Seaweed Farming and Integrated Multi-Trophic Aquaculture (IMTA)

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Seaweed Farming Techniques

Kappaphycus farming is being widely adopted by floating bamboo raft method in Tamil Nadu coast (Plate 1). In few places tube net and monoline culture technique is also being practiced for seaweed cultivation. Floating raft is made of bamboo with 12’ × 12’ for mainframe and 4’ x 4’ for diagonals. In each raft, 20 polypropylene-twisted ropes are used for plantation. Around 150 – 200 grams of seaweed fragments are tied at a spacing of 15 cm along the length of the rope. A total of 20 seaweed fragments can be tied in single rope. The total seed requirement per raft is 60 – 80 kg. Fish net of 4m x 4m size is tied at the bottom of the raft to avoid grazing. In normal season, a cluster of 10 rafts are positioned in the near shore area of 1.0 to 1.5 m depth using a 15 kg anchor. Whereas during rough season the same cluster has to be installed using two or three anchors. Most of the seaweed farmers are using 25 to 45 rafts for their cultivation. Due to lack of space for the farming, in most of the villages a farmer is restricted to use maximum of 45 rafts only (Johnson *et al.,* 2017).

Plate 1 Floating raft method in *K. alvarezii* farming

Plate 2 Raft ready for harvest

Economics of seaweed farming

The total cost of production for making one bamboo raft for *K. alvarezii* farming worked out to be around Rs.1,600/- (Table 1). As the investment is comparatively less and farmers were also supported through subsidy scheme the spread of the technology was rapid.

Table 1. Unit cost for a bamboo raft

S.No	Particulars/Description	Quantity Required	Cost per Raft (Rs)
	FIXED COST		
1.	3-4" dia hallow bamboos of 12'x 12' for main frame + 4' x 4' for diagonals (without any natural holes, crakes etc.,) @ Rs.6.00 per ft of bamboo	64'	384.00
2.	Five-toothed iron anchor of 15 kg each (@ Rs.64 per kg) – one anchor can hold a cluster of 10 rafts	1.5 kg	96.00
3.	3mm PP twisted rope for plantation – 20bits of 4.5m each (@ Rs.230 per kg)	420 gm	97.00
4.	Cost of HDPE braider pieces (20 pcs x 20 ropes = 400 pcs of 25 cm each) (@ Rs.330 per kg)	165 gm	55.00
6.	Raft framing rope 6m x 12 ties per raft i.e., 36mts of 4mm rope(@Rs.230 per kg)	650 gm	150.00
7.	Used HDPE fishing net to protect the raft bottom (4m x 4m size) (@ 70 Rs/ kg)	1 kg	70.00
8.	2mm rope to tie the HDPE net (28 mts) (@ Rs.230 per kg)	100 gm	23.00
9.	Anchoring rope of 10 mm thickness (17m per cluster of 10 rafts) (@ Rs.220 per kg)	100 gm	22.00
10.	Raft linking ropes per cluster 10 rafts – 6mm thick – 2 ties x 3m x 9 pairs = 54m length (@ Rs.230 per kg)	100 gm	23.00
11.	Braider twining charges		80.00
	TOTAL		**1,000**

	OPERATING COST	Quantity Required	Cost per Raft (Rs)
1.	Seed material (150 gm x 400 ties = 60 kg) + 10 kg handling loss = 70kg@ Rs. 4.00 per Kg	70 kg	280.00
2.	Labour (Seeding, Raft / monoline laying & maintenance)		200.00
3.	Transportation		100.00
4.	Miscellaneous expenses		20.00
	TOTAL		**600.00**

Table 2. Economic Feasibility Analysis of Seaweed Farming from 45 rafts per person *(Total 5 cycles in a year; each cycle is 45 days)*

1.	Annual seaweed production (260 kg/raft) *(Retaining 60 kg for next crop, total fresh seaweed production from 45 rafts; 5 cycles)*	45,000 kg
2.	Total seaweed production on dry weight basis (10 %) *(from 45 rafts; 5 cycles)*	4,500 kg
3.	Price of dried seaweed (Rs. per kg)	45
	Gross Revenue in Rs.	**2,02,500**
	Total cost of production (Rs.) (Rs.1,600 × 45 rafts)	**72,000**
	Net income (Rs.) (Gross revenue – Total cost of production)	**1,30,500**

