

Successful experimental cultivation of *Kappaphycus alvarezii* along Odisha coast

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Odisha is one of the maritime states on the north-east coast of India (17.75° N and 22.5° N and 81.5° E and 87.6° E). With a coast line of about 480 km (8% of the coast line of India), continental shelf area of about 25,000 km² (4.5% of Indian total continental shelf area), mangrove wet land area of 215 km² and heavy nutrient influx from three major, six medium and one minor river systems, Odisha represents one of the most productive marine ecosystem of India. The frequent cyclonic weathers and storms in Bay of Bengal along Odisha coast and mandatory fishing bans for the conservation of wild life greatly hampers the livelihood options of fishermen. Since the capture based marine fish production in Odisha is also showing early signs of fatigue or stagnation. It is necessary to develop alternative as well as additional livelihood options to improve the socio-economic status of the fishermen and increase production from marine ecosystem. As such alternative, experimental sea weed farming was conducted during November 2020 to February 2021 by ICAR-CMFRI to assess its feasibility, under a project

funded by Fisheries & Animal Resources Development Department, Government of Odisha. The Four coastal districts selected were Balasore, Jagatsingpur, Puri and Ganjam each having two locations selected based on suitability of physico-chemical and other required oceanographic parameters (Table 1)

After the site selection process was completed with the help of Assistant Directors of Fisheries (ADFs-Marine Fisheries) of the respective districts by scientists of ICAR-CMFRI in November, 2020. Seed material of *Kappaphycus alvarezii* was obtained from Rameshwaram in Tamil Nadu packed in gunny bags adequately moistened with sea water of 35 ppt salinity. These were transported to Bhubaneswar (Odisha) by train which took nearly 48 hours to reach. It was then transported to Chandrabhaga hatchery, which is nearly 45 km from Bhubaneswar, by road. The seed material upon arrival appeared to be healthy even after about 50 hours of transportation. Nevertheless, the materials were acclimatized for 24 hours to ease out any stress from transportation in a

Table 1. Locations of seaweed farming experiment sites along Odisha coast.

District	Experimental Location	Geo-coordinates	Nature of Location	Seeding date
Balasore	Balarampur	21°16'19"N; 86°52'36"E	Receding tidal area	24.02.2021
	Chandipur	21°26'29"N; 87°02'50"E	Receding tidal area	25.02.2021
Jagatsingpur	Noliasahi, Gadakujanga	20°11'00"N; 86°31'34"E	Open sea area	24.02.2021
	Patharabandha, Paradip	20°17'32"N; 86°42'58"E	Bar mouth	25.02.2021
Puri	Ramachandi Muhana, Chandrabhaga	19°51'16"N; 86°03'59"E	Bar mouth	16.02.2021
Puri	Nuagarh, Astaranga	19°58'30"N; 86°20'28"E	Bar mouth	17.02.2021
Ganjam	Markandi	19°11'03"N; 84°49'57"E	Bar mouth	19.02.2021
Ganjam	Puruna Bandha area	19°22'42"N; 85°04'56"E	Bar mouth	19.02.2021

well aerated and lighted tank circulated with running sea water (salinity: 35 ppt). The seeding materials were subsequently transported to the respective experimental locations by packing them in gunny bags adequately moistened with sea water. Sea water was also carried along to rehydrate/ moisten the gunny bags which carried nearly 25-35 kg of seaweed of *Kappaphycus alvarezii* each at regular intervals.

Three square shaped bamboo rafts (3 x 3 m) were fabricated at each experimental site for planting the sea weed. Poly-vinyl ropes (diameter: 10 mm) were tied between the two parallel side arms of the raft at an approximately distance of 30 cm from each other to create multiple lines for seeding. Approximately, 7.5-10.0 kg of seed material was introduced in each raft for experimental cultivation. The seed material was tied to the Nylon rope using an innovative tying method with nylon zip ties. Unlike traditional rope tying

method, this considerably reduced the time and effort for seeding the rafts.

Sea weed biomass of Balarampur and Chandipur, Balasore District showed very low to moderate growth after deployment. The rafts in Chandipur had been deployed in shallow pool like areas, which remained partially exposed to the direct sun light and atmosphere during low tides. Further lack of adequate water depth caused the sea water in these pools to become over heated which adversely affected the sea weeds leading to gradual degeneration in biomass. Nevertheless, the growth of sea weed at Balarampur was moderately better than Chandipur probably due to greater water depth available at the site even during low tide. A biomass of 15-20 kg was obtained from an initial stocking biomass of 7-8 kg after 45 days of cultivation.

