakkadan@gmail.com

Aflatoxins, an unresolved menace in post-harvest management still needs a pragmatic solution for its management in chilli and nutmeg. Moreover, the hunt for developing sustainable yet affordable alternatives has become necessary due to the alarming rate of environmental contamination caused by single-use plastics. The goal of this work is to create bioplastic films made of chitosan that are impregnated with clove oil for aflatoxin management in chilli and nutmeg. To create a clear, flexible, beautiful film that can be used as an active packaging material, three plasticizers were applied in various ratios, including glycerol, sorbitol, and polyethylene glycol along with chitosan. The physical, chemical, optical, mechanical, and biological properties of the formed films were investigated. Physical parameters such as thickness, film density, organoleptic analysis, moisture content, water uptake capacity, swelling degree, water vapour permeability, penetrability; chemical paraments such as pH, pH sensitivity, eugenol release kinetics and chemical resistance; optical property such as film transmittance and opacity; mechanical features such as tensile strength, percentage of elongation at break and Youngs's modulus; biological properties such as anti-oxidant activity, anti-fungal property, total phenol content and biodegradability were tested for the membranes devolved during the study. To evaluate and study the film's quality, the anti-oxidant and total phenol tests were conducted. The soil burying technique was used to illustrate the film's biodegradability. The impregnation of clove essential oil dramatically improved the antimicrobial and antioxidant capabilities. An essential oil release kinetics study revealed that the membrane can be used as a slow-release matrix for clove oil. Moreover, the membrane exhibited antibacterial properties which makes it a superior packaging material. This work demonstrates that the incorporation of clove oil into food packaging polymeric matrices is an interesting approach for two reasons: first, it lowers the amount of EO required for food preservation, thereby reducing costs and second, it helps to release the EO in a controlled manner so that release is sustained for longer duration. Biodegradable chitosan-based edible films with clove oil when used for aflatoxin control in affected chilli and nutmeg samples, were found to successfully manage the aspergillus infection up to six months of storage. Hence the fabricated membrane has the potential to transform the spice packaging industry by controlling aflatoxin contamination and thereby enhancing both environmental and human health

Keywords: Aflatoxin, Chitosan, Clove oil, Impregnation, Release kinetics

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Isolation and characterization of anti-inflammatory isochromanyl compound from an intertidal brown seaweed *Turbinaria conoides*

Shubhajit Dhara[1,2]*, and Kajal Chakraborty[1]

[1]Marine Biotechnology Fish Nutrition and Health Division, ICAR-Central Marine Fisheries Research Institute, P.B. No 1603, Cochin-682 018, Kerala, India
[2]Department of Chemistry, Mangalore University, Mangalagangothri- 574 199, Karnataka, India
*shubhaj111@gmail.com

Seaweeds have been acknowledged for their significant potential in pharmacological activities, encompassing antioxidant, and anti-inflammatory properties due to their distinctive bioactive pharmacophores. *Turbinaria conoides*, a brown seaweed from the Sargassaceae family, is notably abundant in the sub-tropical and tropical regions of the Indo-Pacific Ocean. Numerous naturally occurring compounds have been isolated from marine resources, showing promising potential in reducing various inflammatory mediators. Chromene derivatives are notable for their highly pharmacologically active structures, serving as core framework for numerous marine natural products. These types of compounds possess valuable phytochemical properties. In recent times, there has been a surge in the search for anti-inflammatory agents derived from natural sources due to undesirable side effects associated with synthetic non-steroidal anti-inflammatory drugs (NSAIDs). In this context, the chemical investigation of *Turbinaria conoides* has yielded a structurally and functionally unique bioactive isochromanyl compound. Studied seaweed sample was dried and extracted with organic solvent to prepare crude extract. The bioactivity-guided liquid chromatographic fractionation of crude extract led to the discovery of an isochromanyl compound from the most active fraction, which was then tested for anti-inflammatory enzyme inhibition and free radical scavenging assays. Potent bioactivity of studied compound was confirmed through activity-structure correlation study. Furthermore, pharmacokinetics and *in silico* molecular docking studies were conducted to assess the oral bioavailability and interaction with drug targets of the isochromanyl compound. Attenuation property of isolated isochromanyl compound against, 5-lipoxygenase (IC_{50} 3.70 μM) was comparable with non-steroidal anti-inflammatory agent Zileuton (IC_{50} 2.41 μM). Studied isochromanyl compound exhibited prospective free radical scavenging potential (IC_{50} ~ 24 μM). The greater selectivity index of isochromanyl compound showed selective attenuation potential against inducible cyclooxygenase-2 enzyme. Significant electronic parameters (topological polar surface area, 61.83), balanced hydrophobic-hydrophilic property (octanol-water partition coefficient 3.43) and lower binding energy (-10.32 to -12.08 kcal mol^{-1}) with active site of targeted enzymes, supported the significant anti-inflammatory properties of studied compound. This study revealed the potential of isolated compound as promising pharmacophore against inflammatory mediated disorders.

Keywords: Anti-inflammatory, Isochromenyl compound, Lipoxygenase and cyclooxygenase, *Turbinaria conoides*

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Investigating the potential of bio-optics for assessing the health status of Vembanad Lake in Kerala, south India

Anju, R.[1]*, Grinson George[1], Mini, K. G.[1] and Nandini Menon, N.[2]

[1] ICAR-Central Marine Fisheries Research Institute, Cochin-682 020, Kerala, India
[2] Nansen Environmental Research Centre (India), Cochin -682 506, Kerala, India

*anjurajprameela@gmail.com

Vembanad Lake in Kerala is part of a huge wetland system and one of India's 46 Ramsar sites. The region around the lake is densely populated and much of the population depends on the lake for their sustenance. Extensive anthropogenic activities such as tourism, and domestic and industrial waste disposal have had a detrimental impact on the lake's water quality and health. With the advance in satellite remote sensing to assess the biogeochemical parameters such as chlorophyll-a and suspended particulate matter concentration from water leaving reflectance, water quality monitoring has become an easy and routine process. However, in inland waterbodies such as Vembanad Lake where terrestrial and aquatic inputs of substances complicate the light transfer in water, accurate assessment becomes difficult. Hence, additional data on the apparent and inherent optical properties of such optically complex waters are valuable to the scientific community to better understand marine optics and redefine ocean color algorithms. *In situ* measurements of bio-optical parameters were performed for a span of two years from April 2018 to May 2020 by collecting water samples from 13 stations across the lake. The main optical in-water constituents are Chlorophyll a (Chl a), Coloured Dissolved Organic Matter (CDOM) and Suspended Particulate Matter (SPM). Chl-a concentrations were extremely variable in the stations, in accordance with the seasons. Variations in nutrient input were also reflected in the Chl-a concentration, with values indicating bloom conditions recorded occasionally. Previous studies in the lake showed that the probability of the presence or absence of *Vibrio cholerae* could be expressed as a function of chlorophyll concentration in the water. This leads to an important application of the bio-optical measurements by which maps generated using satellite-derived chlorophyll data could be used as a health indicator. High CDOM concentration reflects the status of watershed pollution. The study showed that the detritus matter made the highest relative contribution to the absorption budget throughout the year. With this study, we intend to point out the importance of bio-optics in assessing the water quality of an inland lake constantly impacted by human activities. Monitoring the health status of Vembanad Lake which is a rich source of fishery and a hub of aquaculture practices can thereby ensure the quality and escalate the quantity of food production from the lake. It also helps build an optical database based on in situ measurements, for a better synoptic assessment of the water quality from space.

Keywords: Aquaculture, Bio-optics, Fishery resources, Vembanad Lake, *Vibrio cholerae*.

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Qualitative and quantitative appraisal of ecosystem services of Chettuva–A small tropical Indian estuary

Sreekanth Giri Bhavan[1,3*], Amritha Priya[1], Praveen Koovalamkadu Velayudhan[2], Karthika Baiju[1], Trivesh Mayekar[3], Parveen Kumar[3], Baban Ingole[4] and Ranjeet Kutty[1]

[1]Kerala University of Fisheries and Ocean Studies, Kochi- 682 506, Kerala, India
[2]ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110 012, India
[3]ICAR-Central Coastal Agricultural Research Institute, Old Goa-403 402, Goa, India
[4]ESSO- National Centre for Polar and Ocean Research, Headland Sada, Vasco da Gama403 802,, Goa, India

*gbsree@gmail.com

The estuaries generate plentiful benefits to support human life- generally known as ecosystem services (ES). However, many times, these services remain unidentified and not evaluated especially for small estuaries (<10 km^2 area spread). In this study, we documented and evaluated the major ES of Chettuva- a small tropical estuary along the southwest coast of India using a multi-mode analysis framework for one-year period from 2022 to 2023. The ES supply was also analysed between different estuarine gradients based on salinity (euhaline, polyhaline, mesohaline and oligohaline). A total of 27 ES (provisioning (P): 13, regulating (R)-6, supporting (S)-3, cultural (C)-5) were recorded from the estuary using a standard schedule based-survey and field records covering a broad stakeholder network (350). The respective contribution of these services to the ES scores from stakeholders were P-44.3%, R-14.1%, S-22.4% and C-18.9% respectively (stakeholder perception). The zone-wise scoring yielded the highest values for polyhaline (0.61) and euhaline (0.45) gradients followed by oligo (0.35) and mesohaline (0.37) types. Stakeholders ranked biodiversity of habitats, fish and shellfish (capture), nursery, and breeding function, recreation, and water for fishing as the most important ES from the estuary. A drastic decline and shift in ES delivery were recorded between zones for different ES from the desired/expected supply (~50% in provisioning, ~70% in cultural, ~50% in supporting). The major services from the oligohaline zone were water for domestic use, disturbance regulation, water for aquaculture, biodiversity, and cultural heritage. For the mesohaline zone, biodiversity, fish and shellfish, aesthetic enjoyment, nursery and breeding function and recreation and pleasure were scored high values. Biodiversity, nursery and breeding function, fish and shellfish, raw materials, soil retention were the major ES from the polyhaline zone of the estuary. The euhaline zone supplied fish and shellfish, biodiversity, water for harbours and ports, recreation and pleasure, and nursery and breeding function as the most important ES. The valuation of the different ES using a hybrid methodology yielded a first-hand estimate of ₹1525. 4 million. The regulating and supporting ES recorded the highest values (R-49% and S-37%)- ₹1325.2 million among the different service types. The comprehensive evaluation of the ES could be helpful in environmental decision-making and in devising strategies that enhance/balance the zone-wise supply of different ES from the estuary.

Keywords: Chettuva, Cultural, Ecosystem service, Evaluation, Provisioning, Regulating, Small estuary, Supporting

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Biochar technology for sustainable aquaculture

Chalungal T. Amal*, Tao Kara, Vidya Shree Bharti, Arun Konduri and Tachangliu
ICAR-Central Institute of Fisheries Education, Mumbai-400 061, Maharashtra, India
*amalthambhi1234@gmail.com

In order to satisfy the rising worldwide demand for seafood while reducing its negative effects on the environment, "sustainable aquaculture" is essential. It supports social and economic sustainability while protecting natural ecosystems and ensuring the long-term survival of aquaculture systems. To maximize yield in the shortest amount of time, farmers use chemicals like fertilizers and antibiotics in culture systems. Although these compounds increase output, they eventually harm the ecosystem. The indiscriminate use of agrochemical inputs causes sterility in the soil, has detrimental effects on the ecosystem, eutrophication of water bodies, poor quality fish products, the rise of illnesses and pests, antibiotic resistance, etc. In such a case, biochar made from agricultural waste appears as a viable alternative to use in aquaculture systems to maximize output while minimizing environmental impact. India has a gross crop residue potential of 696.38 million tonnes per year. 70% of agricultural waste is produced by cereal crops (rice, maize, wheat, and millet), with rice accounting for 34% of this trash. This huge amount of agro-waste can be utilized in zero-budget aquaculture farming. The word "budget" refers to credit and expenses, thus the phrase 'Zero budget' means without using any credit, and without spending any money on purchased inputs. Natural Farming means farming with nature and without chemicals. Biochar exhibits properties that make it suitable for aquaculture applications. These properties include high porosity, surface area, water-holding capacity, cation exchange capacity, pH buffering capacity, and presence of functional groups (Hydroxyl, Amine). These characteristics contribute to better sediment health, improved water quality, nutrient retention, microbial activity, reduced emissions, and enhanced productivity in aquaculture systems.

Keywords: Aquaculture, Biochar, Circular Economy, Natural Farming, Sustainability, Soil health, Waste valorization, Water Quality

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Coastal habitat restoration and improving community resilience by artificial reefs along the Indian coast

Joe K. Kizhakudan*, Shoba Joe Kizhakudan, Remya, L., Narayanakumar, R., Dineshbabu, A. P., Suresh, V. V. R. and Gopalakrishnan, A

ICAR-Central Marine Fisheries Research Institute, Kochi- 682 018, Kerala, India

*joe.kizhakudan@icar.gov.in

Artificial reefs are sheltered manmade structures, placed on the sea bed as a substitute for natural habitats and serve multiple functions such as fish production, conservation, protection, upwelling, recreation, breeding, and nursery. With proper scientific designing, deployment, and layout orientations and management approaches, they could serve as self-sustaining fish production systems. The ICAR-CMFRI has been working on this from the early eighties in the states of Tamil Nadu, Kerala, Andhra Pradesh and Gujarat on various designs, and has standardized the procedures, materials, volume, proportion of modules and fabrication process. Research conducted on the performance and impacts at the deployed sites shows significant improvements in fish abundance, diversity, fishery, CPUE, fuel economy, revival of vulnerable species, and breeding and recruitment rates of resident populations of several important fishes. A tenfold increase is observed on the bottom fish fauna, while a nearly 20-25-fold increase is seen in the pelagic fish availability over reef sites, with standing stock biomass of 25 tonnes over a reef of 0.15 ha area and a 300-time increase over the annual biomass flux. With an increase of fish catch by 2-3-fold in practices over reefs and giving an average revenue of Rupees twenty-five lakhs over one site and 30% reduction in fuel consumption and fishing time, voluntary participatory management approaches over the reef sites for fishing and maintenance have evolved substantially. An increasing interest in traditional hook and line fishing, and overall demand for more of such habitats have lead to a pioneering project of the Union Department of Fisheries (DoF), to deploy artificial reefs in a total of 3477 fishing sites along the Indian coast to promote sustainable fisheries and traditional fishers livelihood, under the PMMSY-NFDB partnering with all maritime states, UTs and primary fisher panchayaths, Associations/Societies, with the technical guidance of ICAR-CMFRI, for the benefit of traditional fishers of the country. This paper discusses the progress made in the research on artificial reefs in the country and the roadmap for the sustainability of marine resources, improving climate resilience in fish and fishers, and follow up on the SDG 14 guidelines.

Keywords: Artificial reefs, Diversity, Habitats, Resilience, Traditional fisheries

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Potential Arka microbial consortium mitigates drought stress and improves yield in cowpea (*Vigna unguiculata*)

Gowryparvathy, B[1]., Pranav, A[1]., Soundharya, S[1]., Iniyakumar, M.[1]*, Selvakumar, G[2]. And Sudheesh Manalil[1]

[1]Amrita School of Agricultural Sciences, Coimbatore–642 109, Tamil Nadu, India
[2]ICAR- Indian Institute of Horticultural Research, Bengaluru–560 089, Karnataka, India

*m_iniyakumar@cb.amrita.edu

Drought is one of the major global concerns in achieving required crop growth, development and productivity. Drought stress is either avoided by modifying the physiological (production of anti-oxidants, secretion of stress-related hormones) biochemical (accumulation of sugars, glyceine beetine and proline) and metabolic activities (activation of drought mitigation pathway) of the drought-tolerant plants. Plant growth-promoting rhizobacteria (PGPR) can alleviate the impact of drought stress by promoting plant physiological, biochemical and metabolic activities. In this study, the effect of Arka Microbial consortium (a combination of N_2 fixing, P and Zn solubilizing and Plant growth-promoting bacteria) on drought stress [30%, 50%, 75% and 100% Moisture Content (MC) on field capacity) in growth and yield of vegetable cowpea VBN2 was evaluated under pot culture conditions during two growing seasons. Photosynthetic pigments, gas exchange parameters, antioxidant enzyme activity, proline concentration in leaves, nodule weight, plant growth and yield were evaluated. Application of Arka microbial consortium as soil drenching, foliar spray and combinations of soil drenching and foliar spray were evaluated. The Arka microbial consortium increased the contents of chlorophyll a, chlorophyll b and total chlorophyll contents when applied as combinations of soil drenching and foliar application, then soil drenching and foliar spray alone. The consortium also increased net photosynthetic rate, internal CO_2 concentration in the combinational treatment. Reduction in leaf content of proline, lipid peroxidation and SOD were recorded in combination of soil drenching and foliar spray. Further, the yield of was higher in soil drenching and foliar spray at 100% MC followed by soil drenching and foliar spray alone. A slightly reduced yield was observed on 75% MC on filed capacity in the treatment of soil drenching and foliar spray. Therefore, Arka Microbial Consortium can mitigate drought in cowpeas when applied as soil drenching and foliar spray than applied individually.

Keywords: Antioxidant activities, Arka microbial consortium, Drought stress alleviation, Physiological response, Yield improvement

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Ecological and biological criteria to prioritize the selected coastal ecosystem for biodiversity conservation: Andhra Pradesh prospective

Pralaya Ranjan Behera,*1., Vinod, K. and Loveson L. Edward

Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam-530 003, Andhra Pradesh, India

*beherapralaya213@gmail.com

Coastal and marine biodiversity is crucial for ecosystem services and livelihoods, but they are threatened by anthropogenic impacts and climate change. So, to develop effective management measures for their conservation, it is essential to identify and prioritize the ecologically and biologically significant areas. A study along the coast of Andhra Pradesh was undertaken to understand the ecological and biological significance of coastal and marine ecosystems using eight criteria: (i) uniqueness and rarity, (ii) special importance for life-history stages of species, (iii) importance of threatened, endangered, or declining species and/or habitats, (iv) vulnerability, fragility, sensitivity and slow recovery, (v) biological productivity, (vi) biological diversity, (vii) naturalness and (viii) ecosystem functions. The input information for various criteria was collected from published literature and by conducting scoping surveys at 23 sites along the coast from April 2019 to March 2022. Out of the 23 surveyed sites, eight sites (Hamsaladevi, Bhairavapalem, Bantumali, Bheemunipatnam, Pudimadaka, Bangarammapalem, Chollangi and Bhavanapadu) were prioritized and studied in detail. The input information of eight criteria indicated Bhairavapalem and Hamsalladevi to have a higher level of relevance in terms of ecological and biological significance. Pudimadaka, Bangarammapalem, Chollangi, Bhavanapadu, and Bantumalli were found to have a medium level of relevance, while Bheemunipatnam showed a lower level of relevance. The findings can help stakeholders to make judicious planning and decision-making for development projects; however, further research is needed to identify more priority areas for biodiversity conservation and to assess their reliability.