The crop duration is for 45 days. In a year, four to six crops/cycle (6 to 9 months) can be harvested depending on the climatic condition. Planting of 150g grows up to 500 to 1000g in 45 days. In one raft of 12 x 12 ft size an average yield of 260 kg can be obtained. After retaining 60 kg as seed material for the next crop, remaining seaweed is sold either in fresh or dry weight basis. The average dry weight percentage of the harvested seaweed is 10 per cent. At present farmers receive Rs. 5 to Rs. 10 and Rs. 40 to 45 per kg for fresh and dried seaweed respectively. On an average a family earns Rs.10,000/- to Rs.15,000/ per month.

Constraints in K. alvarezii farming

i) Grazing

Nibbling of herbivores like siganid, acanthurid, sea urchin and starfish on tips of branches is the major problem faced by the seaweed farmers. During the month of May – June, the grazing intensity is more, which affects the yield up to 50-80 per cent.

ii) Epiphytism

It is the attachment of undesirable seaweeds to the cultured species, which is common among tropical seaweeds that usually occur at the onset of monsoon brought by change in water temperature, trade wind and water motion; drift seaweeds caused by limited substrate contribute also to epiphytism that compete for space, nutrient and sunlight. During the month of May – June, majority of the seaweed framers face this problem.

iii) High temperature / Disease

Diseases are caused by low salinity, high temperature, and light intensity. When the plant is under stress whitening of the branches occurs, which results in crop loss. Even few farmers discontinued the farming due to severe loss during high temperature period.

Apart from the above mentioned problems, natural calamities like heavy storm and cyclone cause complete damage to the *K. alvarezii* farming.

Environmental benefits

Seaweed farming is considered as one of the significant mitigating measures for the adverse impact of climate change. Seaweeds provide shelter to a variety of organisms and enhance biodiversity. They absorb carbon-di-oxide (CO_2) and reduce global warming (Israel *et al.,* 2010). They are also efficient in controlling organic pollution including heavy metals in the inshore waters and thereby ensuring ecological balances. Thus, seaweed cultivation is an eco-friendly option with sustainable income to the coastal fishers. Experimental studies were conducted at Munaikadu, Ramanathapuram district, Tamil Nadu on assessment of carbon sequestration potential of seaweed (*Kappaphycus alvarezii*) and it was found that the specific rate of sequestration (per unit mass of seaweed per unit time) of CO_2 by the seaweed was estimated as 0.0187 $gday^{-1}$ (CMFRI Annual Report, 2015-16).

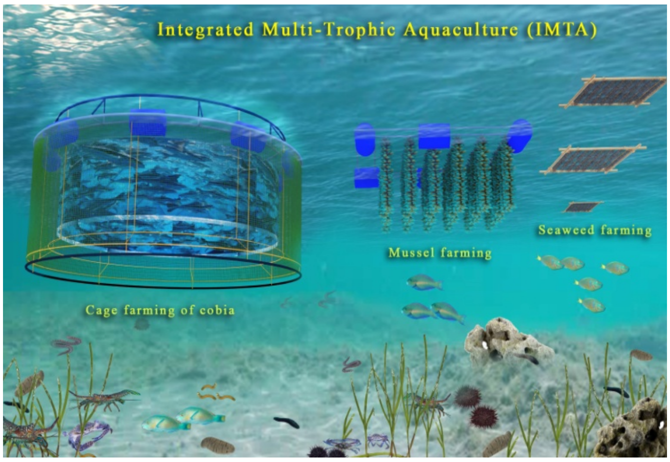
Integrated Multi-Trophic Aquaculture (IMTA)

One of the anticipated issues while expanding the sea cage farming is the environmental degradation 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) which is getting importance at global level. The ICAR-CMFRI, Mandapam has successfully conducted demonstration of Integrated Multi Trophic Aquaculture (IMTA) under participatory mode with a fishermen group at Munaikadu (Palk Bay), Ramanathapuram district, Tamil Nadu by integrating seaweed *Kappaphycus alvarezii* with cage farming of Cobia (*Rachycentron canadum*). Since, seaweed farming is being widely adopted in Tamil Nadu coast; integration of seaweed with cage farming of cobia was initially attempted.

