Seaweed Res. Utiln.
6(1&2):167-176(1993)

GROWTH OF GRACILARIA EDULIS IN RELATION TO ENVIRONMENTAL FACTORS IN FIELD CULTIVATION

N.Kaliaperumal, V.S.K. Chennubhotla *, S.Kalimuthu,
J.R. Ramalingam and K.Muniyandi
Regional Centre of Central Marine Fisheries Research Institute Marine Fisheries,Tamil Nadu - 623 520, India.

Abstract

Field cultivation of *Gracilaria edulis* was carried out in the nearshore areas of Gulf of Mannar and Palk Bay near Mandapam to determine the various environmental factors which affect the growth of this agar yielding seaweed. These culture experiments were conducted in Gulf of Mannar from October to April during the years 1986-89 and in Palk Bay from April to October during the years 1987-88 when the sea was calm at both places. The epiphytes, epifauna, Low light intensity and sedimentation caused by turbulence of water and grazing by fishes were found to be the primary factors hampering the growth of cultured *G. edulis*. There was no good growth of *G. edulis* in Palk Bay during the entire period of this study. But in Gulf of Mannar the growth of *G. edulis* was good between November and March with maximum yield during the months December to February/ March. The suitable period for field cultivation of *G. edulis* in Gulf of Mannar is from December to March.

Introduction

In recent years many agar manufacturing industries have come up in India. The availability of raw material *Gelidiella acerosa, Gracilaria edulis* and *G. crassa* from natural seaweed beds are inadequate to meet the requirements of these seaweed based industries. Hence cultivation of agar yielding seaweeds is necessary in order to maintain a continuous supply of raw material to industries. Some attempts have already been made on experimental field cultivation of agarophytes with *G. acerosa* (Krishnamurthy *et al.*, 1975; Subbaramaiah *et al.*, 1975 and Patel *et al.*, 1979 and 1986) and *G. edulis* (Raju and Thomas, 1971; Umamaheswara Rao, 1973 and 1974; Krishnamurthy *et al.*, 1975 and 1977; Chennubhotla *et al.*, 1978 and 1987 and Paramasivam and Devadoss, 1985 and 1987) at different environments using various culture

* Research Centre of CMFRI, Minicoy (Lakshadweep).

techniques. But only very little information is available on the environmental factors influencing the growth of cultured seaweeds (James *et al.*, 1986 and Chennubhotla *et al.*, 1987).

So detailed study was undertaken to know the effect of various environmental factors affecting the growth of *G. edulis* by culturing on coir rope nets. Culture experiments were done during the calm seasons in the nearshore areas of Gulf of Mannar from October to April during 1986-89 and in Palk Bay from April to October during 1987-88. Data on clarity of water, light intensity, sedimentation, water movement, wave action, water current, epiphytes, epifauna and predators were collected from the culture sites. Data on hydrological parameters were also collected and the results obtained on these aspects are presented in this paper.

Materials and Methods

Culture nets of 2 x 2 m size with 12 cm mesh fabricated with 1" thick coir rope were used in this study. Young and healthy plants of *Gracilaria edulis* (Gmelin) Silva collected from the subtidal region at Thonithurai near Mandapam and transported to the culture sites in plastic drums containing seawater were used as seed material. Seedling of *G. edulis* (about 6 cm long) obtained from mother plants were inserted into the twists of coir ropes. Four kg of seed material was used for seeding each net. This seeded net was tied tightly to the Casuarina poles erected in the culture sites in such a way that they were always submerged in seawater and 30 cm above the sea bottom. The harvest of the seaweed was made after 25 to 60 days growth when the plants reached harvestable size or when the sea became rough. The nets without the growth of seedlings were removed after a maximum of 75 days. Growth and rate of production of G. edulis were computed and given in the Tables 1 and 2.