Keywords: Biological significance, Conservation, Coastal biodiversity, EBSA criteria

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Micro-level environment management plan for aquaculture and allied sector and mapping for Mulavukad, a coastal village, in the Vembanad Lake Ecosystem, Kochi, Kerala, India

Shelton Padua, Prema, D*., Kripa, V., Lavanya Ratheesh., Jenny, B., Shylaja, G., Reena V. Joseph., Shyamala, M. P., Vysakhan, P., Seban John and Akhil Babu

ICAR–Central Marine Fisheries Research Institute, P.B. No.1603, Cochin–682 018, Kerala, India

*premadicar@gmail.com

Ecosystem analysis research so far undertaken in the Indian context, aimed at national or macro-level environment management plan (EMP) options, for coastal ecosystems but the present investigation focused on deriving micro-level environment management plans and solutions through a participatory approach for selected tail-end ecosystems to support efficient implementation of the same for the sustainable development of the ecological units. The newly developed ecosystem health index (EHI) and the community-based micro-level EMP protocol to reduce litter accumulation on a participatory basis are the first of their kind in the micro-level management of coastal ecosystems of India. They were developed through on-field, micro-level ecosystem research with people's participation to solve the location-specific problems so as to improve the production and productivity of selected ecosystems. Based on the ecosystem grading, conscientious activities were suggested ward-wise for implementation as per the EHI status. The aquaculture and allied aspects already present in the study area were also noted and acknowledged along with the suggested responsible activities for eco-friendly living. Spatial plans of proposed responsible livelihood options were made into an interactive map. The recommended responsible interventions are effective tools for micro-level governance, for sustainable development of the selected habitats facilitating optimal production in fisheries and aquaculture to improve the economic security of the stakeholders, without compromising environmental sustainability.

Keywords: Economic security, Ecosystem health index,Micro-level environment management plan, Spatial mapping, Sustainable development,

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Water quality parameters and phytoplankton composition of Kumbalangi backwaters during blooming and non-blooming period

Dipti, N. V.*., Shelton Padua, Sobhana, K. S., Prema, D., Ratheesh Kumar., Sreesanth, L., Lavanya Ratheesh, Aju K. Raju, Reena V. Joseph and Grinson George

ICAR–Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*diptinv@gmail.com

Kumbalangi Village with a vast stretch of backwaters is India's first ecotourism village. These backwaters regularly report algal blooms resulting in bioluminescence phenomenon during summer months mainly during March – April prior to pre -monsoon showers. Algal blooming is the rapid increase of algae in water bodies due to favorable nutrient concentration, salinity, and other environmental factors. The aim of the study is to understand the water quality parameters and phytoplankton composition by analyzing samples during bloom and non-bloom period. This year (2023) blooming occurred during the month of March and vanished by April probably due to pre-monsoon showers. Water and phytoplankton samples were collected and analyzed during the months of March 2023 (bloom period) and May 2023 (non-bloom period) using standard protocols. A total of 12 phytoplankton species (*Coscinodiscus* spp.,*Diploneis* spp., *Entomoneis* sp.,,*Navicula* sp., *Surirella* sp., *Dinophysis* sp, *Gonyaulax* sp, *Gymnodinium* sp, *Protoperidinium* sp, *Prorocentrum* sp*)* were found in Kumbalangi backwaters during bloom period. The total phytoplankton count was 1,22,060 cells/l. Dinoflagellate (*Gymnodinium* sp.) contributed the maximum to the phytoplankton composition (1,15,000 cells l^{-1}) which has luminescent properties. During non-bloom period, 9 phytoplankton species (*Amphiphora* sp., *Gyrosigma* sp., *Navicula sp, Odontella* sp., *Ceratium* s p , *Dinophysis* sp,, *Protoperidinium* sp., *Gomphosphaeria* sp, *Microcystis* sp.*)* were found and the total phytoplankton count was 11,620 cells l^{-1}. Favorable aquatic environment trigger the algae to bloom and if the bloom is due to abundance of bioluminescent phytoplankton, it will result in the appearance of glow in the backwaters. The water quality analysis carried out for bloom period during March 2023 revealed the following values; p H (7.4), salinity (17 ppt), turbidity (5.74 NTU) and total chlorophyll (36.04 mg m^{-3}). High turbidity was observed due to the presence of a maximum cell count of phytoplankton. The water quality analysis carried out for the non-bloom period during May 2023 reported the values; p H (7.7), salinity (10ppt), turbidity (2.80 NTU) and total chlorophyll (15.72 mg m^{-3}). Algal blooms can create a negative impact on the aquatic ecosystem in turn affecting the fish mortality and other natural resources of the affected area. Hence, it is important to closely monitor the aquatic systems and device appropriate strategies to manage the algal blooms.

Keywords: Algal blooms, Bioluminescence, *Gymnodinium* sp., Phytoplankton

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Correlation and regression studies on growth, yield attributes and nutrient uptake of traditional rice varieties under System of Rice Intensification (SRI)

Jennifer Flora, G.*, Udhaya Kumar, K., Gobikashri, N. and Kousalya, A.

Division of Agronomy, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore-641 114, Tamil Nadu, India

*jenniferflora1999@gmail.com

Traditional rice varieties, possess unique genetic traits that enable them to thrive in diverse agroecological conditions, resistant to pests and diseases, and possess exceptional nutritional profiles, contributing to enhanced food quality and potential health benefits for consumers. However, Conventional agricultural practices have often led to adverse environmental impacts, including soil degradation and biodiversity loss. To address these challenges, the concept of Nature-Based Solutions has emerged as a promising approach. By incorporating traditional varieties into modern crop production systems, explores their potential for building a more sustainable and food-secure future. Evaluation of Correlation and Regression studies on Growth, Yield attributes, and Nutrient Uptake of different traditional rice varieties cultivated under SRI and the experiment was carried out in the Samba season of 2022-2023 at the Experimental farm of Karunya Institute of Technology and Sciences, Coimbatore under Western Zone of Tamil Nadu. The field experiment was laid out in Randomized Block Design with three replications and consists of seven treatments *viz*., T_1 – *Illupaipoo samba*, T_2- *Vaalan samba*, T_3 – *Mysore malli*, T_4 – *Thanga samba*, T_5 – *Thooyamalli*, T_6 – *Kitcheli samba*, T_7 – *Bhavani* (control). The findings from the study showed that the grain yield was highly significant and positively correlated with straw yield ($r = 0.961^{**}$), DMP at the harvest stage ($r = 0.964^{**}$), N uptake ($r = 0.945^{**}$), P uptake ($r = 0.936^{**}$), K uptake ($r = 0.919^{**}$), No. of productive tillers showed a significant positive correlation ($r = 0.858^{*}$) and in terms of regression, straw yield ($R^2 = 0.9235^{**}$), DMP at harvest stage ($R^2 = 0.9286^{**}$) were the important positive components of grain yield of traditional rice varieties followed by N uptake ($R^2 = 0.8930^{**}$), P uptake ($R^2 = 0.8763^{**}$), K uptake ($R^2 = 0.8444^{**}$), No. of productive tillers ($R^2 = 0.0133^{*}$). From the experiment, the grain yield of traditional rice varieties was highly positive and significantly influenced by the DMP at the harvest stage, NPK uptake, and Straw yield.

Keywords: Correlation, Grain yield, Regression, Traditional rice varieties

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Drought-tolerant rhizobial and non-rhizobial endophytes induced osmotic stress tolerance in black gram (*Vigna mungo L.*) by the footprints of metabolomics

Brundha Annadurai*[1], Udhaya Kumar, K.[2], John Kennedy, Z.[1] and Sivakumar Uthandi[1]

[1]Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore–641 003, Tamil Nadu, India
[2]Division of Agronomy, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore–641 114, Tamil Nadu, India
*brindha.ajn@gmail.com

Blackgram (*Vigna mungo* L.) is an important leguminous pulse crop belongs to family fabaceae, grown in tropical and subtropical countries. The existence of countless interactions between non- rhizobial endophytic yeast *C. tropicalis* VYW1 and *Rhizobium* sp. VRE1 inside nodules benefiting each partner mediated by distinct chemical signaling contributes to several mechanisms including drought tolerance. Volatile organic compounds could directly or indirectly mediate the improvement in disease resistance and abiotic stress tolerance. In this present investigation proline was produced at higher abundance by VYW1 and its interaction with VRE1. Proline may also function as a regulatory signaling molecule during abiotic stress, and it may help the plants to abate the stress. Propanone and pentanone are the major mVOC compounds produced by VYW1 at a recordable level, whereas it was upregulated upon interaction with VRE1. These two compounds are the major precursors for acetoin biosynthesis, which confers abiotic stress tolerance. Therefore, mutually beneficial effects, including enhancement of plant abiotic stress tolerance by co-inoculum of endophytic metabolites, could have resulted from the co-evolution of VRE1+VYW1 with their plant symbionts. Herein, our study affirmed that the complex volatile blends (2,3-butanediol, butanoic acid, 1-hexanol, dimethyl disulfide, formic acid, fumaric acid, acetic acid, pentadecane and 1-butnol) of nodule endophytic *Rhizobium* and *C. tropicalis* might be involved in the enhancement of the growth of blackgram seeds and elicit induced systemic tolerance against moisture stress.

Keywords: Blackgram, Endophytes, Osmotic stress, Signaling molecules, Volatiles

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Promoting sustainability and adaptation in modern agriculture with nano-enable biomaterials

Jai Vardhan Sangat, Harsh Saini*, Anjilina Pearson, Sakshi Paliwal
Sri Karan Narendra Agriculture University Jobner, Rajasthan, India
*harshsaini888999@gmail.com

A shift in agricultural management and governmental policies towards a more sustainable development model is necessary, according to claims that intensive conventional agriculture and climate change have caused serious ecological damages and compromised world food security. Nanomaterials have the potential to facilitate the transition by boosting mitigation, enhancing efficiency, and lowering pollution. This review compiles the most recent improvements in scientific research on smart nanoformulations and delivery systems that enhance plant nutrition and crop protection, nanoremediation techniques for contaminated soils, nanosensors for plant health and food quality and safety monitoring, and nanomaterials as smart food packaging. Additionally, the effect of engineered nanomaterials on soil microbial populations, potential environmental hazards, and future research prospects are also highlighted. The evidence gathered suggests increases in absorption, usage efficiency, targeted distribution of the active components, and reduction of leaching and pollution, even if large-scale manufacture and in-field testing of nano-agrochemicals are still ongoing. The detrimental effects of nanoremediation on microbial communities appear to be minimal, and it appears to increase diversification. High-resolution agricultural monitoring and resource sustainability are made possible by nanosensors, while food safety and food waste are preserved by nanopackaging's catalytic, antibacterial, and barrier capabilities. However, the use of nanomaterials in the agri-food industry necessitates a thorough risk analysis that is supported by appropriate legislation and widespread support.

Keywords: Food safety, Food security, Nano-agrochemicals, Nanosensors, Smart-packaging, Sustainable development goals

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Using nature-derived polymers, the concept of developing nano-delivery systems for agricultural and food applications

Harsh Saini*, Jai Vardhan Sangat and Sakshi Paliwal

Agriculture Research Station, College of Agriculture, Sumerpur, Pali Rajasthan, India

*harshsaini77889900@gmail.com

Nanotechnology has a wide range of uses, and creating useful nanoparticles from polymers produced from nature for agri-food applications is widely thought to be an environmentally friendly strategy that is also safer for use in food for both humans and animals. The development of nano-delivery systems using polymers generated from nature for agri-food applications is the main emphasis of this review in light of this. The review begins with a section that describes the many kinds of nature-derived polymers that are now being employed in various applications in the agri-food business, with a particular focus on microbial extracellular polymeric materials. The main uses of nano-delivery systems in the food industry, such as food fortification and food preservation, are covered. They are also used in the agricultural industry for the controlled release of agrochemicals using polymers sourced from nature. The article concludes with a viewpoint on the security and reputation of foods using nanotechnology, along with a prediction for the future use of nano-delivery systems in the agri-food industry.

Keywords: Agri-food system, Food science, Nanotechnology, Polymers, Sustainable development

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Natural chemicals and revolutionary nanotechnology-based control strategies for the plant protection and food packaging industries

Jai Vardhan Sangat, Harsh Saini*, Anjilina Pearson, Sakshi Paliwal
Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India
*harshsaini777999@gmail.com

A synopsis of the most recent technological developments (including at the nanoscale level) in plant and/or food protection is given. Additionally, both innovative pesticide formulations and packaging techniques address the potential usage of natural and sustainable chemicals as opposed to conventional synthesised molecules or chemical-based compounds. In this perspective, nanotechnological methods represent promising business models for the entire supply chain of the agriculture sector, from the farm to the consumer. Traditional plant protection techniques are frequently insufficient, and using pesticides with chemical bases harms both people and the environment as well as animals and people and the environment. The use of intriguing greener tools could represent effective alternatives for the management of plant diseases using promising strategies. Nanotechnologies enable the promotion of more efficient assembly and the ensuing release of environmentally sustainable active principles, limiting the use of chemicals in terms of financial losses. In the food packaging industry, new antimicrobial, antioxidant, and sustainable systems have been aggressively promoted as a viable eco-friendly alternative to conventional materials for enhancing food product quality and safety while minimising or eliminating environmental impact. This case study increased interests for the creation of innovative edible and environmentally friendly packaging that minimises waste and any negative environmental effects. This refers to the idea of any combination or solution made using nanotechnology that agricultural products must travel through or dip into to create a transparent coating film that increases or enhances their perishability. These agricultural items, together with the solution film covering them, may be kept for an extended period of time and are also edible without suffering any negative effects. The objective in this situation is to demonstrate the value of pesticide reduction techniques and the potential of nanomaterials in long-term plant and food protection for agricultural management and the packaging industry.

Keywords: Active substances, Agri-food system, Packaging, Plant protection, Nnotechnology, Sustainable development

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Management of insect pests infesting brinjal under organic farming

Hemant Swami*, Manoj Kumar Mahla and Anil Kumar Vyas
Department of Entomology, RCA, MPUAT, Udaipur -313 001, Rajasthan, India
*hemantswamy@gmail.com

The investigation on the management of Insect pests infesting brinjal under organic farming was carried out at the organic farm, Rajasthan College of Agriculture, Udaipur during *kharif* 2021. The major insect pests recorded in the field were aphid (*Aphis gossypii* Glover), jassid (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Genn.) and shoot and fruit borer (*Leucinodes orbonalis* Guen.). Evaluation of bio-efficacy of various organic treatments scheduled against, aphid, jassid, whitefly and shoot and fruit borer reveals that the application of Spinosad 45 SC @ 200 ml/ha was proved to be most effective, which caused maximum per cent mean reduction in aphid (55.21), jassid (55.55), whitefly (57.48) and shoot and fruit borer (55.76), respectively. Among the organic treatments the application of Teekha sat @ 10 per cent proved to be most effective with 50.22, 50.65, 50.76 and 38.22 per cent mean reduction whereas application of Dashparni @ 5 per cent proved to be least effective with 41.14, 38.18, 40.03 and 29.37 per cent mean reduction against aphid, jassid, whitefly and shoot and fruit borer, respectively. The maximum marketable fruit yield of (39.16 kg/plot) was recorded in the treatment of Spinosad 45 SC @ 200 ml / ha. Among the different organic treatments, the application of Teekha sat @ 10 per cent recorded maximum fruit yield of (38.85 kg/plot) whereas the minimum yield of (34.54 kg/plot) was recorded in treatment of Dashparni @ 5 per cent.

Keywords: Brinjal, Dashparni, Insect pest, Organic farming, Teekha sat

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Bio-efficacy of various bio-pesticides against brinjal shoot and fruit borer *Leucinodes orbonalis*

Mahla, M. K., Hemant Swami and Anil Vyas
Department of Entomology, RCA, MPUAT, Udaipur -313 001, Rajasthan, India
*mkmahla2@gmail.com

The experiment on bioefficacy of different biopesticides against the brinjal shoot and fruit borer was conducted in *Rabi*, 2022-23 at the Department of Entomology, Rajasthan College of Agriculture, Udaipur. During the experimental period, the incidence of *Leucinodes orbonalis* was recorded on the basis of Shoot infestation and Fruit infestation of BSFB per 5 plants after the first and second spray. Fruit yield was recorded on a whole plot basis. The minimum shoot infestation was found in Spinosad (12.32) followed by *Bacillus thuringiensis* (13.67), Neem oil (15.16), and *Beauveria bassiana* (16.37) in comparison to untreated control (22.46). The minimum fruit infestation was also found with treatment application of Spinosad (11.86) followed *by Bacillus thurengiensis* (13.55), neem oil (14.40), and *Beauveria bassiana* (16.30). The lowest yield was recorded in the untreated control (10.58 t/h) in comparison to all the treatments. The highest yield of 22.60 t/ha was recorded with the treatment application of Spinosad. It could be concluded that biopesticides had promising results in minimizing pest damage with higher yield.

Keywords: *Bacillus thuringiensis, Beauveria bassiana,* Biopesticides, Brinjal, *Leucinodes orbonalis*

Theme: Nature-based Solutions for Sustainable Agri-food Systems
Sub theme: Ensuring Nutritional Security through Natural Resource Management

Management of brinjal shoot and fruit borer using selected biopesticides

Anil Vyas, Mahla, M. K., Hemant Swami, Kuldeep Kumar and Deependra Saini
Department of Entomology, Rajasthan College of Agriculture (MPUAT), Udaipur -313 001, Rajasthan, India
*vyasdr2004@gmail.com

The experiment was conducted to evaluate the efficacy of seven biopesticides against brinjal shoot and fruit borer, *Leucinoes arbonalis* during Kharif 2023 at agronomy farm, Rajasthan College of Agriculture, Udaipur. The results revealed that the maximum reduction in BSFB population of 64.06% was recorded in the treatment Spinosad 45 SC and significantly superior over rest of the treatment. The next most effective treatments were *Metarhizium anisopliae and Bacillus thuringensis* which gave 49.65 and 47.81% reduction, respectively. A minimum reduction of 24.78% was recorded with the treatment of Azadirechtin. The order of effectiveness of biopesticides on the basis of percent reduction in shoot and fruit population was Spinosad 45 SC 0.4 ml l^{-1}.> *Metarhizium anisopliae* 10 g > *Bacillus thuringensis* 2 g l^{-1} > *Beauveria bassiana* 5 g l^{-1} > *Lecanicillium lecanii* 5 g l^{-1} > *Azadirechtin* 2 ml l^{-1}.

Keywords: Azadirechtin, BIPM, Biopesticides, *Leucinoes arbonalis*, Spinosad

XII AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 8

Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems

Digital Agriculture

Artificial Intelligence based Systems

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Site-specific spraying system for eco-friendly disease management in vegetable crops

Rohit Anand* and Roaf Ahmad Parray
ICAR-Indian Agricultural Research Institute, New Delhi, India
*anandrohit0621@gmail.com

The reduction of chemical wastage and environmental degradation has been a major challenge with traditional techniques of spraying application in agricultural or horticultural crops. Conventional sprayers have limited options for adjustments for varying the rate of chemical application based on requirements. The sensor-based sprayers with capability of detecting the diseased regions and applying inputs directly on specific sites have great potential to save chemicals and protect the environment. During the last decade, there has been a major shift towards the development and use of sensor-based sprayers. In India, about 82% of the farmers are of the small and marginal category that mostly rely on low-volume sprayers like knapsack sprayer for the application of plant protection chemicals. Lack of precision approach in such spraying technology results in the blanket application of pesticides that leads to large environmental pollution and human health issues. An attempt was made to modify the sprayer for targeted application. Machine learning techniques, especially S upport V ector R egression and D ecision T ree algorithms, were employed to develop models that accurately distinguish between diseased and non-diseased regions. The most accurate model was integrated into an electronic control unit, which consisted of a raspberry pi microprocessor, a relay switch, a buck converter, and a pump. The optimum sensor-nozzle holding unit design was created and produced using a 3D printer. The spray characteristics of the developed sprayer were observed under various pressures, heights above the crop canopy, and operational speeds The sensor-controlled discharge unit and electronic control unit were integrated with the knapsack sprayer, for the development of the sensor-based site-specific sprayer. Compared to conventional sprayers, the developed site-specific sprayer resulted in a chemical saving of 69-72 % in black rot-infested and leaf spot disease-infested vegetable crops. The field capacity of the sprayer was observed to be 0.036 $ha.h^{-1}$. This sensor-based site-specific sprayer holds great potential for targeted spraying applications in cauliflower and brinjal crops, offering significant savings in crop protection budget for small and marginal land-holding farmers in India.

