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Global Trends in Rural People Livelihood Practice of Raft Culture of Red Seaweed, *Kappaphycus alvarezii* in Gujarat, India

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Abstract

India is rich in biodiversity, especially of marine biodiversity. Marine biodiversity includes both flora and fauna. There are 20,000 species of seaweed worldwide, half of them are economically important and 280 are edible. *Kappaphycus* is a red alga belonging to Rhodophyceae. It grows profusely in the sea where the bottom is sandy and salinity ranges from 29-34 ppt. it requires only sunlight, transparent seawater with mild wave action for replenishing bottom nutrients. It has also been proved that *Kappaphycus* grow >10 times in open sea where wave action is fairly high. *Kappaphycus* is carrageen yielding res algae cultivated amount of south pacific countries. In Gujarat, *Kappaphycus* grows to throw vegetative propagation using floating rafts. An experimental on *Kappaphycus* cultivation at five different cultivation sites *wiz,* Okha, Dwarka, Porbandar, Chorwad and Veraval. The growth was major at an interval of 15 days. The final weights were major at 45th to 60th days. It was observed that maximum vegetative growths were exhibited by Okha center wild lowest growth was observed in Porbandar. The DGR (%) was found to be maximum at Okha site 61.35 kg, 54.75 kg and 33.15 kg wild to lowest DGR (%) was observed at Porbandar 33.15 kg, 22.2 kg and 20.2 kg. Further, it was significantly correlated to salinity at Dwarka, Okha while at Porbandar and Chorwad, Veraval the same was significantly correlated to nitrate and seawater temperature. Based on this study, commercial cultivation at these localities is quite feasible.

Keywords: Cultivation, five sites, *Kappaphycus alvarezii* (red algae), seaweed

1. Introduction

Commercial cultivation of *Kappaphycus* was started in the Philippines in 1960's and since then many countries like China, Japan, Indonesia, Hawaii and South Africa have been cultivating *Kappaphycus* on a large scale (C.M.F.R.I, 2015). In India, *Kappaphycus alvarezii* (Doty) Doty ex P. C. Silva cultivation was initiated in mid-1990 at Okha, Gujarat on Northwest coast and later in Mandapam, Tamil Nadu on Southeast coast (Chandrasekaran et al., 2008). *Kappaphycus alvarezii*is economically important tropical red seaweed with a high demand worldwide for its cell wall polysaccharide, carrageenan (Mantri et al., 2017). This polysaccharide is used as an additive particularly as gelling, thickening and stabilizing agent in foodstuffs like frozen desserts, chocolate milk, cottage cheese, jellies, sauces etc. (Makwana, 2011; Monica et al., 2016) . It is also used as an additive in cosmetics and pharmaceutical formulations (Ghosh et al., 2014; Naguit et al., 2009). D- type carbohydrates like D-galactose-4-sulfate and 3,6-anhydro-D-galactose-2-sulfate are the main components of carrageenan and have a high potential for fermentation. This alga also acts as a raw material for biofertilizer and bioethanol production (Bixler and Porse, 2011).

Several marine algae have been reported to possess medicinal value and traditionally used in many countries. Carrageenan is useful in ulcer therapy and alginate prolong the period of activity of certain drugs (De Goes and Reis, 2011; Necas and Bartosikova, 2013). Seaweeds grow in many parts of the east and west coasts, but Tamilnadu coast is a paradise for seaweeds and no other coastline of our country can be compared with Tamilnadu coast in diversity and density of seaweed, but now Gujarat state is on momentum toward seaweed cultivation and harvesting natural stock to fulfill the required industrial raw demand.

The present study deals with the cultivation of *Kappaphycus* at various places of Gujarat coast. Since Gujarat has long coast line of about 1600 km which could be utilized for cultivation of the most efficient and fast-growing seaweed like *K. alvarezii.* This seaweed can produce alarge quantity of biomass within a short period of time and the biomass can be harvested several times in a year. The main objective of the work is to cultivate *Kappaphycus* in the coastal region of Gujarat and creating awareness about the benefits of seaweed cultivation among

the people. Biomass produced through cultivation will fulfill the growing need of the industries. More importantly, it will improve the socio-economic status of the native people of the coastal region.