A total of 16 bamboo rafts (12× 12 feet) with 75 kgs of seaweed per raft can be integrated with one of the cobia cage. In one crop of 45 days the seaweed rafts integrated with cobia cage gave a better average yield of 260 kg per raft while the same was 150 kg per raft for the rafts which were not integrated. An addition of 110 kgs of seaweed/ raft was achieved due to the integration with cobia cage farming. Moreover there was increased number (average 90-100 nos.) of newly emerged apical portion/tips in a bunch of harvested seaweed from the rafts integrated with the cobia cages, whereas the same was less (average 30- 40 nos) from the rafts which were not integrated. The bunches having more numbers of newly emerged apical portion/tips, when used for replanting, will be ready for harvest within 40 days, whereas the seaweed with less numbers of newly emerged apical portion/tips, if used as seed, will be ready for harvest only after 54 days.

It was found that the organic waste mitigation of the integrated system of *Kappaphycus* farming is more efficient than the non-integrated system of farming. In addition to the revenue generated in cobia and seaweed sales by conventional method, an additional income of Rs.1,00,000/- could be realized due to increased seaweed and cobia fish yield from IMTA. The total amount of CO_2 sequestered into cultivated seaweed (*Kappaphycus alvarezii*) in the integrated and non-integrated rafts were estimated to be 223 kg and 100 kg respectively. Hence, there is an addition of 123 kg carbon credit due to integration of 16 seaweed rafts (4 cycles) with one cobia cage (one crop).

Integration of seaweed with cobia cages favourably generates additional revenue through increased yields of both cobia and seaweed. Hence fishermen are continuously adopting this technology with their own investment. IMTA is efficient in controlling both organic and inorganic pollution in the natural open waters and thereby ensuring ecological balances. Thus, IMTA is an eco-friendly option with sustainable income to the coastal fishers.



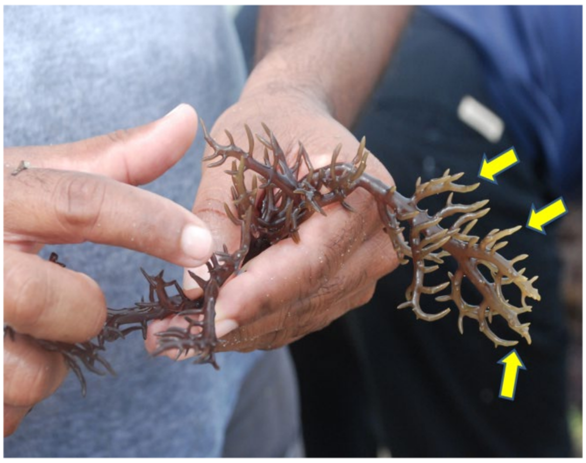
IMTA Cross-sectional view

Seaweed raft along with cobia cage

Staff along with the fishermen group during the harvest

Comparison of seaweed rafts which was integrated and not integrated with cobia cage

Comparison of a bunch of seaweed which was taken from the rafts which was integrated and not integrated with cobia cage



More numbers of newly emerged apical portion/tips from a bunch of harvested seaweed from the rafts integrated with the cobia cages

Conclusion

The seaweed farming has proved to be an economically viable alternate livelihood option in Gulf of Mannar and Palk bay region of Tamil Nadu. Seaweed farming is a low cost simple technology, provides substantial returns and had better adoption among the coastal fisherfolk. Adoption of sea cage farming of cobia is in take off stage and may pave a way to reduce the fishing pressure and contribute additional income to the fisher household. Integration of seaweed with cobia cages favourably generates additional revenue through increased yields of both cobia and seaweed. IMTA is efficient in controlling both organic and inorganic pollution and thereby ensuring ecological balances. Thus, IMTA is an eco-friendly option with sustainable income to the coastal fishers. It is also one of the significant mitigating measures for the adverse impact of climate change and earns carbon credit to our country.