Keywords: 3-D printing, Low volume sprayer, Machine learning, Precision, Site-specific spraying,

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Automation of irrigation pump for enhancing agricultural water productivity

Rautaray, S. K.*, Sethi, D., Sarangi, A., Jena, S. K., Ajit K. Nayak, Pradhan, S., Ashok K. Nayak and Bandyopadhyay, K. K.
ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India
*sachin.rautaray@icar.org.in

Automation of agricultural operations is useful to save time, labour and energy besides developing skill of youth to attract them to agriculture. Automatic on and off of irrigation pump can avoid overuse of water, and save energy. Night irrigation is recommended to reduce evapotranspiration loss, and practised in late night when electric supply is stable and reliable. However, there is risk of snake bite and other hazards at night time while visiting field for operating pump. Farmers prefer to run the pump at night, which continues till subsequent morning as both the electricity and ground water are often free inputs. With the rising crisis of water and energy, their overuse is unaffordable. At this juncture, advancements in electronics and information technology is useful for pump automation. This work introduces an automation system that could mitigate the woes of farmers without overexploiting water resources. Components of the developed automation system of AWD (Alternate wetting and drying) based irrigation scheduler are Arduino Nano based Microchip ATmega328P microcontroller unit, Sim800L, Relay Module, Dc to Dc buck converter, 7805IC (integrated circuit), ultrasonic sensor, perforated PVC pipe (40 cm height and 20 cm diameter). Tentative cost of these components for one unit was Rs 5000. The developed module was tested in rice and was observed to save water by 18% as compared to the conventional irrigation method in puddled rice with a yield penalty of about 5%.

Keywords: Microcontroller, Mobile phone, Pump on and off, Relay Module, Water level sensor

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Picro-DB: A comprehensive genomic resource portal for *Picrorhiza kurroa*, a medicinal plant

Prakash Kumar*, Tanvi Sharma, Nitesh Kumar Sharma, Ravi Shankar and Sanjay Kumar

ICAR-Indian Agricultural Statistics Research Institute, New Delhi, India

*prakash.kumar@icar.gov.in

Picro-DB stands as a pivotal database housing the genome of *Picrorhiza kurroa*, a member of the Scrophulariaceae family renowned for its medicinal properties. Emerging from the Picrorhiza genome sequencing initiative, this repository serves as an inclusive portal for *Picrorhiza kurroa*, providing easy public access. Constructed upon the *de novo* assembled draft genome of *P. kurroa*, it stands as a pioneering reference for genomic and molecular explorations concerning this plant. Notably, this database holds the distinction as the inaugural genomic sequencing resource for the Scrophulariaceae family. Augmenting its utility, Picro-DB offers indispensable tools like BLAST and BOWTIE mapping, facilitating sequence similarity searches and mapping functionalities, thereby bolstering genomic analyses. In its development, Picro-DB incorporates interactive features like radial plots, circle plots, and krona plots, ensuring user-friendliness and comprehensibility. Highlighted by an integrated genome browser and advanced visualization capacities, Picro-DB empowers users to delve into diverse genomic constituents encompassing genes, repeats, miRNAs, transcription factors, and the reference genome. By extending the *P. kurroa* reference genome online, this resource simplifies the acquisition of expansive insights into the *Picrorhiza kurroa* genome, fostering conservation and broader botanical investigations. (Web portal URL : https://scbb.ihbt.res.in/picro-db/)

Keywords: BLAST, BOWTIE mapping, *De novo* assembled draft genome, Integrated genome browser

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Effect of accelerated ageing on seed coat anatomy

Selvarani, K.* and Pallikonda Rajasekaran, M.

[1]Kalasalingam School of Agriculture and Horticulture, Kalasalingam Academy of Research and Education, Virudhunagar-626 126, Tamil Nadu, India
*selvaranimanikandan@gmail.com

The present investigation was carried out in the Seed Science and Technology Laboratory of Kalasalingam School of Agriculture and Horticulture, and anatomical observations were performed under Scanning Electron Microscopy (SEM) from the International Research Centre, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu,

In order to determine the effect of accelerated aging in seed and seedling quality of selected crops and to analyse the changes in seed coat anatomical structure with accelerated ageing. In this study, seeds of five crops *viz.*, paddy, maize, black gram, green gram and groundnut. Seeds were collected and half of the seeds were subjected to accelerated ageing to obtain low-quality seeds. The accelerated aging was done for 5 days by keeping the seeds in perforated butter paper cover and the seeds with butter paper covers were kept in a desiccator with 100% RH and the desiccator was placed in incubator with 40^{0}C for five days. Twice a day the papers were taken out and agitated for few seconds to avoid fungal contamination. After five days the aged seeds were taken from the desiccator and shade-dried for one day. The control seeds (High quality seed) and 5 days accelerated seeds were subjected to germination test by pleated paper method. Parallelly the seed samples were observed under SEM for their anatomical structure. After 7 days, the seedling performance of high and low quality seeds were studied and the performances were compared with SEM images. Significant anatomical structural differences were observed under SEM for maize, black gram and green gram. In green gram the significant difference was only observed in root length. In case of paddy and ground nut, low initial seed quality was observed. Hence the germination did not occur but the anatomical structure changes were observed significantly under SEM. With this concept, the development of a Seed Quality Analyzer with Artificial Intelligence (AI) is possible and it will be highly useful for Seed Testing Laboratories, Seed Industries and Farmers.

Keywords: Accelerated ageing, Seed anatomy, SEM, Seed germination, Seed quality.

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Mid-infrared spectroscopy for assessment of soil health in India

Nishant K. Sinha[1]*, Hati[1], K. M.[1], Mohanty, M.[1], Pramod Jha[1], Coumar, V.[1], Thakur, J. K.[1], Lenka, N. K.[1], Chaudhary, R. S.[1], Akeel Rizvi[2] and Dhyani, S. K.[2]

[1]CAR-Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal, India
[2]South Asia Regional Program (SARP), ICRAF, New Delhi, India

*nishant.sinha76211@gmail.com

Spectroscopy is emerging as one of the most promising technologies for rapid and cost-effective alternatives to routine laboratory analysis for many soil properties. This study was conducted to evaluate the potential of the mid-infrared spectroscopy technique for rapid and non-destructive measurement of some important soil properties in major soil orders of India. More than 1500 geo-referenced soil samples from 0-15 cm soil layer of Alfisols, vertisols, and inceptisols were collected from different parts of India. The partial least-squares regression, random forest, and support vector machines were compared to calibrate spectral data with wet chemistry soil data. The coefficient of determination, root mean square error and residual prediction deviation (RPD) were used for the model evaluation. We found that the PLSR-based predictive models performed better than the other two regression techniques for all the soil properties. Good predictions with independent validation data sets were obtained for clay, sand percentage, and soil organic carbon (SOC) content, while satisfactory predictions were achieved for silt percentage and pH value. However, the performance of the predictive models was poor in the case of EC and extractable nutrients such as available phosphorus and potassium contents of the soil. Specific regions of the MIR spectra that contributed to the prediction of soil SOC, pH, clay, and sand percentage were identified. The study demonstrated the potential of the MIR spectroscopic technique in simultaneous estimation of SOC content, sand, clay, silt percentage, and soil pH.

Keywords : Mid–infrared spectroscopy, Predictive models, Random forest, Support vector machine

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Soil test crop response based online fertilizer recommendation system for FCV tobacco yield targets in northern light soils of Andhra Pradesh

Ravi Sankar, H.[1]*, Prasad, L. K.[1], Sheshu Madhav, M.[1], Poorna Bindu, J.[1], Chandrasekhara Rao, C.[1] and Damodar Reddy, D.[2]

[1]ICAR-Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh, India
[2]ICAR-National Academy of Agriculture Research Management, Hyderabad, Telengana, India

*hravi.sankar@icar.gov.in

Soil testing as a tool for judicious fertilizer application is a recognized practice all over the world which takes care of too little, too much, or disproportionate applications of nutrients. The concept of Soil Test Crop Response (STCR) and targeted yield approach aims at precise quantitative adjustment of fertilizer doses under different soil test values for given yield targets. FCV tobacco leaf quality is very much influenced by the inherent soil fertility and applied fertiliser nutrients, especially nitrogen and potassium. In view of the above, an online software was developed to provide site specific balanced fertilise recommendations for a yield target of FCV tobacco through STCR based prescription equations developed for Northern Light Soils of Andhra Pradesh. Using this software, farmers can get fertiliser recommendations for their fields based on soil test values for a desired FCV tobacco yield target. The software was developed in the form of a web portal with two main modules *viz*., 'Administrator' and 'User'. Administrator module is an authentication-based module which allows the administrators / programmers to view / edit the target yield equations, view the list of users (farmers) data which was entered into this software for computations. The 'User' module allows the user to enter the data such as farmer details and soil test data. Once the 'submit' button is selected, report will be generated for the selected yield target. Provision is also made to print the hard copy of the same. 'Contact' option allows the user to give their suggestions in the 'Message' box which includes their name, email and mobile number. The software was created using 'Bootstrap' a front-end development framework for faster and easy accessing, Code was developed using Personnel Home Page (PhP) and database in 'MySql' with an interface for accessing data and performing computations. The software is developed in such a way that it can be upgraded to provide fertiliser recommendation to the FCV tobacco farmers of the other regions in the country. It is a versatile and easy form of fertiliser recommendation software which will assist the FCV tobacco farmers in getting an efficient, balanced and profitable fertilizer recommendation for specified yield targets and also helps in sustainable FCV tobacco production by maintaining the soil fertility.

Keywords: Bootstrap, Database, Farmer, FCV Tobacco, Software, STCR

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Does the method to calculate soil water dynamics in a crop model change yield predictions, and what it means for climate change impact assessment?

Surendran, S.* and Jaiswal, D.

Environmental Sciences and Sustainable Engineering Centre, Indian Institute of Technology Palakkad, Kanjikode, Palakkad – 678 623, Kerala, India.

*162114001@smail.iitpkd.ac.in

The interdependence of plants, soil, and climate is fundamental to ecosystem functioning. Plant physiology is significantly impacted by the constantly changing climate, which in turn has an impact on soil processes. Plant physiological processes such as stomatal conductance, photosynthesis, root growth etc. are impacted by climate-related factors such as rising temperatures, rising atmospheric CO_2 concentrations, and altering precipitation patterns. These modifications have a substantial impact on interactions between soil and plants, such as root water uptake, plant water use efficiency, transpiration rates etc. Assessing the effects of these climate-induced changes on soil water dynamics, plants and plant processes is crucial for determining how they will impact plant yield. In order to investigate the relationship between soil water dynamics and plant yield we employed a mechanistic plant growth model BioCro and a comprehensive model for soil water transport, HYDRUS 1-D. BioCro excels in accurately simulating critical plant processes including light interception, photosynthesis, biomass partitioning, transpiration etc. at a leaf scale, which can be extended to a canopy scale and a field scale if required. The model incorporates climate variables as input for its simulation. The soil water dynamics in BioCro is simulated using a simple bucket model. While on the other hand HYDRUS 1-D simulates uni-dimensional water, solute and heat transport through unsaturated porous media. The plant dynamics in HYDRUS 1-D are simulated by a simple statistical distribution of roots, crop height and Leaf Area Index (LAI), that needs to be provided as inputs. By integrating the outputs of BioCro into HYDRUS 1-D we examined the resulting effects of dynamic representation of plants in HYDRUS 1-D, which otherwise uses a statistical approach to depict plants as mentioned earlier. We then, in sequence, incorporated the HYDRUS 1-D soil water simulations results onto BioCro to investigate the impact of changing the method to calculate soil water dynamics on crop yield predicted by BioCro. The method used here is an input/output data exchange between the two models. This study also discusses the future prospects of coupling HYDRUS 1-D and BioCro showcasing the necessity and benefits of integrating these models. The coupling of these models holds tremendous potential in addressing future challenges related to sustainable agriculture and water resource management. By combining the capabilities of BioCro and HYDRUS 1-D researchers can gain valuable insights into the complex dynamics between climate, plants and soil allowing for more informed decision making in agriculture.

Keywords: BioCro, Climate Change Impact, HYDRUS 1-D, Plant Yield, Soil water dynamics.

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Benefits and implications of adopting raised bed pneumatic precision multi-crop planter: Ground breaking technology

Avesh Kumar Singh*, Pramod Kumar Sahoo, Dilip Kumar Kushwaha, Nrusingh Charan Pradhan, Soumya Krishnan, V., Aruna, T. N. and Kishan Kumar

Division of Agricultural Engineering, ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India

*avsingh298@gmail.com

The adoption of raised bed pneumatic precision multi-crop planters represents a significant advancement in modern agriculture, addressing key challenges faced by farmers and contributing to sustainable farming practices. This study explores the benefits and implications of integrating this innovative technology into agricultural systems. Cultivation of raised beds has become popular because it improves soil structure, reduces erosion, and improves water management. The pneumatic precision-crop planter for raised beds is a revolutionary tool that meets this end. Pneumatic technology allows for accurate seed placement and consistent spacing across raised beds. Precision planting not only increases seedling emergence, but also reduces seed waste, resulting in higher crop yields and increased resource efficiency. In addition, this planter's multi-crop capability allows farmers to select from a variety of crops, allowing them to diversify their crops and reduce the risk of monoculture. The adoption of this technology can have far-reaching impacts on sustainable agriculture, including improved crop rotation, improved soil health, reduced reliance on chemical inputs, and increased ecosystem resilience. In addition to the agronomic benefits, the Pneumatic Precision Multi-Crop Planter in the raised bed reduces labor costs and the time it takes to sowing. This innovation allows farmers to improve operational efficiency while reducing manual labor, improving the profitability of their farming operations. However, the adoption of this technology also comes with challenges related to initial investment costs and the need for training to operate and maintain the equipment effectively. Policymakers, researchers, and officials manning agricultural extension services must collaborate to facilitate the widespread adoption of this technology and ensure its benefits reach smallholder farmers. In conclusion, the utilization of raised bed Pneumatic Precision Multi-Crop Planters has the potential to revolutionize modern agriculture, potentially leading to higher crop yields, increased resource efficiency, and the promotion of sustainable farming practices. This technology is essential in addressing the ongoing issues of food insecurity and environmental sustainability in the agricultural sector. It is imperative that policy makers and stakeholders collaborate to ensure the successful adoption of this revolutionary technology for the advancement of agriculture and the preservation of the environment.

Keywords: Multi-Crops, Planter, Pneumatic technology, Precision agriculture, Raised bed

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Exploring occupational hazards and the role of life saving gadgets among small-scale motorised fishermen of the southern coast of India

Sabu Mariadason* and Shinoj Parappurathu

Fishery Resources Assessment, Economics and Extension Division, ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*sabumaria@gmail.com

Fishing is widely recognized as one of the most dangerous occupations in the world, with fishermen operating smaller crafts facing increased vulnerability to the unpredictable nature of the ocean. Impactful sea currents, wind speed, direction, wave heights, and other climate-related factors contribute to various accidents at sea. Additionally, lack of awareness regarding life safety gadgets (LSGs) and their ineffective utilization further intensify the risks associated with life at sea. Moreover, the absence of physical boundaries increases the likelihood of fishermen unintentionally straying into areas beyond Exclusive Economic Zones (EEZ) and other countries' territorial waters, highlighting the urgent need for research in this area. This study aims to identify the major occupational accidents and analyze the role of life safety gadgets among small-scale motorised fishermen in the southernmost coastal regions of India. A qualitative study and survey based analytics were employed to collect data. Data analysis involved content analysis and statistical measures such as the arithmetic mean, standard deviation, standard error, and an effective five-point Likert-scale mean score method. Among the seven identified occupational hazards, physical hazards emerged as the most prominent (mean score: 172.8), followed by environmental hazards (mean score: 112.44) and psychological hazards (mean score: 101.14). Communication devices, such as Very High Frequency wireless sets(VHF), were found to be the most useful for obtaining weather information at sea, with satellite phones being in high demand for deep-sea communication purposes. It was observed that a significant portion of the active fishermen population in the study areas still lacked a reliable and effective boat-to-shore communication network. The findings of this study have implications for the amendment of fishery policies and the implementation of effective fishery management in India. By shedding light on the prevalent occupational hazards and the role of life gadgets, this research provides valuable insights that can contribute to enhancing the safety and well-being of small-scale motorised fishermen in India's southernmost coastal regions.

Keywords: Life gadgets, Motorised crafts , Occupational hazards, Small-scale fishermen

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Revolutionising agriculture: Harnessing the power of digital technology

Dilip Kumar Kushwaha, Pramod Kumar Sahoo, Nrusingh Charan Pradhan, Soumya Krishnan, V., Aruna, T. N., Kishan Kumar and Avesh Kumar Singh*

Division of Agricultural Engineering, ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India

*avsingh298@gmail.com

India accounts for 11 percent of global agriculture production, and is also home to the world's highest malnutrition rate. Agriculture sustains about half of India's population, with small-scale farmers making up the majority. However, most government agricultural subsidies go to medium-to-large-scale farmers. In a time of growing global population and environmental challenges, digital agriculture offers sustainable solutions that improve productivity, reduce resource waste, and promote resilience. Through the integration of Internet of Things (IoT) devices, sensors, and data analytics, farmers gain real-time insights into crop health, soil conditions, and weather patterns. This allows them to make data-driven decisions, optimize resource allocation and minimize environmental impact. In addition, digital-based precision farming practices enable precise planting, irrigation, and pest control, thereby optimizing crop yields while saving water and reducing usage. This abstract will discuss how the digital frontier is transforming the way we farm, harvest, and deliver the food that feeds us all. The adoption of drones and automated robots further streamlines labour-intensive tasks and ensures efficient farm management. By creating a supportive ecosystem that integrates innovation with inclusion, India can unlock its full potential in digital technologies in agriculture.

Keywords: Automated robots, Drones, Internet of Things (IoT), Precision farming

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Adoption of agricultural technologies *vis-à-vis* communication networks

Anshida Beevi, K., Ravi Shankar, C. N. and Singh V. K.

ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Santoshnagar, Hyderabad, Telangana-500059

*anshida.cn@icar.gov.in

The adoption of agricultural production technologies and natural resource management practices is an essential means for boosting agricultural productivity particularly in developing economies. The importance of developing appropriate technologies and promoting their adoption by the farmers is the most fundamental component of this process. The policy makers, donors and development practitioners have given due importance and recognition for extension and advisory services which are meant for this purpose and are critical for improving agricultural productivity, promoting overall development of the economy. Extension and Advisory Services (EAS) have been saddled with the responsibility to develop appropriate technologies and promote its adoption. But over the years under-investment and top-down approaches have led to inefficient service provision and low rates of technology adoption. In this context, the novel extension approaches should be formulated by considering farmers' specific needs, constraints and capacities. One of the keys to success in the design of such novel extension approach is more intensive leveraging of farmers' social networks which are mostly informal communication channels, which farmers employ to receive and share information on new technologies. Such networks are particularly important to small-scale, resource-poor farmers, who tend to rely more on informal than formal sources of information, as well as to women farmers, whose information needs are often not addressed by the existing formal extension services. Hence, leveraging farmers' networks would be very time efficient and cost effective, as these social structures already exist and would not have to be constructed artificially, as in other extension approaches.

Keywords : Extension, Advisory services, informal communication channels

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Development of sustainable agri-food system by digital food hubs

Harsh Saini* and Sakshi Paliwal*
Agricultural Research Sub-Station, College of Agriculture. Sumerpur, Pali, Rajasthan
*harshsaini7187@gmail.com

This writeup is based on insights into what a community digital food hub is with the perspective of de-agrarianization and its causes, as well as topics like the sustainability of agri-food systems, and concepts like "shared value" that can be used to boost an organization's competitiveness and the economic and social conditions in the communities where it operates. In addition to these forums, an excursus is performed on the actual advancements of the "field to table" model appliances, with the new opportunities derived from contemporary types of distribution networks, focusing especially on Food Hubs and the initial justifications for the system's validity. After addressing these concerns, the focus is solely on the Food Hub topic, with a definition of the topic's nature and the models that have been used to establish its many structures, as well as an analysis of the social and local settings in which this reality is situated or developed. The study's findings must be seen in the prospects of developing a digitalized food hub for industries and organisation to make it possible "from field to table". This could be a source of economic recovery in this sector with the potential for both digital and non-digital development along with the development of sustainable agriculture. The moot case of food hub in Italy is taken into account while determining potential legal changes for the innovation, the present issues facing by Italian politics are moreover, the "New Generation EU" European Plan has allocated significant funds to Italy for the development of digital innovations. However, with the assistance of ATMA (agricultural and technology management administration), as well as the marketing of the "made in India" label by a digital food hub through import and export, this is quite achievable for Indian scenario.

Keywords: Agri-food system, Food, Food hubs, Sustainable development

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Digital Agriculture

Integrating digital and Hi-Tech farming practices for enhanced agricultural safety and productivity: A case study in Pali District, Rajasthan, India

Sanjay Khatri* and Sanwal S. Meena

Department of Farm Machinery and Power Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India

*anjaykhatri518@gmail.com

A case study was conducted in Pali district, Rajasthan, India, to examine the link between digital and hi-tech farming practices and their impact on agricultural safety, productivity, and overall farm development. The study investigates factors such as land holding patterns, mechanization levels, government support services, and their influence on agricultural practices in the surveyed villages. The analysis reveals that the level of farm mechanization was highest in Marwar Junction block, Pali district. Farms utilizing custom hiring mechanization with tractors of average 30-35 horsepower exhibited the highest average yields of rabi and kharif crops. This efficient use of mechanized farming practices resulted in increased net returns per hectare, showcasing the potential benefits of adopting digital and hi-tech solutions in farming. Furthermore, the study highlights the occurrence of agricultural injuries within the surveyed area during the year 2021-22. The agricultural injury incidence rate was found to be 0.3 per 1000 workers per year, with farm machinery-related injuries accounting for 33.33% of reported cases. The remaining injuries were attributed to factors such as animal bites, slips, and falls in the field. The majority of victims were in the age group of 40-50 years, emphasizing the need for improved safety measures and awareness among farmers. To address these safety concerns, demonstrations and distributions of safety gears were conducted within the villages, leading to increased awareness and adoption of protective equipment among farmers. As digital agriculture continues to advance, prioritizing operator safety is crucial for the successful implementation and widespread adoption of digital technologies. By integrating safety features leveraging real-time monitoring and AI-powered systems, providing comprehensive training, and fostering collaboration among stakeholders, a secure farming environment can be created. This will not only protect the well-being of operators but also contribute to the overall sustainability and success of digital agriculture. By embracing technology-driven solutions and mechanization, farmers can optimize their yields, improve income prospects, and minimize the risks associated with traditional farming practices. Government support services and awareness campaigns play a crucial role in promoting the adoption of safety gear and fostering a culture of health and safety within the farming community. In conclusion, the findings of this study demonstrate the positive impact of digital and hi-tech farming practices on agricultural safety and productivity. Encouraging the adoption of digital and hi-tech farming practices through supportive policies and awareness campaigns will contribute to the growth and prosperity of the agricultural sector.

Keywords: Farm mechanization, Machinery accidents, Machinery safety, Mechanization status.

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Diversity in fished taxa of Andhra Pradesh: Mined insights from marine fishery resources database

Sreepriya, V., Jayasankar, J., Eldho Varghese*, Muktha, M., Manu, V. K., Sindhu K. Augustine, Manjeesh, R. and Pooja Krishna

ICAR-Central Marine Fisheries Research Institute, Post Box No. 1603, Ernakulam North P.O., Kochi-682 018.

*eldhoiasri@gmail.com

Marine fishery resources database plays a critical role in the conservation and sustainable management process of marine fishery resources. It allows researchers to analyze historical data, detect trends, and investigate the factors that influence fish populations and ecosystems. Understanding the composition of resources is particularly important in biodiversity-rich tropical regions as it helps comprehend ecosystem changes resulting from fishing activities. Furthermore, having information on fished taxa is essential for gaining insights into biodiversity, ecological processes, and the impact of human activities on marine environments. Template-driven mixture of taxa often have limited scope in giving the correct picture of the species that are landed in a region, both in terms of their availability and being targeted on a regular basis. However, species-level information is very vital in determining which species should be assessed in a multispecies context to develop effective fishery management strategies and plans. Therefore, this study highlights the wealth of information available in the Marine Resources Data Warehouse (SARDINE@ICAR-CMFRI) pertaining to Andhra Pradesh. The diverse range of fished taxa has been classified based on the frequency of their occurrence over time. This database will prove immensely valuable to researchers and policymakers in assessing fish stock status, identifying trends in landings/occurrence of vulnerable or endangered species, and designing effective management strategies to prevent overfishing and ensure long-term sustainability.

Keywords: Data warehouse, NMFDC, SARDINE@ICAR-CMFRI, Species diversity, Stock assessment

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Dugong habitat and distribution: An Ensemble Distribution Model-based approach for conservation planning

Vinayak, S.*, Durga, V., Mohamed Nisin, K. M. N., Sreenath, K. R., Ratheesh Kumar, R., Gopalakrishnan, A.

[1]ICAR–Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*vinayakmanu2@gmail.com

The *Dugong dugon* (Müller, 1776) Palmer, 1895 possesses noteworthy biodiversity value given its unique position as the sole extant sea cow species of the Dugongidae family and its reliance on declining seagrass communities. Dugongs encounter a diverse array of challenges throughout their geographical range, encompassing inadvertent net entanglement, direct hunting practices, alteration and deterioration of their vital seagrass habitats, collisions with watercraft, pollution, and the consequences of climate change. The combined influence of these factors plays a significant role in the vulnerability condition of its geographically isolated populations, ultimately pushing them towards the threshold of extinction. Recognizing the importance of delineating their optimal habitats for focused conservation, this study employed ensemble Species Distribution Modelling (SDM) to assess the habitat suitability of dugongs globally. The ensemble modelling method, which integrates species occurrence and environmental data, was used to build eleven different models (ANN, CTA, FDA, GAM, GBM, GLM, MARS, MAXENT, RF, SRE, XGBOOST). Our results highlight a strong habitat preference in regions of the western Indian Ocean, particularly on both sides of the Mozambique channel, the Persian Gulf, the northwest coast of India, the Gulf of Mannar and the northeast Australian coast. In light of this unique animal's heightened sensitivity to anthropogenic disruptions and climate variances, this study offers insights into the essential habitats demanding immediate conservation attention.

Keywords: Environmental determinants, Global distribution, Habitat suitability, Species distribution model,

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Long short-term memory based regression approach for freshness assessment of Genetically Improved Farmed Tilapia

Murali, S.*, Reshma, R., Sreelekshmi, B., Aniesrani Delfiya, D. S., Murugadas, V., Binsi, P. K. and George Ninan
ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India
*murali.s@icar.gov.in

The study focuses on the development and implementation of an algorithm which is capable of predicting the shelf-life and freshness of genetically improved farmed tilapia (GIFT) using shape-based feature descriptors and a deep learning technique. The fresh GIFT samples were subjected to iced storage under good manufacturing practice (GMP) conditions for 30 days. The variations in the eye region of fishes evidently indicated different stages of edibility and spoilage. The K-value, Psychrotrophic count and image acquisition of fish samples were performed daily to obtain valid reference data for classification and algorithm development. The daily acquired images were preprocessed and the eye region was segmented using openCV. The image dataset is subjected to augmentation by varying Saturation, Contrast, Hue, Reflection, Brightness and Gaussian Noise. These variations were interpreted using shape-based descriptors such as convexity, solidity, contour curvature, and ellipse variance and were fed as inputs to long-short term memory (LSTM) regression network. The optimized model is then used for the assessment of the shelf-life and freshness of test samples. The performance evaluation results show that the root mean square error (RMSE) value and mean absolute percentage error (MAPE) of the optimized LSTM model are 0.327 and 12.956 %, respectively. The results of quality indicators, i.e. K-value, and Psychrotrophic count classified the fish samples into extremely fresh (till 12 days), fresh (13-24 days) and spoiled (> 24 days). The test results showed that the algorithm with the optimized model exactly predicted the remaining shelf-life and classified the freshness level of fish into Extremely Fresh, Fresh or Spoiled with an average prediction accuracy of 83.21 %. The methodology can be adapted to different fish species and can provide practical solutions to consumers for the freshness assessment of fish.

Keywords: Deep learning, Convex Hull, K-value, Psychrotrophic count Recurrent neural network

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Convolution neural network-based nitrogen deficiency detection in plants using leaf images

Anish Sathyan* and Palanisamy, P.[1]

CIG, CDAC, Vellayambalam, Thiruvananthapuram-695 033, Kerala, India
National Institute of Technology, Thiruchirapalli, Tamil Nadu, India

*satyan@cdac.in

In agriculture, our farmers are not equipped with the precise methods to classify & identify nutrient deficiency or plant diseases. S o they cannot take appropriate remedial measures. Nutrient deficiency causes adverse effects on both the uptake and yield of the plant. The metabolic activities of the crop changes, and this results in a reduced life span. Nutrients are essential in correct proportion for the ideal growth and uptake of the plant and to ensure optimum yield. In this scenario, the real-time plant nutrient assessment at a regular interval of the plant's life cycle and the timely application of fertilisers to optimise growth and yield is highly imperative. Plant nutrient deficiency can be identified at an early stage by analysing the colour gradient or patterns developed over the leaves. The latest advancements in Image Processing, Deep Learning (DL) and Artificial Intelligence (AI) could help farmers in various ways. This paper describes the deep learning-based nutrient deficiency segregation methods from the leaf images. We have used the International Plant Nutrition Institute (IPNI) dataset for the analysis. Integrating data processing/analytic methods backed by Artificial Intelligence / Machine Learning is essential for making precise decisions in controlled cultivation. Convolution Neural Network (CNN) and learning algorithms are implemented to reduce the loss and increase the accuracy. The model used more than 1.5 million parameters to predict the deficiency correctly. We propose an SGD-based training mechanism to balance the localisation and classification tasks. Image segmentation, clustering, Convolution Neural Network (CNN) and Pooling algorithms are developed as part of the learning model. Transfer learning techniques and CNN are used to reduce the training time. Thus, the developed sophisticated system delivers an accuracy of 96.67% or more with a loss value of 1.48%.

Keywords: AI, CNN, Classification, Deep learning, Nutrient deficiency, Prediction, SGD

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Introducing the AI-DISC Mobile App: Advancing intelligent crop health management through Artificial Intelligence for disease identification in crops

Sudeep Marwaha[1], Agrawal, R. C[2], Rajender Parsad[1], Ramasubramanian, V[1]., Alka Arora[1], Anshu Bharadwaj[1], Ajit[1], Shashi Dahiya[1], S. N. Islam[1], Chandan Kumar Deb[1*], Md. Ashraful Haque[1], Sapna Nigam[1], Mrinmoy Ray[1], Achal Lama[1], Soumen Pal[1], Rajni Jain[5], Sujay Rakshit, P. Lakshmi Soujanya[3], Sumit Kumar Aggarwal[3], K. S. Hooda[3], Brejesh Lall[4], Lokesh Gupta[17], Kalpit Dipakkumar Shah[6], Prasannakumar MK[7], V. S. Acharya[8], Abhishek Shukla[9], Ladhu Ram Choudhary[10], Palash Deb Nath[11], Shubha Trivedi[12], Mehraj Ul Din Shah[13], Ravinder Singh Rana[14], Subrata Dutta[15] and Vaibhav Kumar Singh[16]

[1]ICAR-Indian Agricultural Statistics Research Institute, New Delhi, India
[2]National Agricultural Higher Education Project, New Delhi, India
[3]ICAR-Indian Institute of Maize Research, Ludhiana, Punjab, India
[4]Indian Institute of Technology-Delhi, New Delhi, India
[5]ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi, India
[6-17]State Agricultural University

*chandan.deb@icar.gov.in

AI-DISC, acronym for the Artificial Intelligence-Based Disease Identification for Crops, stands as an advanced Android mobile application developed by the ICAR-Indian Agricultural Statistics Research Institute. This cutting-edge application harnesses the power of deep learning techniques to unconventionally recognize and diagnose a staggering 50 plant diseases across 19 major crop varieties. The AI-DISC app is bestowed with an intuitive user interface, enabling users to effortlessly capture images of afflicted plants. In return, it offers prompt disease identification and provides valuable guidance on potential remedies. Its scope encompasses a broad spectrum of crops and their associated diseases, rendering it an invaluable tool for farmers and agriculturists. As a flagship digital tool, AI-DISC occupies a distinguished position as a premier artificial intelligence application tailored for plant disease identification. It comprehensively addresses 19 major crops, and their potential diseases. The development of AI-DISC was underpinned by an extensive data collection effort facilitated by the National Imagebase for Plant Protection (NIBPP) mobile app. Collaborating with 11 State Agricultural Universities and ICAR Institutes, this initiative amassed a colossal dataset of over 400,000 images over a span of three years. To prepare this voluminous dataset for deep learning, it underwent meticulous preprocessing steps, including resizing and brightness adjustments. In the realm of deep learning, AI-DISC leveraged sophisticated models such as GoogleNet, EfficientNet, and DenseNet for precise disease classification. What sets AI-DISC apart is its accessibility. Its user-friendly mobile app interface ensures that farmers, extension workers, researchers, and professionals in the agriculture industry can seamlessly access and utilize its capabilities. The app not only identifies diseases but also enables users to analyze images directly through its interface. During its developmental stages, the AI-DISC model consistently demonstrated impressive accuracy rates, ranging from 95% to 98%. Field testing conducted by domain experts corroborated this, with accuracy levels remaining consistently still remaining, typically ranging from 85% to 88%. In essence, AI-DISC has emerged as a game-changing solution for the timely identification of diseases in crops. It holds the promise of improving crop management practices and ultimately increasing yields for a diverse range of agricultural stakeholders.

Keywords : AI based disease identification, Deep learning, crop management

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Compact field-savvy instrument for rapid detection of aflatoxins-B1 in maize using a hyperspectral imaging system with machine learning

Chakraborty, S. K.*, Mansuri, S. M., Kumar, D. and Tripathi, M. K.

Agro Produce Processing Division, ICAR-Central Institute of Agricultural Engineering, Nabibagh, Berasia Road, Bhopal – 462 038, Madhya Pradesh, India

*subir.kumar@icar.gov.in

Exposure of maize to *aspergillus flavus* while being on and off the fields lead to *aflatoxin contamination. This is a very serious food safety concern in food and feed supply. Rapid detection of contamination in the grain on-site, preferably with a hand-held instrument, before it comes into the food chain is necessary and much-awaited.* Hyperspectral imaging (HSI) is a popular non-invasive technique for detection of fungal contamination in food grains. HSI data secures its acceptance for development of tools and gadgets that can be used for rapid detection of fungal contamination. *HSI spectral data was obtained using maize samples, (i)* inoculated with six different concentrations (25, 40, 70, 200, 300 and 500 ppb) of aflatoxin-B1, and (ii) under *natural contamination with aspergillus flavus. Spectral signature from HSI data was collected in vis-NIR (*398-1003 nm) and SWIR (1000-1700 nm) ranges while the germ orientation of maize kernel were switched with respect to imaging aperture. Reflectance spectral data were pre-processed (multiplicative scatter correction, standard normal variate, Savitsky–Golay smoothing and their combinations) and classified using partial least square discriminant analysis (PLS-DA) and k-nearest neighbour for obtaining the characteristic wave length/band representing the aflatoxin content in maize kernel. PLS model was also developed to predict the concentration of aflatoxin-B1 in naturally contaminated maize kernels. The potential wavelength band (580-620 nm) was selected based on principal component analysis to distinguish between sterile and infected maize kernels. While it was observed that in terms of "error-rate" the prediction capability of PLS-DA, artificial neural network (ANN) and 1D-convolutional neural network (1D-CNN) for predicting fungal contamination was better for maize kernel in germ up (1.31, 1D-CNN) as compared to germ down (1.95, ANN). Based on this result a hand-held hardware was developed that comprised a multispectral sensor having 18-channels in the UV, visible and IR ranging from 410 to 940 nm with a built-in aperture, 16-bit ADC and operating at 2.7 to 3.6 V, LEDs (white, UV and IR) that could illuminate the target with the largest swath, a micro controller (Arduino Mega 2560), a power bank (5V, 2A, 5000 mAh) and a 2.4" touch display. All the components were fitted in a 3D-printed asbestos cuboidal housing with an opening to capture reflectance spectra of maize kernels held in the half turn self locking cap right beneath the spectral sensor. The accuracy of identification of aflatoxin-B1 infected maize kernels by the developed hardware was more than 0.91.

