Research Article

Marine Macrophyte - An Alternative Livelihood for Coastal Community

Asirvatham Doss[1,*], Duraisamy Radhika[2], Ramakrishnan Rajalakshmi[1]

[1]PG & Research Department of Botany, V. O. Chidambaram College, Tuticorin, Tamil Nadu, INDIA.
[2]PG & Research Department of Zoology, V.O.Chidambaram College, Tuticorin, Tamil Nadu, INDIA.

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ABSTRACT

Background: Coastal fisher folk, especially fisher women find mass propagation of seaweed is an economically smart alternative livelihood. In Tamil Nadu, in the year 2000, the fishing villages of Ramanathapuram District Gulf of Mannar, South-East coast of India, started seaweed farming on industrial scale. Knowing the economic feasibility of seaweed farming, the fishermen were encouraged to farm seaweed on a large scale. In this paper, an assessment was carried out on the socioeconomic status of fisher folk who farm seaweed in the Tuticorin District, Tamil Nadu is presented. The economically viable *Kappaphycus alvarezii*, a red alga, is extensively cultivated along the coastal waters of Tamil Nadu. **Materials and Methods:** Experiments were conducted in the shallow subtidal waters on the southeast coast of India at Kovalm Beach, Thoothukudi. From January to the present (2022), the monocline synthetic rope (16 mm in diameter) culture of *K. alvarezii* was tested. **Results and Conclusion:** In the present study, it is found that the total cost of production for construcing a single monoline plot [94 long-line ropes (94x18)] was 35, 000/-. The harvest cycle from planting to harvesting took 33 days with a yield of 80 kg per long-line rope. Based on the current selling price of Rs. 6 per kg of fresh *Kappaphycus alvarezii* from the long-line rope farming method adopted, a seaweed farmer earned Rs. 45, 120/- per plot.

Keywords: Economic status, Constraints, *Kappaphycus alvarezii*, Seaweed, Monoline method.

Correspondence:
Asirvatham Doss,
PG & Research Department of Botany, V. O. Chidambaram College, Tuticorin, Tamil Nadu, INDIA.

Email id: androdoss@gmail.com

INTRODUCTION

Seaweeds are considered to be ecologically and biologically dominant in marine ecosystems. The term "seaweed" refers to macroscopic and multicellular marine algal species include chlorophytes (green), phaeophytes (brown) and rhodophytes (red). This categorization is primarily based on the pigmentation that they possess. There are about 900 chlorophytes, 4,000 red seaweeds, and 1,500 brown seaweeds found in nature.[1] Of these different species of seaweed, about 200 are valued commercially. Seaweeds are the new renewable sources of food, energy, chemicals, and medicines. The commercial seaweed industry is likely to witness a considerable increase in seaweed production and is a beneficial biomass with multiple applications. Seaweeds are used as food in many forms, like fresh, dried, powdered, salted, canned, flakes, prepared foods, or as liquid extracts for human consumption, as food additives, nutraceuticals, cosmetics and medicines; feeds, fertilizers, biofuels, and so on. The tremendous applications of seaweeds demand their increased production globally. Seaweed cultivation could also convert the pollutants that cause coastal water eutrophication into nutrients, which generates tremendous environmental benefits in addition to socio-monetary values.

Globally, seaweed is cultivated as both a food sources and as an exportable commodity for the manufacture of agar and carrageenan products. About 83% of sea vegetables are produced for human consumption,[2] with the remaining utilized for fertilizers and animal feed additives, medical applications.[3,4] and biotechnological applications.[5] In 2011, more over 18 million tonnes

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of macroalgae were generated by global capture and aquaculture, with annual macroalgal production growth of 5.7%.[6] About 90% of seaweed production comes from culture based practices and China holds first rank in seaweed production, with *Saccharina* (*Laminaria*) sp. accounting for most of its production. China is followed by North Korea, South Korea, Japan, Philippines, Chile, Norway, Indonesia, and the USA. *Kappaphycus* and *Eucheuma* cultivation is successfully going on in the following countries China, India, Indonesia, Madagascar, Malaysia, Philippines and Tanzania.[7]