2. Materials and Methods

The experiment was conducted during three seasons at five different coastal villages of the Gujarat region from November 2017 to October 2017. (summer, winter and monsoon, Table 1). *K. alvarezii* seed was selected for the experiment. *K. alvarezii* (around 58 kg) was procured from Okha (Research station, JAU, Gujarat, India). Plastic ropes of 3 mm thickness were used as a bit, where ten individual bunches of germplasm were tied by means of braider twine termed a loop. Loops of about 2 cm were secured by one end through the line plaits at intervals of about 15–20 cm. The other end of the loop was left loose. During planting the line was pushed through the loop, propagate inserted and the line snug pulled to secure the germplasm (Renuga et al., 2013). There were five main ropes in a raft holding ten germplasm. The growth of the *K. alvarezii*was measured by weighing near the shore.

Table 1: Seaweed stocking details

Sl. No.	Winter			Summer		Monsoon	
	Location	Raft place on dated	Harvested date	Raft place on dated	Harvested date	Raft place on dated	Harvested date
1.	Okha	15-11-2016	2-2-2017	5-2-2017	8-5-2017	22-6-2017	15-10-2017
2.	Dwarka	17-11-2016	2-2-2017	5-2-2017	8-5-2017	22-6-2017	15-10-2017
3.	Porbandar	17-11-2016	3-2-2017	5-2-2017	9-5-2017	24-6-2017	17-10-2017
4.	Chorwad	18-11-2016	3-2-2017	7-2-2017	11-5-2017	27-6-2017	19-10-2017
5.	Veraval	19-11-2016	3-2-2017	7-2-2017	11-5-2017	27-6-2017	19-10-2017

2.1. Experimental setup

Four good floating 12 feet bamboo poles for mainframes and four 6 feet bamboo poles for additional frames were selected for construction of a bamboo raft with the help of ropes. The interior part of the main frame was 3×3 m^2 in size. Fish nets were tied under the raft to avoid the grazing. Around 11.0 kg of *K. alvarezii* germplasm was utilized at each selected site (5.5 kg per single floating raft). Approximately 5.5 kg of *K. alvarezii*were planted in each raft, total 5.5×2 = 11.0 kg (1×1 m^2). Each raft had a total of five ropes of 3 mm thickness and the ropes consisted of five loops. The distance between the loops was 20–22 cm. The 25 loops in the raft were inserted with 100 g *K.alvarezii* germplasm. A similar procedure was used for all the rafts at all five stations. *K. alvarezii* growth was calculated after totally 45–60 days culture periods for each season (summer, winter and monsoon).

2.2. Statistical analysis

Daily Growth Rate (DGR) in percent study was calculated by using following formula given by Dawes et al., 1994.

$$DGR\ \% = \frac{\ln (W_f - W_0)}{t} \times 100$$

W_f is the final fresh weight (g) at the day,
W_0 is the initial fresh weight (g),
t is the number of culture days

The physic-chemical data recorded for these stations were used in the subsequent statistical analyses. In the present study viz., water temperature, salinity, concentrations of nitrate, and total phosphates within each site including surface and bottom samples were analyzed separately by the Pearson product-movement correlation coefficient (Khambhaty et al., 2012; Thirumaran and Anantharaman, 2009).

3. Results and Discussion

The cultivation of *Kappaphycus alvarezii* was carried out for three seasons during the month of November (2016) to October (2017). The crop was ready to harvest after 45-60 days of planting (Figure 1). Average yield per sites in per season (3×3 m^2) was 61.35±1.63 kg (Summer), 54.75±0.78 kg (Winter), 33.15±0.92 kg (Monsoon). The maximum average was recorded in Okha (summer, winter and monsoon seasons

Figure 1: Raft culture of *Kappaphycus alvarezii* during harvesting

61.35 kg, 54.75 kg and 33.15 kg in 45 days. In Chorwad was recorded next with 59.65 kg, 52.15 kg, 30.25 kg and the minimum average growth was recorded 33.15 kg, 22.2 kg and 20.2 kg in all three season in Porbandar. Medium growth was recorded at Veraval in all seasons (20.64, 15.48 and 9.64 kg) seen in Table 2.