Keywords: *Apergillus flavus*, Hand-held, Micro controller, Multispectral sensor, Spectral signature

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Evaluating the impact of agricultural practices on Lake Vembanad through water colour assessment using Forel-Ule datasets

Ancy C Stoy*[1], Gopalakrishnan, A.[1], Grinson George[1], Mini, K. G.[1], Nandini Menon[2] and Shubha Sathyendranath[3]

[1]ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala, India
[2]Nansen Environmental Research Centre, Kochi, Kerala, India
[3]Plymouth Marine Laboratory, Plymouth, Devon, UK

*ancycstoy17@gmail.com

In this research, we compare the fluctuating water colour patterns of Lake Vembanad using the first three years' data (2019-2021) from the 'Citizen Science Programme' in the Vembanad Lake, Kerala. Vembanad Lake is a large, brackish lagoon situated in the state of Kerala. 'Padasekarams' (paddy fields) surrounding the Lake have a deep interconnection and a significant role in the agricultural landscape of Kerala. The symbiotic relationship between Vembanad Lake and 'Padasekarams' is evident in the 'Pokkali' systems. However, this delicate balance has faced challenges in recent times. "Water-colouring" is always placed a high priority in the process of agricultural management activities. Water colour in lakes, rivers, and other water bodies can vary due to natural and human-induced factors. Changes in water colour may have a direct impact on crop growth and yield. Additionally, brown or muddy water can clog irrigation systems, affecting water distribution. We use a Mini Secchi Disk (MSD) equipped with Forel-Ule colour scale and a mobile application named 'TurbAqua' for crowdsourcing data to achieve our goals. We present the first FUI (Forel-Ule index) dataset for Vembanad Lake during the past three years, 2019-2021. We use a smartphone camera and auxiliary sensors to sense the water body's colour remotely. People use smartphones' built-in cameras for water quality mapping of the Vembanad Lake. The Lake's colour is undergoing variations, exhibiting specific patterns in different regions. Specifically, the Lake is transitioning from 'Greenish brown to Brownish Green' towards 'Greenish' in colour, especially in the southern parts. The water colour data from the rivers draining into the Lake indicates the presence of sediments in the water column. Using the water colour data, we plot the FU index of the Lake to create Forel-Ule water colour maps for the Vembanad Lake. Our results have revealed previously unexamined information on spatial and temporal changes in water colour dynamics of Lake Vembanad, especially in its southern arm. Detailed inspection is needed for agricultural and land management activities around the lake, particularly on the southern side of the lake. Therefore, this study provides a detailed analysis of the potential of using the Forel-Ule Index, derived from digital images, as indicators of optical water characteristics.

Keywords: Forel-Ule colour, Smartphone camera, Vembanad Lake, Water colour

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Potential of Generative AI and Large Language Models (LLMs) in advancing digital agriculture – A review

Debabrata Sethi*, Arjamadutta Sarangi and Ajit Kumar Nayak
ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India
*debabrata.sethi@icar.gov.in

Digital agriculture has become integral to modern farming, facilitating knowledge dissemination, advisory support and sustainable practices. However, the limitations of traditional extension methods have prompted the exploration of innovative technologies, including Generative Artificial Intelligence (G-AI) and Large Language Models (LLMs), to revolutionize agro-advisory services. This study presents a comprehensive review of the transformative potential of G-Aland LLMs in advancing digital agriculture. G-AI, when coupled with LLMs, enables the automatic creation of contextually relevant, locally specific and personalized agricultural content. Such content generation includes crop-specific recommendations, irrigation management, disease and pest control strategies and tailored solutions to farmers' queries in local language. The multilingual capabilities of LLMs broaden the reach of digital agricultural extension, bridging language barriers. Currently, LLMs are trained to cater to many Indian Languages. Advisory services can engage a diverse global audience, even beyond national boundaries by harnessing the modules. Chatbots powered by such technologies can be used to provide solution to agricultural issues on real time basis. Moreover, it is capable of enhancing the scalability of digital agricultural extension, ensuring that a broader spectrum of farmers can access advisory services effectively. This scalability mitigates the constraints associated with limited human resources. AI-driven analytics in tandem with LLMs enable the processing of huge agricultural datasets that yields actionable insights and facilitates trend analysis thus helping farmers adapt to dynamic conditions and optimizing agricultural yields. Further, improved natural language understanding and generation abilities of LLMs foster user feedback, which can result in a more accessible and interactive experience for farmers availing digital extension services. However, such models necessitate ethical considerations with respect to issues related to data privacy, bias and its responsible use, which is imperative to ensure equitable and authentic deployment. This review emphasizes the transformative potential of Generative AI and LLMs in redefining digital agriculture which necessitates interdisciplinary collaboration among AI experts, agricultural scientists and extension service providers.

Keywords : Agricultural extension, Generative AI, Large language model (LLM),

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Denoising based Stacked Autoencoder Deep Learning Models for onion price forecasting

Singh, K. N.*, Kamal Sharma, Avinash, G., Mrinmoy Ray, Achal Lama and Rajeev Ranjan Kumar
ICAR-Indian Agricultural Statistics Research Institute, New Delhi-110 012, India.
*kn.singh@icar.gov.in

Onion holds a significant position in India as a staple vegetable, playing a vital role in ensuring food security across the country. However, due to its perishable nature, the onion market in India experiences high volatility, with prices fluctuating rapidly based on factors such as supply and demand, seasonal variations, weather conditions, and transportation costs. Given the significant role of onions in the Indian economy, accurate onion price forecasting is a crucial area of research and policymaking. Deep learning models have emerged as the predominant approach for agricultural price forecasting in recent times. Nevertheless, conventional deep learning models tend to lose valuable information about the underlying dynamics during the process of dimensionality reduction. To overcome this challenge, recent advancements like Stacked Autoencoder (SAE) deep learning models, which utilize unsupervised layer-wise training to capture hierarchical representations, ensuring the preservation of crucial information, can be explored. The SAE based deep learning models has several advantages over conventional deep learning models like improved feature extraction, reduced dimensionality, better generalization, interpretable model outputs, flexible architectures, Pre-processing tool. However, deep learning models based on SAE can at times lead to overfitting as they do not effectively remove noise from the data. This article focuses on the development of denoising-based deep learning models using SAE for five distinct variants: Multilayer Perceptron (MLP), Recurrent Neural Network (RNN), Gated Recurrent Unit (GRU), Long Short Term Memory (LSTM) and 1d Convolution Neural Network (1dCNN). Weekly Onion prices in Indian Rupees (INR) was obtained from the "Agmarknet" website (https://agmarknet.gov.in) pertaining to the period January, 2006, to June, 2023 and denoising based SAE deep learning model fitted. The model exhibited superior forecast accuracy compared to both SAE deep learning models and conventional deep learning models. The RNN architecture is notable among denoising-based SAE deep learning models, as it achieves the lowest values for all three evaluation metrics: RMSE = 121.33, MAE = 90.32, MAPE = 6.09. To assess the efficacy of the models developed, the accuracy was compared to baseline deep learning models using the Diebold-Mariano (DM) test, which established the superiority of denoising SAE deep learning model.

Keywords: Autoencoder, Deep learning, Denoising, Onion price forecasting.

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Integrated robotic weed management using AI and Internet of Things

Kushwaha, D. K., Sahoo, P. K., Singh, A. K., Aruna, T. N., Kishan Kumar, Soumya Krishnan, V. and Pradhan, N. C.
Division of Agricultural Engineering, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India
*avsingh298@gmail.com

Agriculture is facing a significant labor shortage in many parts of the world. Robotic weeders can help alleviate this problem by reducing the need for manual labor in weed management tasks. Traditional weed control methods often rely on herbicides, which can have adverse environmental effects and contribute to chemical residues in crops. To address the above issues, robots are increasingly being used for weeding. They use computer vision to identify what is weed and what is not; some spray them, some dig them out and others zap them with laser. The incorporation of AI enables the robotic weeders to accurately distinguish between crops and weeds, minimizing the risk of false identifications and preventing damage to valuable plants. AI algorithms can continuously learn and adapt to local weed species, optimizing the weeding process and ensuring efficient weed management practices. This targeted approach reduces the need for chemical herbicides, minimizing environmental impact and improving sustainability. Moreover, Integrated Robotic Weeding Systems(IRWM), artificial intelligence (AI), and the Internet of Things (IoT) in Indian agriculture presents numerous benefits for farmers. In Integrated Robotic weed management, weeders are equipped with sensors and cameras that collect valuable data about the field conditions, weed types, and growth patterns. Robotic weeders offer a transformative solution to weed management in agriculture, combining precision, efficiency, and sustainability to enhance productivity and alleviate labor-intensive tasks to farmers.

Keywords: AI, IRWM, Mechatronics, Robotics,Weeds

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Patents on artificial intelligence provides insights for technological advancements and Competitive intelligence in aquaculture sector

Poonam Jayant Singh* and Abhijeet Srivastava

ICAR- National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh, India

*Poonam.jayant@icar.gov.in

The entry of Artificial Intelligence (AI) entering the domain of agriculture and aquaculture has opened up avenues for precision without human error through data integration, enabled connectivity and computational power. Moreover, next gen technologies have been using the power of language processing, deep learning and machine learning for prediction of gene, protein and metabolome. Patents were mined in the domain of Artificial Intelligence for understanding industrial technology development and understanding companies and competition in the field. Searches were made from 2002 to 2022 to get insights in new technologies associated with aquaculture. The overall patents in the field of AI were 4,,46,793 under International Patent Classification Code G06N that provides information on patents associated with Computer arrangements based on specific computational models, with China leading ahead with 2,45,428 patents followed by USA (25,957) and Republic of Korea (25,957). Artificial Intelligence integrates into the technological domain of aquaculture by intelligent grading system for fish cultured in circulating water, automatic feeding system, automation of floating mobile filtration and aeration system, live fish classification and conveying based on ai identification, biofloc system capable of copying environment by AI, computer aided programme to improve productivity of aquaculture systems. AI is also been used for intelligent disease diagnosis through sensor-based methods and image vision capture. AI controls time i.e. feeding time, aeration, temperature with uniformity and does not succumb to human error. The scope of integrating biology with computational tools has also multiplied manifold through Machine learning and Deep learning like the Alphafold prediction for proteins which provides machine hand for fast discovery and validation that human intelligence that would have taken many years for identification. The integration of intelligent learning systems incorporating Artificial intelligence opens up multiple avenues for growth of the sector as evidenced through empirical analysis of Patents and Publications.

Keywords: Artificial Intelligence, Aquaculture, Deep learning, Patent

Theme: Next Generation Technologies: Digital Agriculture, Precision Farming and AI-based Systems
Sub theme: Artificial Intelligence based Systems

Harnessing modern agriculture: The growing role of Internet of Things (IoT) and Machine Learning technologies in predictive analytics

Kundan Chaudhary[1], Ankit Goyal[1]* and Manisha Bhatol[2]

[1] Mansinhbhai Institute of Dairy and Food Technology, Dudhsagar Dairy, Mehsana-3840 02, Gujarat, India
[2]Indus Institute of Information and Communication Technology, Indus University, Ahmedabad-382 115, Gujarat, India.

*ankit.ndri@gmail.com

The integration of Internet of Things (IoT) and machine learning technology in modern agriculture has enabled the creation of predictive analytics systems that provide farmers with valuable information to enhance their decision-making, farm management, and reduce crop production volatility. These tools utilize data from various sources, including soil sensors, atmospheric sensors such as those tracking temperature and humidity, and satellite imagery, to assess soil health, and predict planting, irrigation, crop yields, and other critical factors affecting agricultural productivity. Machine learning and data analytics, two forms of AI technology, are essential for the success of contemporary farming. Machine learning algorithms seek patterns and relationships in vast amounts of data collected from IoT devices, satellites, and drones. This data-driven knowledge empowers farmers to take precise actions through the power of predictive analytics. By leveraging predictive analytics, farmers can make better-informed decisions regarding crop selection, land management practices, and resource allocation. This can help optimize their real-time monitoring operations, crop yield production, predict future outcomes, and enhance overall profitability. Ultimately, the application of IoT and machine learning in predictive analytics has the potential to revolutionize agriculture in India and assist farmers in thriving in a more competitive global market.

Keywords: Internet of Things, Machine learning, Modern agriculture, Precision farming, Predictive analytics,

XII AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 9

Policies and Institutions for Transforming Agri-food Systems

Food System Transformation: Role of Policies and Institutions

Diet Diversification and Food System Transformation

Agri-food system transformation towards high-value commodities

XVI ASC | T9S1-01

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Impact of improved forage cultivation on milk productivity and fodder availability in Bundelkhand region of Uttar Pradesh: A doubly robust analysis

Purushottam Sharma*, Bishwa Bhaskar Choudhary, Deepak Upadhyay, Sunil Kumar, Gaurendra Gupta, Kantwa, S. R., Vinod Wasnik, Mahendra Prasad, Nitesh Kumar, Rajeev Gupta and Vijay Kant

ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284003, Uttar Pradesh

*Purushottam.Sharma@icar.gov.in

The present study examined the drivers of adopting improved forage technologies and their impact on milk yield and feed self-sufficiency in central India. A total of 300 dairy farmers were surveyed under the study, and the inverse-propensity-weighting regression adjustment (IPWRA) technique was employed to assess the impact. The findings suggest that education status, adult cattle unit, animal breed type, off-farm income activities, farm size, and access to training and markets significantly influence the adoption of improved forage technologies and practices. Moreover, this adoption resulted in a noteworthy rise in daily milk yield (from 1.07 to 1.34 liters), a 27% increase in total dry matter availability, and an 80% increase in green fodder availability. Ration balancing has been identified as a significant concern in the study region. Consequently, the study suggests that adopting a comprehensive approach is necessary to address the issue of proper ration balancing and fully harness the production potential of dairy animals.

Keywords: Bundelkhand, Fodder, Forage technologies, IPWRA, Milk productivity

XVI ASC | T9S1-02

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Impact of blending policy on mustard oil prices in India: Insights from a Bayesian Structural Causal Inference Model

Md Yeasin*

ICAR-Indian Agricultural Statistics Research Institute, Library Avenue, New Delhi-110 012, India

*yeasin.iasri@gmail.com

Oilseeds belonging to the Brassicaceae family, such as rapeseed and mustard, play a crucial role in global vegetable oil production for dietary consumption. The concept of blending, within the context of mustard oil, refers to combining mustard oil with other oils, including vegetable or palm oils. In the third Amendment of 2021 to the Food Safety and Standards (Prohibition and Restrictions on Sales) Regulations, the Food Safety Standards Authority of India (FSSAI) has imposed a prohibition on blending mustard oil for the creation of Multi-Sourced Edible Vegetable Oils (MSEVOs). This development brings relief to mustard farmers who have been adversely affected by the extensive blending of other oils with mustard oil. The Bayesian Structural Causal Inference Model is a powerful tool for estimating the impact of policy interventions. In this study, both the Bayesian Structural Causal Inference Model and the Difference-in-Difference model have been applied to assess the effects of the blending policy on mustard prices. To execute these models, the monthly price data for mustard in Rajasthan was collected from the AGMARKNET portal. The findings reveal that all mustard markets have experienced increased prices due to the new blending policy. This policy is anticipated to serve as an incentive for mustard farmers and contribute to achieving self-sufficiency in oilseed production.

Keywords: Agriculture, Blending, Casual inference, Mustard price

XVI ASC | T9S1-03

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Role of local leadership and collective action to adopt soybean cultivation innovations in ex-sand quarry land: A case study from Cibulan Village in West Java, Indonesia

Suhirman* and Eko Fajar Setiawan

Bandung Institute of Technology, School of Architecture and Development Policy, Bandung City, West Java Province, Indonesia

*eshm2009@gmail.com

The decision to adopt innovations for soybean cultivation in ex-sand quarry land, Cibulan Village, Cidahu District, Kuningan Regency, West Java Province, Indonesia, was initiated by the Local Head of Cibulan Village and the Government of Kuningan Regency. With the intervention of local leadership, especially the village administration, soybean cultivation on ex-sand quarry land has revegetated 115 ha of land in five (5) areas from 2018 until 2022. The presence of leadership has facilitated the transformation of the food supply in Indonesia as a good practice for developing food security in the soybean sector. This study used a mixed methods approach using Rogers' innovation-diffusion analysis, Spearman's correlation analysis, Kruskall Wallis (KW) analysis, collective action analysis, and actor-network analysis (ANT). The secondary data pertained to soybean planting season reports for 2018-2022, Cibulan village regulations (Perdes Cibulan), and other relevant documents. The primary data collection involved in-depth interviews with farmer group leaders, Cibulan Village Officials and Heads, Farmer Extensionists, members of Indonesian Tofu Cooperatives (KOPTI) in Kuningan, Kuningan Agriculture Service Officials, West Java Seed Certification Monitoring Center officials and the Ministry of Agriculture who has the right to supervise the implementation of soybean cultivation in Cibulan Village. In addition, field observations and focus group discussions were also carried out from January 2023 to April 2023. Rogers' diffusion-innovation analysis results show that cropping patterns, planting techniques, and economic motives (planting incentives) influenced farmers' decision to adopt soybean cultivation. Furthermore, Spearman's correlation analysis shows that the value of the correlation coefficient between soybean planting incentives is significantly related to crop productivity and farmer participation. KW analysis shows that planting incentives strongly affect crop productivity and farmer participation in planting soybeans. The farmers rely on informal communication channels so that social relations are considered to influence the achievement of planting area and productivity of soybean harvest. The expansion and narrowing of the soybean planting area were found to be influenced by local leadership. The results of the ANT show that the availability of soybean drying machines (dryer) and soybean seeds, besides local leadership, facilitated soybean cultivation on ex-sand quarry land.

Keywords: Collective action, Innovation diffusion, Local leadership, Soybean cultivation,

XVI ASC | T9S1-04

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Drivers of adoption of sustainable land management practices and its impact on food security and income variability: A case study from Jhansi District of Uttar Pradesh

Priyanka Singh*, Sushil Kumar, R. P. Dwivedi, A. Arunachalam and A. K. Handa

ICAR-Central Agroforestry Research Institute, Jhansi-284 003, Uttar Pradesh, India

*89singhpriyanka@gmail.com

This study investigate the adoption patterns and drivers of various sustainable land management practices (SLMPs), namely agroforestry bund and block plantation, soil bunding, and forage grass stripping in Uttar Pradesh's Bundelkhand region. It also delved into the socio-economic impacts, specifically food security and income stability, of tree-based farming. The study used data from around 549 farm households from Parasai, Chattpur, and Bachhauni villages of the Jhansi District. The findings suggest that only 2% of households have embraced all SLMPs, with 12% opting for agroforestry alone. Notably, 29% have not adopted any SLMPs, emphasizing the necessity for increased promotion and awareness among farmers. To foster adoption, the study suggests targeting experienced and educated farmers, bolstering extension services, and offering training. It underscores the importance of considering diverse agroecological and socio-economic factors influencing farmers' decisions. Agroforestry is found to improve food security as indicated by positive elasticity with tree density (0.231%) and diversity (0.141%). Moreover, unit percentage increase in tree density and tree diversity decreases income variability by 0.38% and 0.16%, respectively. In the context of global climate change, these findings highlight the significance of agroforestry as a climate-smart agricultural approach in semi-arid tropical regions worldwide.

Keywords: Agro-forestry, Semi-arid tropics, Sustainable land management practices

XVI ASC | T9S1-05

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Enhancing entrepreneurship in fisheries through effective client management from Agri-Business Incubation Centre: Strategies and policies for success

Razia Mohamed, A.*, Lijin Nambiar, M. M., Arshaya Rajesh, Remya, S., Mohan, C. O., Suresh, A. and George Ninan

ICAR–Central Institute of Fisheries Technology, Matsyapuri P. O., Willingdon Island, Kochi, India

*razia.mohamed.a@gmail.com

In the dynamic landscape of fisheries and aquaculture, the role of agribusiness incubation centers has become paramount in fostering innovation, entrepreneurship, and commercialization of cutting-edge technologies in the food sector. This study delves into the client management strategies employed at the Agri-business Incubation Centre of ICAR–Central Institute of Fisheries Technology (ICAR-CIFT), Kochi, a fisheries technology innovation and entrepreneurship development hub. The incubation centre plays a pivotal role in nurturing startups and early-stage ventures in the fisheries sector. A comprehensive analysis was conducted to assess the effectiveness of client management in this incubation ecosystem. This analysis encompassed client onboarding, mentoring, access to resources, policy support, and impact assessment. Key findings highlight the tailored approach adopted to client onboarding, including rigorous selection processes and alignment with the centre's core mission. Startups benefiting from mentorship at the Centre exhibit a 32% faster growth rate in revenue and a 24% higher likelihood of securing external funding. The mentorship programs emerged as a cornerstone of the incubation centre's success, providing startups with domain expertise, business acumen, and network access. Access to specialized resources, infrastructure, and funding avenues was critical in driving innovation and growth among incubated ventures. This has led to a 20% increase in research and development activities and a 36% higher rate of technology adoption. The incubation centre's role in bridging the gap between academia, industry, and government agencies was also examined, showcasing its potential in shaping fisheries policies and regulations. Finally, the impact assessment revealed a positive correlation between effective client management and the overall success of incubated ventures, as measured by factors such as revenue generation, job creation, and technology adoption in the fisheries sector. This research sheds light on the vital role played by the ICAR-CIFT Agri-business Incubation Centre in nurturing entrepreneurship, fostering innovation, and facilitating the commercialization of fisheries technologies. The findings provide valuable insights for policymakers, incubation centre administrators, and stakeholders in the fisheries industry, ultimately contributing to the sustainable development of the sector and the broader entrepreneurial ecosystem.