Kappa Carrageenan, a commercially important polysaccharide, is extracted from *Kappaphycus alvarezii*. Carrageenans are employed in several fields, including food, pharmaceuticals, cosmetics, and mining.[8] *K. alvarezii* cultivation was first cultivated in 1996 at Okha, on the west coast of India. This alga is native to Philippines and was grown in Japan in the 1980s. CSMCRI scientists imported this species from Japan.[7] The cultivation of *K. alvarezii* began in India in 1995 - 1997 at Mandapam.[9] Pepsico India holdings popularised the cultivation in 2002, and Aquagri Processing Pvt. Ltd., later acquired PepsiCo in 2008.[10] The findings of *K. alvarezii* cultivation demonstrations and field adoption showed that it generates additional income for coastal fishermen.[11-15] Of the thirteen coastal districts in Tamil Nadu, now a days, *K. alvarezii* farming is being adopted only in Ramanathapuram, Pudukottai, Thanjavur, Thoothukudi, and Kanyakumari districts. In this scenario, a study was attempted to assess the socio-economic status of fisher folk farms seaweed in the Tuticorin District, Tamil Nadu.

MATERIALS AND METHODS

Kovalam (Mullakadu) was selected for the present study. Briefly, the raft (5 m × 5 m in dimension) was made with ropes. In a plot, there were 94 polypropylene ropes of 3-mm diameter deployed parallely. The adjacent ropes were tied in between, at 25-cm intervals, leave them in parallel arrangement. On an average, seedlings of 200 g of fresh fragments were chosen and inserted into each polypropylene rope. Taking each rope into consideration, 90 seedlings at 25-cm intervals were inserted, with a total Fresh Weight (FW) of 18 kg (Plate 1). Totally, in a plot, about 1692 kg FW of seedlings was used which comprised 94 ropes with 90 seedlings each. The growth rate was observed and recorded for a period of 2 months (45-days×6 cycles), and the daily growth rate and biomass were also calculated by the method adopted by Thirumaran and Anantharaman.[16] From February and March (2022), the

Figure 1: Site view of the sea surveyed.

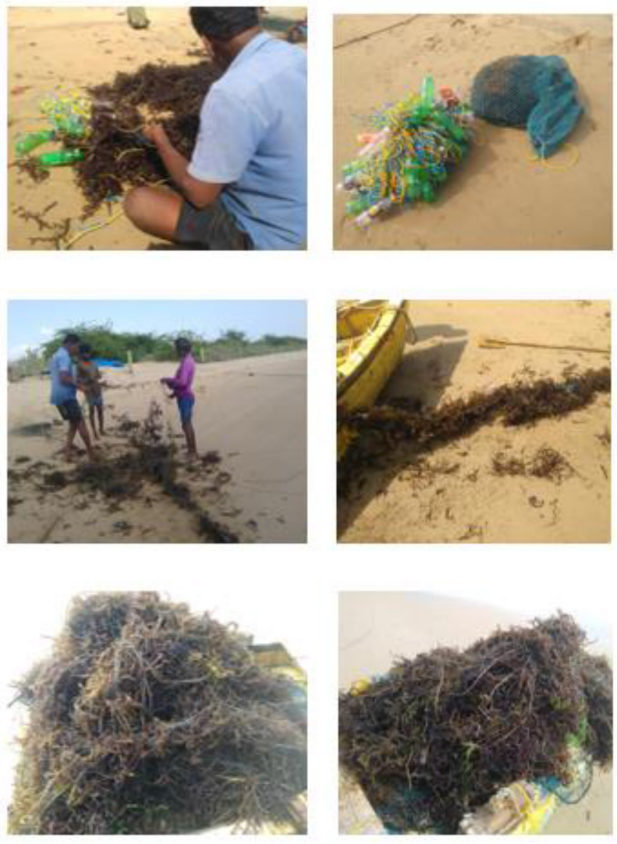

Plate 1: Farming and harvesting of seaweeds.

monocline synthetic rope (16 mm in diameter) culture of *K. alvarezii* was tested. The seedlings were collected from other farmers and transported to culture sites; a 20 kg of seedlings were used in each culture site. Seawater temperature and salinity was determined in the field on the sampling day.