The water quality parameters salinity and temperature

Table 2: Growth of Kappaphycus alvarezii in raft culture

Location		Mean of raft in kg			Mean of raft in kg			Mean of raft in kg		
		Summer			Winter			Monsoon		
		15 D	30 D	45 D	15 D	30 D	45 D	15 D	30 D	45 D
Okha	R_1	20.4	34.2	60.2	18.6	32.5	55.3	12.3	19.5	33.8
	R_2	21.5	35.0	62.5	19.5	31.9	54.2	11.5	17.8	32.5
Dwarka	R_1	19.4	40.5	52.4	15.7	27.4	40.2	10.2	16.5	24.2
	R_2	18.2	39.4	50.5	14.2	28.8	39.7	9.4	15.2	25.3
Porbandar	R_1	12.3	19.5	33.8	9.5	15.3	21.8	9.2	15.0	20.4
	R_2	11.5	17.8	32.5	10.0	16.4	22.6	9.0	15.0	20.0
Chorwad	R_1	19.3	31.5	59.8	16.2	29.3	52.3	10.5	19.0	30.5
	R_2	18.5	31.0	59.5	18.4	30.1	52.0	10.0	18.8	30.0
Veraval	R_1	20.8	33.6	48.5	18.6	30.5	44.5	9.5	15.3	21.8
	R_2	19.6	35.8	50.7	20.4	31.4	42.5	10.0	16.4	22.6

in all stations at summer, winter and monsoon not much variation were recorded. The nitrate and total phosphorus was high in Okha area (summer 20.4 and 2.4, winter 17.56 and 1.97, monsoon 14.23 and 1.23) and lowest was recorded in Porbandar with nutrient NO3-N 11.31 (S), 8.68 (W), 8.56 (M) and total phosphate 2.4 (S), 0.84 (W), 0.74 (M).

So this study shows that Okha, Dwarka and Chorwad coastal areas are suitable for *K. alvarezii* culture in summer, winter and monsoon seasons. The most extensive growth is found in the summer season. (Table 3, 4 and 5).

Table 3: Water quality parameters in summer 15, 30 and 45 days collected surface water sample during the study period (Average summer values)

Site (Summer)	W. Temp (°C)	Salinity (g kg^{-1})	NO_3 - N (µg l^{-1})	Total P (µg l^{-1})
Okha	30	32	20.4	2.4
Dwarka	31	34.25	13.62	0.9
Porbandar	33	36.54	11.31	1.5
Chorwad	30	31.52	16.56	1.89
Veraval	32	34.56	14.71	1.57

Table 4: Water quality parameters in winter 15, 30 and 45 days collected surface water sample during the study period (Average winter values)

Site (Summer)	W. Temp (°C)	Salinity (g kg^{-1})	NO_3 - N (µg l^{-1})	Total P (µg l^{-1})
Okha	27	31.2	17.56	1.97
Dwarka	28	33.5	10.57	1.23
Porbandar	29	35.2	8.68	0.84
Chorwad	28	31.7	15.40	1.28
Veraval	30	33.4	13.87	2.25

Table 5: Water quality parameters in monsoon 15, 30 and 45 days collected surface water sample during the study period (Average winter values)

Site (Summer)	W. Temp (°C)	Salinity (g kg^{-1})	NO_3 - N (µg l^{-1})	Total P (µg l^{-1})
Okha	26	32.1	14.23	1.23
Dwarka	26.3	31.5	10.55	0.98
Porbandar	27.4	31.8	8.56	0.74
Chorwad	27	32.8	15.74	1.02
Veraval	28	33.4	13.21	1.24

4. Conclusion

Successful of commercial cultivation of *K. alvarezii* has shown that scientific innovations can benefit coastal rural populations which lack alternative economic opportunities. The continued advancement in both farming methods as well as integrated product development is crucial for attracting business entrepreneurs. The rural economy not only will be boosted though commercial seaweed cultivation but also by employing liquid and solid fertilizers produced from the algal biomass.

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