Keywords: Agri-business incubation, Client management, Entrepreneurship, Fisheries

XVI ASC | T9S1-06

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Promotion of spice cultivation in agroforestry systems in Palakkad District, Kerala, south India

Rajeev, P.*, Sellaperumal, C. and Biju, C. N.

ICAR-Indian Institute of Spices Research, Kozhikode-673 012, Kerala, India

*Rajeev.P@icar.gov.in

The cultivation of many spices is inextricably linked with the farming systems in areas adjoining forests of Kerala, India. Institutions of farmers and indigenous tribes have evolved over time to conserve, sustain, and promote the cultivation of spices and herbs in the agroforestry system. The tribal communities are also involved in collective farming in village clusters. This paper presents the impact pathways of intervention made by the ICAR-Indian Institute of Spices Research (ICAR-IISR), Kozhikode, Kerala, in two locations viz., Poopara village under Parambikulam Tiger Reserve and large spice plantations managed by Attapady Co-operative Society (ACFS), a tribal rehabilitation imitative of the Government of Kerala. In both locations, the selected sample of farmers follows certified organic farming. In Poopara village, interventions were carried out for the rehabilitation of black pepper plantations on 34 acres owned by 52 tribal families, which suffered a huge crop loss due to the incidence of foot rot disease and nematode complex since 2018. Phytophthora was found to be associated with wilted vines and diverse genera of nematodes viz., root-knot, Radopholus similis, reniform, Helicotylenchus, Hoplolaimus, and Criconema was found associated with the vines exhibiting yellowing and declining symptoms. The farmers jointly adopted management measures following cultural practices of rouging dead vines, maintaining drainage channels, and applying bio inputs developed by ICAR IISR, like Trichoderma and plant growth-promoting rhizobacteria (PGPR). The varietal evaluation trials carried out revealed that Njallani Green Gold cardamom is the most suitable variety for the agroecological zone. Trial plots for two improved varieties developed by ICAR-IISR, namely Appangala 1 and IISR Avinash, are in the second year of trial. Support was provided by capacity building of farmers to adopt in situ composting and fortification of organic manures with encapsulated Trichoderma and PGPR, besides improving the drainage and irrigation. Mother gardens of improved varieties of IISR Keralashree and IISR Vishwashree were established. The work summarizes as follows: (1) Intervention by ICAR-IISR helped promote organic farming in hill ecosystems through institutional collaboration, (2) Improved the livelihood of indigenous communities through the adoption of sustainable cultivation practices to enhance the yield and (3) Developing extension model for agroforestry systems through co-operative institutions and peoples planning programme at the Panchayat level.

Keywords: Hill ecosystems, Organic cultivation, Spices

XVI ASC | T9S1-07

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

A silver bullet or a policy quagmire: An evaluation of the prospects of FDI in spices and plantation crops

Lijo Thomas* and Rajeev, P.

ICAR-Indian Institute of Spices Research, Kozhikode-673 012. Kerala, India

*lijoiari@gmail.com

The Government of India has taken several policy measures to attract Foreign Direct Investments (FDI) in various sectors of the economy. There has been a gradual easing of restrictions on FDI in several sectors. In this study, we analyze the implications of increasing FDI in spices and plantation crops, a sector with unique features within the agricultural sector. We develop possible outcome scenarios and socio-economic implications based on documented evidence on the impact of FDI in tea plantations. We find that the spices and plantation crops share similar characteristics with respect to production challenges, output market scenarios, and aggregation and marketing arrangements. It is generally observed that even after FDI norms were eased in the tea plantations, the sector failed to attract substantial investments from abroad. In fact, anecdotal evidence suggests that the opposite seems to have happened with Indian companies acquiring plantations abroad and foreign capital exiting some of the plantations. It is widely held that the limitations imposed by the Plantation Labour Act and other regulations under FEMA seem to have made FDI in the sector unattractive. All this points to the fact that no sector can reap the theoretically suggested dividends from FDI inflows by merely allowing FDI through an automatic route. We conclude that in the case of black pepper, crop cultivation is dominated by smallholder producers, and as such, there is little evidence in the literature that FDI will have a beneficial influence on small and marginal producers of a commodity. The critical issue seems to be the yield gap and technology gap, which is a persistent and critical focus in bridging these gaps can give the desired technology push for attaining higher average productivity in the country. Considering factors like sustainability, intercropping, and biodiversity within spices and plantation cropping systems, it is difficult to visualize a paradigm shift in cultivation technology in black pepper through FDI. However, we cannot rule out the possibility of better technology in the sphere of organizing production, post-harvest processing, and business models, which can come in through the FDI route. The study, inter alia, specifically recommends measures such as limiting monocropping while promoting biodiversity and sustainability of the cropping system; directing FDI to processing and post-harvest technology/ product development; bundling FDI through automatic route with registration and periodic reporting on area, production, and other business processes; a focus on business models and value chain interactions; and establishing mechanisms to address oversights for FDI in black pepper.

Keywords: FDI policy, Plantation crops, Spices

XVI ASC | T9S1-08

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

The value chains of selected agribusinesses in the states of Uttar Pradesh and Uttarakhand: An analytical framework for way forward

Dubey, S. K.*, Uma Sah, Reshma Gills and Burman, R. R.

Agriculture Technology Application Research Institute, Kanpur, Uttar Pradesh, India

*skumar710@gmail.com

Value chain analysis is gaining popularity across all agricultural industries as it acts as a catalyst for development. Observing how value chains vary from time to time for a single commodity at a particular territorial boundary and across locations during a specific temporal framework is quite dynamic and surprising. Therefore, a thorough value chain analysis from pre-production to post-sale is essential to make market policy recommendations and implement effective marketing plans. The study was thus conceptualized and carried out to capture the value chains of the selected horticultural commodities in Uttar Pradesh and Uttarakhand states holistically, provide knowledge and information about the current status of the value-creating actions, and explore strategic and policy-based reforms. From Uttar Pradesh and Uttarakhand, the districts of Champawat for off-season vegetables such as capsicum and tomato, Pratagarh for vegetable pea, Kannauj for potato, and Pratagarh for fruit crops such as Aonla, Banana, Mango, and Guava were purposively sampled for the study. Consequently, 1110 respondents were chosen to participate in the survey from 70 villages and 4 districts in both states. Three important marketing choices were found during the process of title change in the case of fruits and vegetables produced. i.e., the direct marketing channel of Producer-Consumer, Producer–Retailer–Consumer, and Producer-Wholeseller-Retailers-Consumers. Potato (68%) in the producers-retailers-consumers channel and mango (62%) in the Producers-Wholesellers-Retailers-Consumers channel were found to have the highest percentage of net producers' share in consumers' prices. The findings indicate that retailers accrued greater profitability (B:C ratio 20.08) in the case of guava, and wholesalers accrued greater profitability (B:C ratio 16.45) in the case of mango as a result of value addition. The value chain mapping approach followed in the study depicted the marketing-led extension systems and their potential in the study region for various commodities. The results of the study will assist in prioritizing interventions based on value chains and determining which products, agents, and technologies have the greatest potential to impact sustainable livelihood creation for the farmers.

Keywords: Market-led extension, Value chain mapping

XVI ASC | T9S1-09

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Learning from the pandemic: Lessons on resilience from the marine fisheries sector in India

Anuja, A. R.*, Shyam S. Salim, Narayanakumar, R. and Akhila Kumaran

ICAR- Central Marine Fisheries Research Institute, Kochi, Kerala, India

*anuja.akathoottu@gmail.com

The COVID-19 pandemic had multifaceted effects on different sectors of the Indian economy, and the marine fisheries sector was no exception. Given that the rebuilding of the economy and sector post-pandemic needs to be guided by the principle of resilience, this paper attempts to analyze the various adaptation and mitigation policies adopted by the major stakeholders of the Indian marine fisheries sector. The major stakeholders identified are boat owners, labourers, traders, marketing functionaries, women, and exporters. While there could be state-wise as well as stakeholder-wise differences in the adaptation and mitigation interventions, we focus on stakeholders for the purpose of the paper. The strategies identified are consolidated across four domains related to the Indian marine fisheries sector- fishing (entire fish supply chain), employment (alternative livelihood options other than fishing and allied activities), health, and social. Once the most important domain for each stakeholder was identified, information was also sought on who had been the most important factor in accessing the particular domain, i.e., who were the sources of coping domains. The sources were listed a priori as Self, Family, Community, and Government. Our findings were drawn from all nine coastal states in India, covering a sample of 2520 stakeholders. Across the states, 14 rural and urban districts were identified, and 180 sample units (stakeholders) were surveyed across each coastal district. Employment was featured as the top strategy for labourers, marketing functionaries, and exporters, followed by health and fishing. The most important coping domain for women was social, followed by employment and health. For boat owners, it was fishing that featured as the most important coping strategy, followed by health and social. Consequently, the source of coping domains varied across the stakeholders. Labourers and marketing functionaries showed greater dependency on their employers while for women, it was the community, and for boat owners, greater reliance was on themselves to cope with the impact of the pandemic. According to the exporters, government policies and interventions proved crucial during the pandemic. The findings from the study aid in developing stakeholder-specific interventions and strategies so that the overall vulnerabilities of the marine fisheries sector can be reduced, adding to its resilient capacity.

Keywords: Adaptation, Coping strategy, COVID-19, Marine fisheries, Resilience

XVI ASC | T9S1-10

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Rebuilding with communities: CIT model analysis of stakeholder consultation in marine fisheries sector in India

Akhila Kumaran, Shyam S. Salim, Sunil P. V., Narayanakumar, R., Anuja, A. R. and Steny Rebello

ICAR–Central Marine Fisheries Research Institute, Kochi, Kerala, India

*shyam.icar@gmail.com

Stakeholder interactions represent the crucial link in governance whereby policies are designed not just for people but rather with people. Owing to the disproportionate social and economic burdens on marginalized communities, the appeals for community engagement emerged intensely during COVID-19, especially as it could serve as a bulwark against scientific disinformation, mistrust of authorities, and environment mismanagement. An initial survey across all 9 coastal states, using a semi-structured schedule covering 3360 stakeholders–comprising laborers, boat owners, marketing functionaries, traders, women, consumers, and exporters–was undertaken in 2022. Drawing on this survey, six major topics were selected for further deliberation. These were: Public health, Role of government, Fishing Holidays, Positive externalities due to COVID-19, Inter-generational mobility, Change in taste and preferences, as well as Lessons from COVID-19. Using the conceptual framework of Communication Infrastructure Theory, the paper explored difference-managing community strategies (DMS) and difference-reducing strategies (DRS) and subsequently developed a Problem-Status-Solution matrix in order to conduct workshops at four selected states–Kerala, Tamil Nadu, Andhra Pradesh, and Maharashtra. Through the workshops, the study team identified 4 specific adaptation and mitigation strategies adopted by each state. The findings led to the conclusion that both – DMCS (defined as "communication among residents to identify, understand, tell stories, discover value and meaning, and take advantage of the differences") and DRS (defined as "communicative actions among residents who share identities, values, interests, and action plans as resources to identify and strengthen in-group connectedness and to reduce, avoid, or eliminate differences between groups")–were deemed necessary in order to address issues involving multiple identities. For example, in the states of Kerala and Maharashtra, there was a need for an institutional framework to promote alternate livelihood options (ALO) and generate employment, and Difference Managing Strategies were considered the most crucial component. In Tamil Nadu and Andhra Pradesh, the need to involve more economic activities and health-focused recovery was apparent, thereby advocating Difference Reducing Strategies. Thus, by centering the outlier fisher community and acknowledging the sector's heterogeneity, the paper attempts to co-produce knowledge and learning and build a roadmap for the future.

Keywords: Community engagement, COVID-19 pandemic, Knowledge co-production, Marine fisheries, Stakeholder consultation

XVI ASC | T9S1-11

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Technology-led transformation in a Kerala fishing village: Evidence and insights for a policy shift

Aiswarya Sali[1]*, Ananthan, P. S.[1], Nikita Gopal[2] and Neha W. Qureshi[1]

[1]ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra, India
[2]ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, India

*aiswarya.fexmb101@cife.edu.in

Kerala's marine fisheries are characterized by a declining growth trend during the last two decades, after considerable growth during the 1980s and 1990s. From 1980 to 2016, the sector underwent a structural transformation: a multi-fold increase in fishing capacity (number, horsepower, and composition of fishing vessels) and a doubling of fishing dependency (number of active fishers involved in capture fisheries), aided by technological modernization and development-oriented policy climate. While this has translated into higher catch per unit effort and improved livelihoods (better education, housing, and income) for coastal fishing families, sustaining the past gains made in the near future appears daunting. Situating the study within this macro-level context, this study examines the interconnected dynamics of technology-led changes in fishing and expansion of fishing capacity, regulatory framework over the years, changes in governance and livelihoods at the micro-level, i.e., as it unfolded at the Munambam fishing village, one of the largest sites of fishing in Kerala. Sourcing data from secondary sources and the primary field study, including key informant interviews with fishers, DoF staff, and other stakeholders, it weaves a historical trajectory of change at the grassroots: the transformation of a traditional fishery in the post-independence era through the subsequent phases of motorization, mechanization, and consolidation. It explores the impact of these technological changes on the emergence of two distinct classes of motorized small-scale fishers and mechanized large-scale fishers, the ensuing pressure on finite fishing resources, and the widening gap. It also chronicles the State's policy and other initiatives to address these challenges, especially the implementation of a monsoon trawl ban, mesh size regulations, resolving conflict between ring seiners and trawlers, enforcing karavali regulations that prohibit mechanized craft within specific depth limits, etc. Underscoring the complexity of food production systems that depend on a natural common property resource whose future is increasingly threatened by climate change and over-exploitation, this case study offers a possible way forward: the policy-induced shift towards reduced fishing dependency (and effort), incentivizing responsible fishing practices, removing ecologically harmful subsidies, and diversified livelihood opportunities.

Keywords: Kerala, Mechanisation, Seafood system, Small-scale fishers, Technological change

XVI ASC | T9S1-12

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Unleashing the potential of aquaculture for youth employment and livelihood security

Abigail Fernandes*, Deepesh Priolkar and Christabelle Fernandes

Directorate of Fisheries, Government of Goa, Dayanand Bandodkar Marg, Panaji, Goa, India

*abigailfernandes13@gmail.com

As one of the fastest-growing food production industries, aquaculture has a high potential to meet global food demands. Aquaculture can contribute to many of the Sustainable Development Goals (SDGs 2030), particularly SDG 14: Life Below Water and SDG 8: Decent Work and Economic Growth. However, there is a lack of information about the perception of aquaculture among youth, the factors that enable their participation, and the constraints necessary for developing effective aquaculture policies. Aquapreneurship possibilities in the state are under-exploited, and the aquaculture sector can serve as a profitable venture for the unemployed youth. This study tried to investigate the attitudes, aspirations, willingness, and perceptions of youth towards aquaculture. The paper also focuses on identifying strategies to encourage youth participation in this sector. This study showcases the success stories of youth aquapreneurs, particularly in open sea cage culture and bivalve farming in Goa. Promoting youth engagement in aquaculture will lead to employment generation, aid in sustainable livelihoods, increase their socio-economic status, and overall development of aquaculture in Goa.

Keywords: Aquapreneurship, Fisheries, Indian Aquaculture, PMMSY, SDGs 2030

XVI ASC | T9S1-13

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Governance gateway for achieving sustainable food system – A case of marine fisheries governance in Andhra Pradesh

Charles Jeeva, J.*, Ramachandran, C., Raju, S. S., Shinoj, P., Vipinkumar, V. P. and Jayasankar, J.

ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India

*jcjeeva@gmail.com

The total marine fish landings from the state of Andhra Pradesh, India, during the year 2022 was estimated to be 2.16 lakh tonnes, which was 5% higher than the previous year. The highest contribution was from the mechanized sector (49%), followed by the motorized (42%) and non-motorized sectors (9%). With 1,50,868 active fishermen and 31,741 fishing crafts, the marine fisheries sector is an important source of employment and income generation in the State. However, the sector is vulnerable to external influences, namely, overcapacity and resulting overuse of marine resources, environmental degradation, and climate change. A sustainable food system in fisheries and aquaculture aims to restore the productive potential to support food security, poverty alleviation, and sustainable management of aquatic resources. It supports the growth of the maritime sector in a sustainable manner and also aims at building resilience in coastal communities. This paper discusses the role of governance in achieving a sustainable food system, with the significant contributions of three important stakeholders, viz., the research system, state machinery, and the fishers, in the formulation, implementation, and compliance of institutional frameworks to sustain the marine fisheries of Andhra Pradesh. This study documents the extent of perceived monitoring, implementation, and compliance with fishing regulations. It was observed that the level of enforcement and compliance by the fishers was at the core of seasonal fishing regulation. More than 80% of the respondents were aware of mesh size regulations, juvenile fishing restrictions, and conservation requirements. Almost all the respondents were aware of the penalty structures for non-compliance. Various challenges and the way forward are also discussed.

Keywords: Compliance, Conservation, Governance, Sustainability

XVI ASC | T9S1-14

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Buyer-seller meet as a tool to foster farmer-market linkage towards assured marketing of farm produce: An experience of Ernakulam KVK

Pushparaj Anjelo, F.*, Vikas, P. A. and Shinoj Subramannian

ICAR-Krishi Vigyan Kendra (Ernakulam), ICAR-Central Marine Fisheries Research Institute, Narakkal, Kochi-682 505, Kerala, India

*info@kvkernakulam.org.in

Buyer-seller meets serve as a platform for farmers and farmer organizations to market their products at fair prices, avoiding intermediaries. The Krishi Vigyan Kendra (KVK)-Ernakulam, ICAR-Central Marine Fisheries Research Institute (CMFRI) organized a Buyer–Seller Meet, from 14th to 16th November 2019 at Kochi with funding from NABARD, Kerala. A total of 100 buyers, 31 to purchase spices, 22 for millets, 8 for honey, 18 for seed spices, 10 for paddy, and 11 for agricultural value-added products from Kerala, Karnataka, Telangana, and Tamil Nadu attended the meet. A total of 36 farmer producer organizations, including 2 dealing with honey, 2 jack fruit, 4 handling millets and pulses, 2 dealing gingelly and groundnut oil, 1 chia products, 2 dealing with coffee powder, 2 making tea varieties, 9 dealing spices, 2 dealing seed spices, 2 handling paddy and 1 dealing traditional rice varieties and 7 dealing multiple commodities participated. In addition, 13 Agri startups participated, including 4 dealing with value-added food products, 1 dealing with honey, 4 dealing with farming inputs, 1 dealing with black soldier flies, 1 manufacturing drones for agricultural purposes, and 2 dealing with value-added products. Cereals, pulses, millets, vegetable oils, spices, coffee, tea, jaggery, honey, masala powders, and value-added products made from millets, coconut, cereals, banana, papaya, and tapioca received the attention of buyers. The participating organizations also displayed and sold their products worth 8.5 lakhs during the programme. Deals on the green gram (5 million t, MT), green gram dhal (5 MT), black gram dhal (5 MT), chilly (20 MT), chilli powder (5 MT), and barnyard millets (20 MT), worth `1.2 Crores could be finalized.