RESULTS

Site selection

A survey was undertaken from Periyathazhai to Spic Nagar in Tuticorin Districts. Each, place total area was estimated where cultivation is proposed. Depth, salinity and temperature were recorded (Figure 1). A total of six places were visited to survey the area for cultivation. The site Periya Thazhai was the southern border of Tuticorin district. The proposed location was covered by artificially made bait cures using rocky stones to provide the best landing area for fishing boats. Depth was found around 1.5 meters near the bank of the bait curve. However, Manapadu and Amalinagar are found in the open sea and tidal amplitude is uncontrolled which may not favor placing the plant in the sea despite the area being huge. Kalamozhai and Alanthali were also open seas but the site was under construction for making bait curve. The remaining site Kovalam (Mullakadu) found open sea and fishing boats were also fewer in number. The salinity and temperature recorded were optimum for the growth of algae. In all the sites observed data on Salinity and Temperature were also found suitable and not much variation was found. Accessibility to the site was also found good for all the sites except Periyathazhai site was disconnected from the road by a sandy beach for some distance.

Water parameters are more important for algal growth. The preliminary data such as salinity and temperature collected from the sites during the survey do not have much variation. The purpose of the study is to identify the location where the cultivation can be made. However, considering the other feature like the tidal amplitude, Mullakadu is an ideal site among the other site because; the total area of the site is covered by the bait curve that prevents severe waves. If the local fishermen community is interested and trained in seaweed farming, Mullakadu site may be considered for cultivation. This is based on purely moderate water motion with fewer tidal waves and accessibility of the coast.

Kovalam, selected as a good site for *Kappaphycus alvarezii* farming, was further investigated at the field level during the second stage of screening by verifying other risk factors and socio-economic considerations. Kovalam is about 15 kilometres from Tuticorin. The total population of Kovalam is about 200 people in 30 families, and almost 100 percent of the population is illiterate. Experiments were conducted in the shallow subtidal waters on the southeast coast of India at Kovalm Beach, Thoothukudi. From February and March (2022), the monocline synthetic rope (16 mm in diameter) culture of *K. alvarezii* was tested. The seedlings were collected from other farmers and transported to culture sites; a 20 kg of seedlings were used in each culture site. The unit cost of a plot is given in Table 1.

Table 1: Unit cost per plot for seaweed cultivation.

Particulars/ Description	Quantity required	Cost per plot (Rs.)	Economic life (years)
4mm rope	15 kg	2925	2 years
12 mm rope	15 kg	2975	2 years
6 mm rope	10 kg	1950	2 years
2.5 mm rope	2 kg	440	2 years
2 mm twine	5 kg	1600	2 years
Anchor	22 kg × 2 no.	5750	10 years
Seeds	6000/ton	12,000 (2 ton)	
Total		**27, 640**	

Table 2: Income generation in one culture cycle of 33 days.

Particulars/Description	Cost
Number of harvests per day	10 ropes
Seaweed biomass harvest per day (wet weight) 80 kg/rope	800 kg (10 ropes)
Total seaweed biomass (98 × 80) (retaining 1764 kg as seed for the next cycle)	6076 kg
Selling price Rs. 6 per kg (6076 × 6)	36, 456
Unit cost per plot	27, 640
Income per cycle	8,816

The farming is done for two months (i.e., February and March, 2022) in a year. The crop is ready for harvest after 33 days from planting. Every day, beginning on the 33rd day, ten ropes are harvested, planted, and floated in the sea. Hence, one crop's or cycle's duration is 33 days. The average yield per rope is 80 - 85 kg. They retain 18 kg seaweed as seedling for the next crop. Currently, the price for harvested seaweed is Rs. 6.00 per kg on a wet weight basis and 50 per kg on a dry weight basis. A fisherman's family earns around Rs. 8000 per month. (If hired labour is used for rope preparation at a cost of Rs.1000 - 1500). In this farming, mostly family labour is involved; hence, a fisherman's family earns around Rs. 10,000 per month (Table 2).