In the experimental units deployed at Nuagarh (Astaranga) and Ramachandi Muhana (Chandrabhaga),



Fig. 1. Acclimatization of seeding materials at Chandrabhaga hatchery (Odisha)



Fig. 2. Fabrication and seeding of rafts with *Kappaphycus alvarezii* using zip tie method

low to moderate growth of *K. alvarezii* was noticed; other opportunistic algae like *Ulva intestinalis* overinfested the rafts. The former site being situated at

bar mouth gets a heavy river flow from Devi River, one of the principal tributaries of Mahanadi especially during low tide. Similarly, the latter site is influenced



Fig. 3. Deployment and installation of rafts seeded with *Kappaphycus alvarezii*



Fig. 4. Sea weed, *Kappaphycus alvarezii* growth in rafts at Balarampur, Odisha after 45 days of culture



Fig. 5. Low to moderate growth of Sea weed, *Kappaphycus alvarezii* and overwhelming infestation by *Enteromorpha* sp. at Nuagarh, Odisha after 45 days of culture



Fig. 6. Sea weed, *Kappaphycus alvarezii* growth at Markandi, Odisha after 45 days of culture



Fig. 7. Sea weed, *Kappaphycus alvarezii* growth at Noliasahi, Odisha after 45 days of culture

by Kushabhadra River, another tributary of Mahanadi. Moreover, the bar mouth opening is quite constricted which might have reduced the salinity at the site during low tide and there by facilitated the luxuriant growth of the opportunistic *Enteromorpha* sp., significantly arresting growth of *K. alvarezii*. A sea weed biomass of about 15-25 kg was produced from an initial stocking biomass of 7-8 kg during the culture duration of 45 days.

Units deployed at Purana Bandha area and Markandi showed moderate to high growth of sea weed. Purana Bandha was situated in the river bar mouth area of Rushikulya River while Markandi was situated on a minor water outlet from nearby swampy area that provided optimum salinity due to lesser fresh water influx. About 25-30 kg of sea weed biomass was

produced from an initial stocking biomass of 7-8 kg during the culture duration of 45 days in these experimental sites.

Growth of sea weed at Patharabandha (Paradip) was poor, mainly due to strong water current of the Mahanadi River. The steep decline in salinity due to heavy freshwater during low tides further affected the sea weed growth. Remarkable luxuriant growth of *K. alvarezii* was observed at Noliasahi (Gadakuja) where about 70-120 kg production was made from each raft at an Initial stocking weight of 7-10 kg, within a culture duration of 45 days. The site located in the river bar mouth area of Jatadhari River probably got the minimal freshwater influx and maintained the ideal salinity throughout the culture duration. Based on the encouraging results obtained from Noliasahi

Table 2. Cost benefit based on the experimental farming of seaweed in Noliasahi, Gadakujang, Odisha.

Input cost

Item	Quantity	Amount (₹)
Seed material from Rameswaram to the site including transport	100 kg	10,000
Preparation of raft	10 numbers	10,000
Miscellaneous expenditure	10 rafts	4,000
Total		24,000

Output cost

Item	Production (kg) & value(₹)/ raft	Total Production (kg) & Value(₹)
Production from each raft during one culture cycle	80 kg	800 kg
Quantity with 35% moisture	28 kg	280 kg
Value of dried seaweed @ ₹.50/kg per cycle	1,400/raft	14,000
Value of dried seaweed for 3 cycles in a year	4200/ raft	42,000
Profit per annum		18,000

(Gadakujanaga, Odisha), an economic model for successful sea weed cultivation in Odisha has been worked out (Table 2).

One culture cycle for sea weed is 45 days. Considering all adverse situations especially during monsoon season, if the ideal 4 months (January to April) is utilized for cultivation, there could be 3-4 culture cycles possible using the same raft in a year which will give an approximate profit of ₹18,000 per annum from 10 rafts.

Evidently, growth of sea weed in coastal areas of Odisha is mainly influenced by salinity, which is greatly affected by the heavy fresh water influx from its vast riverine systems. Frequent adverse cyclonic weathers and storms also make the sea rough and unsuitable, especially during monsoon season. However, because of the heavy nutrient influx, a unique opportunity for seaweed cultivation for almost 4 months of the year during January to April is available along Odisha coast. The encouraging results obtained, especially from Noliasahi Gadakujanga clearly indicate that the farming of *Kappaphycus alvarezii* is feasible. Wherever a competitive inhibition of *K. alvarezii* was observed due to *Enteromorpha* sp. Infestation, the

possibilities of cultivating other low salinity tolerant species like *Gracilariopsis longissima* can be explored. The experiment also showed prospects for diversification of species like *Enteromorpha*, *Caulerpa* and *Gracilariopsis longissima* for cultivation which can be used for human consumption. The receding tidal areas like Chandipur and Balarampur in Balasore district could be efficiently utilized for seaweed farming with certain structural modifications by digging the area to retain the water at least 2 ft during receding tide period. Onshore collapsible seaweed farm can be established on the seashore with regular supply of seawater. Most of the river bar mouth area provides ideal condition for sea weed farming as the sand strips neutralize the heavy tidal action of the open sea. Proper dredging of the bar mouth connection to sea and deployment of mechanical pumps to prevent salinity drops during low tide could give very encouraging results. The experimental location at Noliasahi, Gadakujanga (Jagatsingpur, Odisha) was found to be ideal for mass culture of *Kappaphycus alvarezii* and therefore, fisherfolks should be encouraged to participate in sea weed farming by forming self-help groups (SHGs). Popularization of cultivation technique and large scale participation will open up new avenues for the sea weed industry in Odisha.