Keywords: Buyer-seller meet, Farmer-market linkage

XVI ASC | T9S1-15

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Policy perspectives on emerging invasive alien aquatic species in Indian waters: Balancing contemporary fish-food demand, national priorities, and sustainable development goals

Tarachand Kumawat* and Uttam Kumar Sarkar

ICAR-National Bureau of Fish Genetic Resources, Lucknow – 226 002, Uttar Pradesh, India

*tarachand.kumawat@icar.gov.in

Invasive alien aquatic species (IAAS) represent a growing ecological and economic threat to Indian waters, disrupting local ecosystems and fisheries and potentially jeopardizing national food security. The present assessment highlights the critical policy perspectives required to address the present status and multifaceted challenges associated with IAAS in Indian aquatic environments while aligning with contemporary fish-food demand, national priorities, and sustainable development goals. With its vast and diverse aquatic ecosystems, India is witnessing a surge in IAAS introductions, primarily due to globalization, trade, and climate change. These IAAS often outcompete native species, leading to biodiversity loss and altering the structure and function of aquatic ecosystems. The associated economic costs are substantial, as IAAS can negatively impact fisheries, aquaculture, and water infrastructure. Addressing this complex issue demands a comprehensive policy framework. First and foremost, India's policymakers must recognize IAAS as a critical concern and allocate resources for research, monitoring, and management. Effective legislation and regulations are imperative to prevent the unintentional introduction of IAAS and to control their spread. Collaboration between government agencies, research institutions, and civil society organizations is essential to pool resources and expertise. Policymakers must promote sustainable aquaculture practices and invest in research to develop resistant native species to meet the rising demand for fish as a primary source of protein and income. Moreover, enhancing public awareness and education about IAAS can encourage responsible behavior among the public, including fishers, to prevent further introductions. Aligning policies related to IAAS with national priorities and Sustainable Development Goals (SDGs) is crucial for achieving long-term environmental sustainability and socio-economic development. These efforts should minimize the ecological footprint of aquaculture, enhance rural livelihoods, and foster innovation in fisheries management. In conclusion, the emergence of IAAS in Indian waters poses a significant challenge to ecosystems, fisheries, and food security. Practical policy perspectives must be implemented to address this issue while considering contemporary fish-food demand, national priorities, and the broader context of sustainable development goals. By fostering collaboration, investing in research and education, and aligning policies with overarching sustainability objectives, India can mitigate the threats posed by IAAS and secure its aquatic ecosystems for future generations.

Keywords: Fish-food demand, Invasive species, National priorities, Policy perspectives, SDG

XVI ASC | T9S1-16

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Role of policies and institutions in transforming millet-based food systems

Ritambhara Singh[1]* and Sweta Mishra[2]

[1]School of Agribusiness and Rural Management, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar., India
[2]Genetics and Plant Breeding, Post Graduate College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

*ritambharasingh@rpcau.ac.in

The country's vision in the 21st century is to establish sustainable food systems with rightly designed policies that are able to integrate production, post-production, and consumption subsystems of the food system. The envisaged sustainable outcomes include food and nutrition security, reducing losses and wastages, improving livelihoods, developing infrastructure, enhancing R&D, and developing need-based food systems. India voted in favor of the United Nations to bring International acceptance for Millets, and 2023 is celebrated worldwide as the International Year of Millets. The Millet-based food systems have rapidly evolved in India since Independence. The policy environment that focused more on volumes is now more focused on quality and nutrition availability. To ensure protein availability and nutrition security in the country, the Government of India introduced the National Millets mission, aiming at expanding the production to 36 million tons by 2024. The Government also introduced millets in the Public Distributing System. The country declared 2018 as the National Year of Millets and promoted their consumption all across the country. The Initiative for Nutritional Security through Intensive Millet Promotion (INSIMP), a part of Rashtriya Krishi Vikas Yojana (RKVY), was launched in 2011-12 to increase millet production in the country and to enhance nutritional security. The scheme covers all states and union territories and targets all millets (sorghum, pearl millet, finger millet, and five other small millets). Awareness campaigns have also been conducted to include millet and its products in diets. The Indian Institute of Millets Research has developed several products from Millets and are popularizing them. Millets Farmers' Producers Organizations have also been formed to reap the scale benefits and enhanced income. Start-up India has facilitated several budding entrepreneurs to add value to the millets in a way that they have started finding acceptance among a wider consumer base, irrespective of age. India has around 500 strat ups working on the Millets value chain; of them, more than 250 have been incubated by IIMR under RKVY RAFTAAR. The Government of India also distributes millet through the public distribution system along with rice, wheat, and maize, which are now promoted as nutri-cereals.

Keywords: Food security, Millets, Nutritional security

XVI ASC | T9S1-17

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Food System Transformation: Role of Policies and Institutions

Current trends, constraints, and future prospects of biopesticides in pest management

Devindrappa, M.*, Sanjay M. Bandi, Bansa Singh and Akram Mohd

ICAR-Indian Institute of Pulses Research (IIPR), Kanpur-208 024, Uttar Pradesh, India

*dnayak4505@gmail.com

The awareness about the safety and environmental concerns arising from the injudicious use of chemical pesticides for pest and disease management shifted the focus on use of biopesticides for sustainable crop protection. Biopesticides are specific forms of pesticides made of microbial and plant substances including bacteria, fungus, virus and plants to manage the pests and diseases. There has been an increase in demand for biopesticides, as they are eco-friendly in nature and are promoted through various government policies. The research and development in biopesticides have been on the rise and annually over 3000 tons of biopesticides are produced globally. However, biopesticides still comprise a relatively small fraction of pest and disease management solutions. In India, biopesticides consumption accounts for just ≥ 5% of the country's total pesticide market. According to the Central Insecticides Board and Registration Committee (CIBRC), about 970 biopesticide products have been registered in India. This includes over 200 fungi-based biopesticides (*Trichoderma viride, T. harzianum, T. asperellum, T. virence, Beauveria bassiana, B. brongniartii, Metarhizium anisopliae s.l., Lecanicillium lecanii, Hirsutella thompsonii, Purpureocillium lilacinum* and *Pochonia chlamydosporia*) for use against soil bore pathogens, arthropods and plant parasitic nematodes; over 30 products based on *Bacillus* spp., and *Pseudomonas* spp., including *B. subtilis, Bacillus thuringiensis* (Bt) subsp. Kurstaki and *Pseudomonas fluorescens* for use against insect pest, pathogens and nematodes; about 12 products based on Bt subsp. Israelensis; and 3 products with Bt subsp. sphaericus for mosquito control. About 27 products based on two viruses are registered, namely *Helicoverpa armigera nucleopolyhedrovirus* (HaNPV) and *Spodoptera litura nucleopolyhedrovirus* (SlNPV) for use against bollworms and armyworms. Four entomopathogenic nematode (EPNs) species are sold in the Indian market. These include wettable powder formulations of *Steinernema carpocapsae* and *Heterorhabditis indica* for managing white grubs in sugarcane and other crops. Plant-based neem is registered for use against more than 100 species of arthropods, 12 species of nematodes, 15 species of fungi, 3 viruses, 2 species of snails, and 1 crustacean species. The future potential in biopesticides can be leveraged through investment in domestic fermentation technologies, improved delivery systems, and promotion through private and public initiatives for ensuring sustainable crop production in the country.

Keywords: Bacteria, Biopesticides, Diseases, Fungi, Nematodes, Pathogens, Pest, Sustainable, Viruses.

XVI ASC | T9S2-01

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Diet Diversification and Food System Transformation

Cereal market outlook for India to 2040-41 and crop diversification: Implications for nutrition and environment

Jaiprakash Bisen*, Shiv Kumar, Dharam Raj Singh, Manjeet Singh Nain, Pravin Arya, Utkarsh Tiwari and Biswajit Mondal

*jpbisen.iari@gmail.com

In addressing the pressing concern of food security amid the backdrop of a growing population and socioeconomic, climatic, and technological transformations, it becomes imperative to develop a future outlook for major food commodities. This article employs a robust analytical approach involving structural equations within the framework of a dynamic and spatial partial equilibrium model to forecast the market dynamics extending up to the year 2040-41 for three major cereals in India, namely corn, rice, and wheat. Notwithstanding the intermittent disruptions witnessed in the short-term market dynamics, the medium to long-term forecasts pertaining to the demand and supply dynamics of corn, rice, and wheat reveal a national surplus across these commodities as compared to the base year of 2017-18. Our projections are contingent upon assuming a macroeconomic growth rate of 5.9%, considering the uncertain global geopolitical landscape and the limited potential for horizontal expansion of agricultural land. By the target year of 2040-41, India is anticipated to maintain a net surplus of +5.61 million tons of corn, +74.08 million tons of rice, and +9.31 million tons of wheat. Leveraging this surplus food balance, we conducted two simulation exercises to explore the ramifications of crop diversification, specifically focusing on oilseeds and pulses, with regard to nutritional availability and the reduction of greenhouse gas emissions stemming from the rice production system in India. The simulation results demonstrate that the utilization of fallow rice lands can yield additional quantities of carbohydrates ranging from 2.20 to 4.70 thousand tonnes, proteins from 2.15 to 2.96 thousand tonnes, and substantial gains in energy output from 12.75 to 30.35 ´109 kilo Joules. Conversely, substituting unsuitable rice-growing areas based on the national rice yield levels of the base year (2017-18) would result in a production penalty of approximately 19.05 million tons of rice. Furthermore, the scenarios of replacing rice cultivation in unsuitable regions, particularly during the rabi season, would lead to a noteworthy reduction in global warming potential, mitigating emissions by 2.54´1010 and 3.72´109 to 2.50´1010 kg of CO2 equivalent. These findings underscore the significance of strategic planning and policy formulation in leveraging surplus crop production to enhance food security, address nutritional deficiencies, and reduce the environmental footprint of agriculture in India. The insights derived from this study can inform policymakers, agricultural stakeholders, and researchers in making informed decisions and formulating sustainable strategies to meet the challenges posed by a growing population, changing climates, and evolving socioeconomic dynamics while ensuring food security and environmental sustainability.

Keywords: Cereals, Commodity outlook, Demand and supply, Partial equilibrium model

XVI ASC | T9S2-02

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Diet Diversification and Food System Transformation

Impact of integrated farming systems on farmers income and dietary diversity in India: A case study

Raghavendra, K. J.*, Jacob, D., Rajendran, T. N., Ravisankar, A. K., Prusty, M. A., Ansari, P., Punia, Nirmal, Sunil Kumar, Jacob John, Shamim, M., Raghuveer Singh, A. L. and Meena

ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250110, Uttar Pradesh, India

*raghavakj@gmail.com

In India, smallholders have become increasingly susceptible to risks and uncertainties over time, primarily due to their heavy reliance on cereal crops. A potential solution to mitigate this vulnerability involves embracing diversified agriculture and integrating various practices to optimize resource utilization effectively. Integrated Farming Systems (IFS) are more promising in this direction to adapt to changing climate and build resilience for production systems. This study analyses the economic effects of integrated farming systems and assesses their determinants, as well as the dietary diversity pattern of farmers in two states of southern India, i.e., Kerala and Tamil Nadu. These states have implemented schemes to promote agriculture in a holistic manner through IFS. A multistage sampling technique was used to obtain cross-sectional data from 367 farmers randomly chosen from two districts from Kerala and two districts of Tamil Nadu. The study identified three major farming systems which are in practice by farmers in the study area. Participants in schemes have Crop+Horticulture+Animal husbandry (38.86) as the major system, whereas non-participants have Crop+Animal husbandry (43.1) as the predominant system. Statistical methods like coarsened exact matching and logit regression methods were used to evaluate the economic impacts of IFS, and the determining factors for their participation and dietary diversity were evaluated. The findings of the study indicate that age, education, livestock holding, access to credit, and plantation area are the variables that have a positive and significant effect on participation by farmers in the program and their dietary diversity. The outcomes of the matching analysis indicate that the adoption of IFS has led to a substantial economic effect, yielding an extra gross income of `36,165 and a net income of `35,852 per ha. Additionally, it has enhanced the dietary diversity of farm households by 8.6%. This study proposes that IFS holds significant potential as a strategy to enhance farmers' livelihoods, achieve economic benefits, and enhance nutritional security within the rural economy. As a result, the expansion of IFS models is recommended by coordinating government initiatives in various regions of India to support smallholders and the farming community.

Keywords: Coarsened exact matching, Dietary diversity, Impact assessment, Integrated farming systems

XVI ASC | T9S2-03

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Diet Diversification and Food System Transformation

Transformative research priorities for gelatinous marine organisms in India: Exploring the diversified potential future food resource and its sustainable management plan

Tarachand Kumawat* and Uttam Kumar Sarkar

ICAR-National Bureau of Fish Genetic Resources, Lucknow – 226 002, Uttar Pradesh, India

*tarachand.kumawat@icar.gov.in

Gelatinous marine organisms, including various species of jellyfish, comb jellies, and salps, have emerged as a topic of growing interest in marine biology and fisheries management. The present assessment outlines the transformative research priorities necessary to unlock the potential of these organisms as a sustainable future food resource in the Indian context. Gelatinous marine organisms have often been regarded as a nuisance or bycatch in traditional fisheries due to their increasing abundance in Indian waters. However, recent scientific discoveries have revealed their untapped potential as a source of high-quality protein and other valuable bioactive compounds. The assessment underscores the need for comprehensive research to explore and harness gelatinous marine organisms' nutritional, economic, and ecological significance. The research priorities encompass taxonomic diversity, ecology, nutritional value, processing, sustainable harvesting, and management. Understanding gelatinous organisms' taxonomic diversity and ecological roles in Indian waters is essential. Comprehensive taxonomic studies are required to identify species, assess their distribution, and unravel their ecological interactions within marine ecosystems. This knowledge will inform sustainable harvesting practices and ecosystem-based management approaches. Investigating the nutritional composition of gelatinous organisms is crucial for assessing their suitability as a food resource. Research should focus on characterizing their protein content, amino acid profiles, and bioactive compounds. Innovative processing techniques must also be developed to ensure gelatinous-based food products' safety, palatability, and shelf stability. Developing a sustainable management plan for gelatinous marine organisms is imperative to prevent overexploitation and maintain ecosystem health. Research should explore harvesting methods, seasonal variability, and potential impacts on other fisheries. Moreover, socio-economic studies should evaluate the feasibility of gelatinous organism-based industries, including their market potential and socio-cultural acceptance. In conclusion, gelatinous marine organisms hold immense potential as a future food resource in India, offering nutritional benefits and economic opportunities. However, realizing this potential requires a concerted effort to address the outlined research priorities. The assessment calls for interdisciplinary collaborations among marine biologists, fisheries scientists, nutritionists, and policymakers to pave the way for sustainable utilization of gelatinous organisms, ultimately contributing to food security and environmental conservation in Indian coastal regions.

Keywords: Diversified food, Gelatinous marine organisms, Research priorities, Sustainable management plan

XVI ASC | T9S3-01

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Agri-food system transformation towards high-value commodities

Sustainability of the sugar sector vis-a-vis new biofuel policy in India

Viswanathan, R.* and Gangwar, L. S.

ICAR- Indian Institute of Sugarcane Research, Lucknow-226 002, Uttar Pradesh, India

*r.viswanathan@icar.gov.in

The Indian sugar industry is the second largest agro-based industry after the textile sector, catering to the needs of the food and bioenergy sector. The scope for the diversion of excess sugar for ethanol production was limited due to a lack of policy support, and the export of sugar was not remunerative. At this critical juncture, the Government of India had rescued the sector by implementing a new biofuel policy – in 2018. Ethanol production from cane juice and B-heavy molasses was permitted with differential pricing based on the feedstock. With this proactive policy, ethanol blending with petrol (EBP) picked up from a meagre level to 10% during 2021-22. This effort has supported the revival of the sugar industry in the country with the timely payment of cane dues to the farmers. The EBP target of 20% has been advanced to 2025-26 from 2029-30. A critical analysis was made on the economic analysis of sugar and bioethanol production in the country using primary and secondary data collected from a number of sugar mills and published sources. The results highlight that the sugar recovery, cost of sugar processing, and profitability have wide gaps in India, which need to be addressed through cutting-edge sugar processing technological interventions. In the EBP program, oil marketing companies (OMCs) had paid sugar mills nearly ₹81,796 crores (2014-2022) for ethanol supply, which helped in improving the financial viability of sugar mills and timely payment of cane prices to the farmers. The estimated foreign exchange saving due to the EBP Program was ₹53,894 crores (2014 -2022). A crore litre EBP is projected to save 20,000 tons of carbon dioxide (CO2) emissions. The economics of ethanol production reveals that ethanol produced by B-heavy molasses has a net income of ₹21.77 per litre compared to ₹13.43 per litre by final molasses. The estimated ethanol demand for 20% EBP by 2025 could be 1020-1090 crore litres. The distilleries attached to sugar mills are expected to supply 70 percent and 30 percent from the grain-based feedstock. To achieve the higher ethanol target, India needs to produce 550 MT sugarcane with sugar recovery of 11.50% and 100-110 t/ha, productivity as cane area may stabilize 5.0-5.2 m ha by 2030. Developing varieties for high biomass/ energy would be needed through cutting-edge biotechnological tools. To achieve enhanced productivity with high sugar recovery, integrated crop management is required by addressing major biotic and abiotic constraints. Also, the country should have a global crop monitoring system utilizing an AI approach, ably supported by the scientific team of IISR.

Keywords: EBP, E10, E20, New biofuel policy, Sugar production

XVI ASC | T9S3-02

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Agri-food system transformation towards high-value commodities

Impact of agricultural interventions on farm income and asset holding of SC farmers: A case study of the Schedule Caste Sub Plan (SCSP) scheme in Jhansi, Uttar Pradesh

Bishwa Bhaskar Choudhary*, Purushottam Sharma, Sunil Kumar, Gaurendra Gupta, Amit Kumar Patil, Sachendra, Prateek Kumar and Rohit Verma

ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284 003, Uttar Pradesh, India

*bishwa606@gmail.com

The present study using cross-sectional data collected from 398 schedule caste (SC) farmers in the Jhansi district of Uttar Pradesh, has analyzed the welfare impact of agriculture-based technological interventions promoted under the ambitious "Schedule Caste Sub Plan (SCSP)" scheme of the Indian government. We used the inverse-propensity-weighting regression adjustment (IPWRA) method as the main technique for impact evaluation and also checked the robustness of the results using inverse propensity weighting (IPW) and coarsened exact matching (CEM). The impact pathway was assessed through simultaneous equation modeling. The results show that the technological interventions accentuated farm income by 45-51% and farm & and domestic asset possession by SC farmers to the tune of 23-27%. Farming experience, livestock holding, off-farm activities, and extension and training were major drivers of technology adoption in the study area.