The present study reveals an average daily growth (ADG) and the specific growth rate obtained were recorded as

36.21 g per day, and 3.64% per day, respectively. The relative growth rates (RGR) of *K. alvarezii* have already been well reported and are in line with that of the present study.[17,9] In the present study, on an average, 200g weighed young seaweeds were tied in each seeding twine (totalling 18 kg) and grown to an average weight of 80 kg in a span of 33 days. It is found to be with an average wet weight gain of 62 kg. In the commercial cultivation of *Eucheuma* spp., a growth rate of 3.5% per day is considered to be significant.[18,19]

DISCUSSION

Seaweeds are a macroscopic form of marine algae found in the shallow region to deeper water in the sea. Unlike the terrestrial higher plant, seaweeds are made of simple tissue and it has been categorized as Green, Red and Brown seaweeds as each category has a unique pigment which gives their respective colors. Seaweeds are important to know for their specific product known as phycocolloid. Due to increasing phycocolloid demand in the market for various industries as used as a thickener, emulsifier and stabilizing substance, seaweeds are being cultivated globally. In turn seaweed cultivation gradually to the attention as the best livelihood option for the coastal community because of the declining fishing sector. With respect to seaweed cultivation in India, Southeast coast is the proven area where seaweed cultivation is successful. However, certain location in this region is not covered under seaweed cultivation. Therefore to complete the cap area where no cultivation is found, a survey has been carried out which provides a livelihood through farming seaweed to the coastal community. Hehre and Meeuwig[20] reported that globally, farmed seaweed production is expanding rapidly in shallow marine habitats and also said that the importance of seaweed farming. Apart from its export potential, introduction of seaweed farming in the country's coastal areas could provide an alternative source of income for the coastal communities.

The present study reveals an Average Daily Growth (ADG) and the specific growth rate obtained were recorded as 36.21 g per day, and 3.64% per day, respectively. The studies reveal that the average growth rates of *Eucheuma denticulatum*, *Kappaphycus alvarezii*, and *Kappaphycus striatum* of about 3.5%.[21] A lower growth rate of 3% in unfertilized *E. denticulatum* cultivated in a land-based integrated system was reported in Zanzibar.[22] However, slightly higher growth rates for *K. alvarezii* were also reported.[8] An interesting finding was the lower stocking density of seaweeds results in higher growth rates than that of the high stocking density used by seaweed farmers in Tanzania. Further, studies have revealed that higher nutrient levels have little effect on the growth rates of both *E. denticulatum* and *K. alvarezii*. However, additional nutrient supply would be necessary and beneficial in other set-ups such as land-based systems.[23]

Constraints in *K. alvarezii* farming

Grazing

Nibbling by herbivores like siganids, acanthurids, sea urchins and starfish on the tips of branches is the major problem faced by seaweed farmers. During the months of May – June, the grazing intensity is higher, which affects the yield by 50-80%.

SUMMARY

The results of the present study clearly demonstrated that the long monocline rope method offers a feasible alternative for cultivating seaweed in open sea conditions. The acceptance of this cultivation practice by the fisherfolk of the selected area is indicative of the fact that a low-cost simple technology, which can provide substantial returns, can find a better adoption among the coastal fisher folk.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

ABBREVIATIONS

ADG: Average Daily Growth; **FW:** Fresh Weight; **RGR:** Relative Growth Rates.

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