Keywords: Farm income Impact, IPWRA, SCSP scheme, Uttar Pradesh

XVI ASC | T9S3-03

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Agri-food system transformation towards high-value commodities

Crop size fixation in FCV tobacco: A proficient policy instrument to ensure supply-demand balance and price stability

Viswanatha Reddy, K.*, Sheshu Madhav, M. and Prasad, L. K.

ICAR-Central Tobacco Research Institute, Rajahmundry-533 105, Andhra Pradesh, India

*vishwanatha.reddy@icar.gov.in

FCV tobacco, a commercial crop, plays a vital role in the Indian economy and is valued for its high returns, livelihood prospects, and export potential. Commercial crops like tomato, chilli, and onion recently exhibited high demand-supply imbalance and price volatility, creating a crisis-like situation in India. In contrast, FCV tobacco farming, regulated by crop size fixation policy, is highly vibrant and operates in an organized environment. Against this backdrop, an attempt has been made to evaluate the effectiveness of crop size fixation policy and Information Technology (IT)-enabled e-auctioning system in the FCV tobacco sector. Trend analysis and instability index were employed using time-series data. It was found that the difference between the average crop size fixed (143.5 M kg) and the average actual production realized (142.2 M kg) in Andhra Pradesh during the last decade is very insignificant, i.e. 0.7 million kg, while in Karnataka, there was a slight difference (3M kg) between the annual average of crop size fixed (99.3 M kg) and the average of actual production realized (96.2 M kg) during the last decade. On the price front, it was found that price instability has significantly decreased from 40 % to 13 % in Andhra Pradesh and 38 % to 8 % in Karnataka during the manual action period (2002-2012) compared to IT-enabled e-auctioning period (2012-2022) of marketing. This indicated that the kind of regulation mechanism and IT-enabled market ecosystem operating in FCV tobacco has led to impart stability for the smooth functioning of the production system and price discovery in India. Therefore, the policy of crop size regulation and IT-enabled e-auctioning in accordance with domestic and international demand could be viewed as a potential device to ensure supply-demand balance and price stability. However, such a policy for regulation was not in place for other commercial crops such as chilli, turmeric, tomato, and onion which experience high price volatility. Thus, there is an immediate need for such crops to have a similar kind of policy intervention to ensure supply-demand balance, better prices, and farmers' income to protect farmer producers and consumers from violent price fluctuations.

Keywords: Crop size regulation, Exports, FCV Tobacco, India, Price, Production, Stability

XVI ASC | T9S3-04

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Agri-food system transformation towards high-value commodities

Litchi-based integrated nutri-farming systems for augmenting farm income and sustainability

Bhagya Vijayan*, Bikash Das, Prabhat Kumar and Ankit Kumar

ICAR- National Research Centre on Litchi, Muzaffarpur-842 002, Bihar, India

*bhagyavijayan11@gmail.com

India has committed to sustainable development goals, of which SDG 12 and SDG 13 mandate the country to have responsible consumption, production, and climate action, respectively. India can achieve the same by ensuring the active participation of small and marginal farmers who occupy 85 % of the population. Of the 146 million operational land holdings, the highest number of holders belonged to Uttar Pradesh (23.82 million), followed by Bihar (16.41). Hence, assessing the present practices prevalent among these agricultural landholders is inevitable to strengthen sustainable production. Accordingly, a study was undertaken to assess the sustainability of litchi-based integrated nutri-farming systems prevalent in the Muzaffarpur, Vaishali, and Samastipur districts of Bihar. Purposive sampling was employed in the study with a sample size of 30. The farmers' present production system was compared with the litchi integrated farming system developed by ICAR-NRCL. Most (93%) farmers had been giving the litchi fruit trees on the lease, thereby not harnessing full profit. The farmers surveyed had incorporated an integrated farming system but the agricultural produce was utilized for their own consumption. Based on the production data, a sustainability index for Litchi-based Farming Systems (LFSI, Litchi Farmer Sustainability Index) is based on the four pillars of sustainability human, social, economic, and environmental dimensions. It was seen that the small and marginal farmers under 1.0 ha, generate Rs 253230/ha gross returns with a net profit of Rs 123045/ha, which were far higher than the prevailing dominant rice-based cropping systems. Of the surveyed farmers, farmers who had incorporated intercrops, fishery, and poultry maintained a benefit-cost ratio of 2.1. Pathways to different farming systems were analyzed using Classification and Regression Tree (CART) analysis. Based on the sustainability index, sampled farming systems were classified as highly sustainable, sustainable, and fragile. Farming systems with integrated components such as poultry, fishery, and proper management practices in litchi were found to be highly sustainable (5%). It was also observed that the farmers (25%) who had integrated different crop systems along with litchi automatically catered to their family's nutritional security.

Keywords: Integrated farming system, LFSI, Nutritional security, Sustainability

XVI ASC | T9S3-05

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Agri-food system transformation towards high-value commodities

Crop diversification towards high-value commodities in the state of Maharashtra

Sachin More, S.[1], and Kaveri Khairnar, Y.[2]*

[1] Department of Agricultural Economics, VNMKV, Parbhani, Maharashtra, India
[2] Department of Agricultural Economics, M.P.K.V. Rahuri, Maharashtra, India

*kaveriyk@gmail.com

Crop diversification is considered a pathway to promote agricultural development. The status of crop diversification was examined in Maharashtra for the period from 1960-61 to 2019-20 using the Composite Entropy Index (CEI). The extent of crop diversification in Maharashtra state was analyzed for cereals, pulses, foodgrains, oilseeds, commercial crops, non-food grains, and the total crop sector on a long-term basis. The study revealed that Maharashtra state has witnessed a high level of crop diversification in the total crop sector as the magnitude of Composite Entropy Indices (CEI) was more than 0.70 on a scale of zero to one. The CEI for different crop categories has shown that all the crop groups have a higher crop diversification index except for the oilseed group. There has been a vast increase in the diversification of commercial crops after the 1990s. However, there was a substantial reduction in the diversification of oilseeds after 1990 due to the supremacy of soybean in the oilseed group. The state has moved towards specialization in pulse crop cultivation. An admirable level of diversification in non-foodgrain crops was also observed at the state level over the period of time. The findings of the study confirmed that the agricultural economy in Maharashtra state is transforming from food grains to non-food grains, i.e., from low-value to high-value crops such as oilseeds, cotton, sugarcane, fruits, vegetables, and other crops. Therefore, the government should encourage the farmers to diversify to higher-value commodities by conducting awareness generation campaigns and promoting research-based recommendations and technologies on the farm. This will help the state and the country reap the benefit of crop diversification.

Keywords: Composite entropy index, Crop diversification, Maharashtra

XVI ASC | T9S3-06

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Agri-food system transformation towards high-value commodities

Sustainability assessment of banana value chains in Palakkad District, Kerala: An insight into the 'Auction System Value chain'

Nikhil, K. S.[1]*, Aparna Radhakrishnan[2] and Dileep Kumar, R.[3]

[1]Department of Agricultural Extension Education, College of Agriculture, Vellayani, Kerala Agricultural University, Thrissur, Kerala, India
[2]Agricultural Extension Education, Krishi Vigyan Kendra, Thrissur, Kerala Agricultural University, Thrissur, Kerala, India
[3]KSMDB College, Sasthamcotta, Kollam, Kerala, India

*nikhilks7428@gmail.com

Value chain analysis has the potential to formulate competitive strategies and identify interrelationships between activities that create value. This study explored the sustainability assessment of banana value chains in Agali, Kumaramputhur, and Karimpuzha panchayaths of Palakkad district of Kerala. The study analyzed economic, social, environmental, and technical factors to measure sustainability. We employed key informant interviews and focus group discussions to collect information from the major actors in the chains and a weighted index approach to calculate the sustainability of indicators. The auction system value chain exhibited the highest sustainability compared to the other value chains on statistical analysis. The auction system value chain actors have a high level of economic expertise as well as social and environmental progressivity and technological competence. VFPCK market and its auction system brought the particular chain into a more advanced stage and enabled an environment where the banana farmers and dependent marketing intermediaries meet each other and ensure reasonable earnings for the raw banana. Since the auction system value chain is highlighted by the VFPCK market, policy-level interventions to establish and execute these kinds of procuring markets with a joined association between farming communities will strengthen the dispersed producers into a common platform and could earn more by collective bargaining and add more value in terms of processing industries. Banana cultivation would most likely gain momentum in major areas by streamlining the market support mechanism and processing facilities.

Keywords: Agricultural marketing, Banana value chain, Financial earnings, Information sharing

XVI ASC | T9S3-07

Theme: Policies and Institutions for Transforming Agri-food Systems
Sub theme: Agri-food system transformation towards high-value commodities

'Urban-agri'–A transformation in agri-food system to achieve sustainable development

Harsh Saini*, Sakshi Paliwal and Shashank Sen

Agriculture Research Station, College of Agriculture Sumerpur, Pali (Rajasthan), Punjab Agricultural University (Punjab)

*harrypotts59@gmail.com

This study mainly pertains to the definition of urban agriculture and goals relating to the agri-food system and sustainable development. Additionally, it discusses the "shared values" initiative started by the W.H.O. to eliminate or make use of agricultural waste or ruined products. Furthermore, an excursus is created on the actual development of the "Agri every door" model, with the new opportunities attained from contemporary forms of digitalization and novel techniques specifically focusing on preventing agri-food waste through which the nation's hunger can be addressed, and soil fertility can be improved. Urban agriculture refers to the idea of transferring rural agriculture to urban areas through government initiatives and financial aid. In this system, urban residents are required to either install an agricultural system in their homes or just engage in subsistence farming on 10% of their house grounds. In this program, government organizations will train urban residents to practice agriculture on their own land by providing well-organized, affordable equipment kits through training sessions, advertisements, digital mobile applications, etc. and for crops, experts will recommend crops or vegetables to the locals based on their interests, needs, climate, suitability, environmental friendliness, etc. The government should implement advantageous policies and subsidy programs to encourage people to embrace this project. To increase production, the government can work with other institutions like the Agriculture and Technology Management Administration (ATMA), IFRF, RDF, Kalinga Institute of Social Science, etc. This prevents approximately 68000 crores in yearly agri-food waste, potentially improving soil fertility and alleviating hunger across the country. In 2012, TNAU created 'Do it yourself' as a variation of a very identical concept. However, the issues that were encountered, such as lack of knowledge, funding, significant funding, and political participation, led to the demise of that initiative. However, with innovative methods and assistance from the government, the concept of "urban-agri" is entirely feasible. The kits utilized in this system can also be exported with the label "made in India," which can boost the nation's economy.

Keywords: Agri-food system, ATMA, Sustainable development, Urban-agri, Urbanization

XVI AGRICULTURAL SCIENCE CONGRESS 2023

10-13 OCTOBER 2023 | KOCHI | KERALA

THEME 10

International Partnership for Research, Education and Development

Impact assessment of Academia: Accounting and valuation of human capital in indian fisheries higher education

Neha Wajahat Qureshi*, Abhilash Thapa, Ananthan, P. S. and Talib Mohhammad

*Fisheries Economics, Extension and Statistics Division, ICAR-Central Institute of Fisheries Education, Mumbai-400 061, Maharashtra, India

*nehaq@cife.edu.in

Universities play a significant role in producing human capital for the country. To justify the budgetary allocation to these public funded universities, it becomes imperative to calculate the value of the assets they generate to improve the education system. The current study assessed the expenditure incurred on producing the human capital in Fisheries colleges and evaluated their worth. For this study, two Colleges of Fisheries (CoF) from the North-Eastern region of India, *i.e.*, College of Fisheries (CoF), Assam and CoF, Tripura, Central Agriculture University, were chosen. A novel methodological framework developed by ICAR-Central Institute of Fisheries Education, Mumbai (HCVaF) has been used to analyze the data. It consists of Modified Flamholtz's human cost accounting method used to examine the investments. The Lev and Shwartz and TFP models value the human capital and quantify its contribution to the Fisheries economy. The data has been collected using a checklist and placement data validated through telephonic conversations with the alumni. The results showed the net investment made by CoF, Assam on each B.F.Sc., M.F.Sc. and Ph..D. student were ₹3,48,156, ₹7,80,043 and ₹14,61,729 per degree program respectively, whereas for CoF, Tripura were ₹1,57,193, ₹5,06,627 and ₹ 9,50,705, respectively. The placement details from 2011-2020 for CoF, Assam revealed that the majority (65.7%) of the passed out were working with the Department of Fisheries (DoF), followed by industry (18.1%). Whereas for CoF, Tripura, the majority worked under DoF (56.5%) followed by SAU (11.2%). In Assam (98.7%) and Tripura (81.9%), most students were placed in jobs where B.F.Sc. was the minimum eligibility. Around 5.43% of students in CoF, Assam, and 7.67% of CoF, Tripura, were found to be unemployed. Among the career options, entrepreneurship was found to have the highest net worth in both colleges, with ₹7,71,106 and ₹6,76,925 for Assam and Tripura. Between 2011 and 2020, CoF, Assam expended a total of ₹17.1 crores on human capital, while the total value of students was found to be ₹266.7 crores, contributing ₹249.6 crores to the country, almost 15.63 times the investment. Whereas for CoF, Tripura`s total expenditure on human capital was ₹12.8 crores, the total value of students was found to be ₹351.8 crores, thereby contributing ₹339 crores to the nation, almost 17.56 times the investment. According to the TFP model, CoF, Assam's contribution to the Fisheries economy through human capital was ₹71.94 crores in 2020-21, while CoF, Tripura's contribution was ₹128.43 crores in 2020-21 (if the contribution of professional fisheries HR to total fisheries HRD is assumed to be 50%). There is a scope to increase investment, especially in fellowships and capacity-building programs to attract brighter students, followed by the inclusion of entrepreneurship development courses in UG and PG to sow the entrepreneurial spirit among the students.

Keywords: College of Fisheries, Human resource accounting, Impact, Valuation

News value of the Agriculture Sector

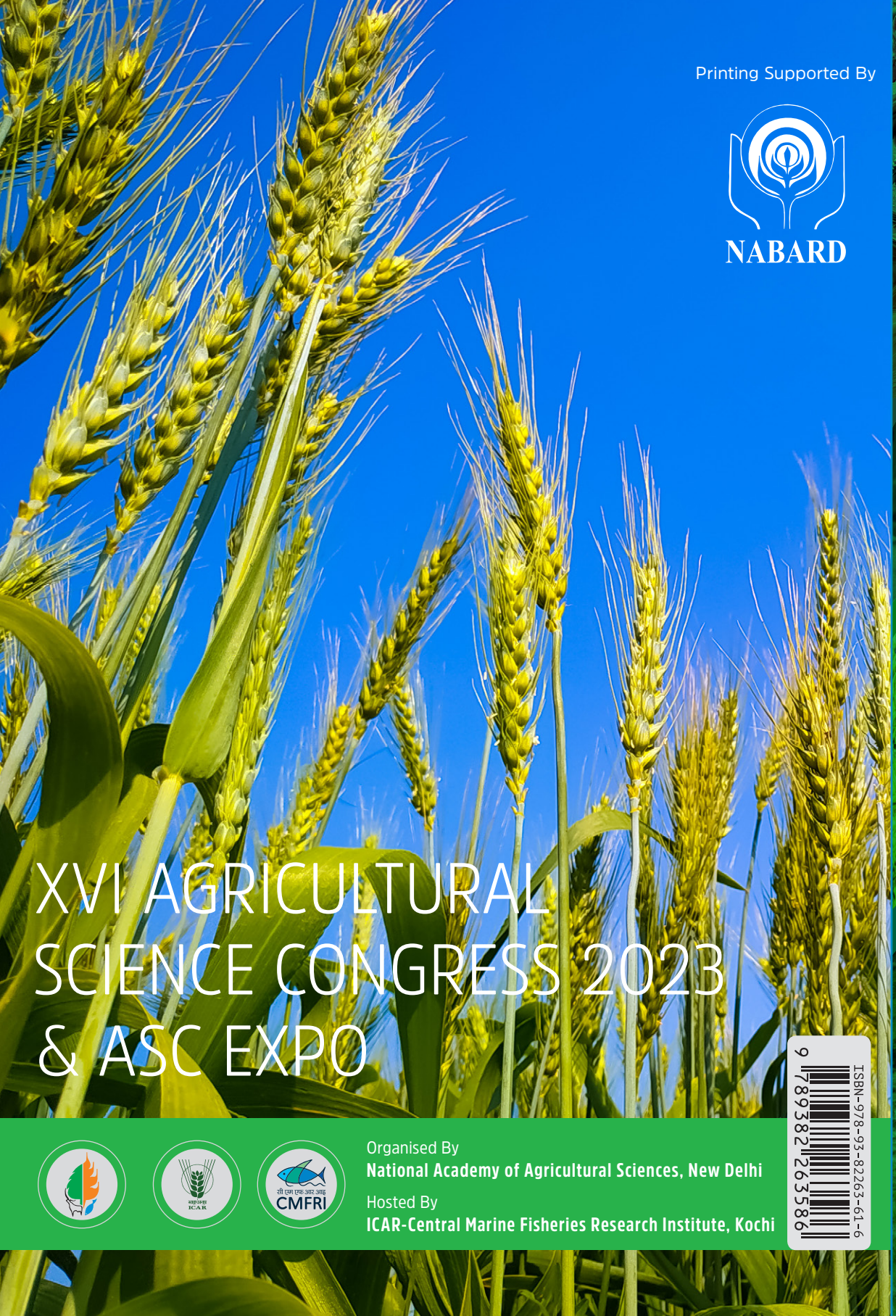
Siseena, J.*

Kerala State Health Department, Govt. of Kerala, Kerala, India

*sisiwils17@gmail.com

Worldover, the agriculture sector continues to be the primary source of livelihood for most of the population, with fisheries and animal husbandry as sub-sectors. The subsectors play a vital role in the socio-economic development of rural households. Fishing and fisheries are essential to coastal countries' social and economic heritage. Presently, the agriculture sector in the world has been severely impacted due to unforeseen adversities of natural calamities, climate change, environmental degradation, and the COVID-19 pandemic. Much importance is given to the agriculture-related news by the press and media. Here, the researcher investigated the new value of the agriculture sector. For this purpose, five well-established daily newspapers published in Kerala, one of the world's most agrarian-friendly states, were selected, namely the Malayalam daily newspapers Malayala Manorama, Mathrubhoomi, Deshabhimani, and English daily newspapers, The Hindu and Indian Express for 31 days in July 2023 and the news coverage on the first page evaluated. News items were classified as politics, judiciary, agriculture, crime, transportation, national news, international news, sports, education and health. Results showed that the coverage given to the agriculture-related information could have been better.

Keywords: Coverage, Daily new papers, Press, Public



Printing Supported By

NABARD

XVI AGRICULTURAL SCIENCE CONGRESS 2023 & ASC EXPO

Organised By

National Academy of Agricultural Sciences, New Delhi

Hosted By

ICAR-Central Marine Fisheries Research Institute, Kochi

ISBN-978-93-82263-61-6

XVI AGRICULTURAL SCIENCE CONGRESS 2023