Data on environmental factors such as water clarity, water temperature, water movement and sedimentation were collected from the culture sites at weekly interval. For obtaining data on water movement the clod card method suggested by Doty (1971) was followed. For collecting data on sedimentation three numbers of wide mouth (7 cm) polythene bottles of one litre capacity - one with 1 cm opening at both ends in vertical position; second with 1 cm opening at both ends in horizontal position and third without lid in vertical position were tied to the Casuarina poles at the level of seaweed culture nets and they were removed after 24 hrs. The water with sediments from each bottle was filtered separately using filter paper. The filter paper with sediments were dried to a constant weight in an oven at 60°C and the weight of sediments in each filter paper was taken.

Water samples were also collected at 12 hrs once in a week from the culture sites and analysed for salinity, dissolved oxygen and nutrients such as phosphate, silicate, nitrite and nitrate following the method given by Strickland and Parsons (1968). Periodical observations were made on the growth of *G. edulis*, sedimentation on nets, other algal growth, attachment of animals, grazing by fishes and sea conditions. Monthly mean values obtained for different ecological and hydrological parameters are given in Tables 3 and 4.

Results

The data collected on the growth and production of G. edulis cultured at Gulf of Mannar during the months October to April in 1986-89 are presented in Table 1. The reasons for the failure of crop in certain months are also indicated. Although the period of good growth varied from year to year, November to February/March was found to be generally suitable for good growth. The rate of production in *G. edulis* cultivation was comparatively high during December-February in 1986-87, December-January in 1987-88 and January-March in 1989.

The results obtained on the growth and production of G. edulis cultured from May to August 1987 and April to September 1988 in Palk Bay along with the reasons for failure of crop are shown in Table 2. There was no growth of *G. edulis* introduced during May to August '87 while slight increase in yield over the seed material was obtained during April to August '88.

The reasons for failure of crop in different months in Gulf of Mannar and Palk Bay were mainly due to attachment and growth of several other algae and animals on the nets and cultured plants, sedimentation and low light intensity caused by turbulence of water and grazing by fishes. The algae which hampered the growth of *G. edulis* by heavy epiphytic growth were *Ulva lactuca, Enteromorpha compressa, E. intestinalis, Chaetomorpha aerea, Cladophora fasicularis and Boergesenia forbesii* (green algae); *Jania rubens, Hypnea musciformis, Champia parvula and Acanthophora spicifera* (red algae).

The other algae which attached in small quantities on the nets were *Ulva reticulata, chaetomorpha linoides, Microdictyon agardhianum, Anadyomene stellata, Caulerpa scalpelliformis, C. peltata and Halimeda gracilis* (green algae); *Dictyota bartayresiana, D. dichotoma, Stoechospermum marginatum, Padina boergesenii, Colpomenia sinuosa, Hydroclathrus clathratus, Turbinaria Conoides and Sargassum myriocystum* (brown algae); *Liagora erecta, Amphiroa fragilissima, Cheilosporum spectabile, Gracilaria crassa, Solieria*

Table 1. Growth and production of *G. edulis* on culture nets in Gulf of Mannar

Month of planting	Seed material introduced (kg)	Month of harvest/ removal of nets	Growth period (days)	Crop harvested (wet wt in kg)	Increase in yield (kg/m²)	Rate of production (g/days/m²)	Reason for failure of crop
October '86	28.0	December'86	60	14.0	Nil	Nil	Epiphytes
November	28.0	January	60	51.4	0.835	14	Nil
December	12.0	February	60	50.65	3.220	54	Nil
January '87	12.0	March	60	13.6	0.133	2	Epiphytes
February	4.0	April	60	Nil	Nil	Nil	Low light intensity,turbid water, sedimentation and epiphytes
March	4.0	April	30	Nil	Nil	Nil	- do -
November '87	32.0	January '88	50	101.2	2.162	43	Nil
December	32.0	January	55	167.8	4.243	77	Nil
January '88	32.0	February	35	66.8	1.087	31	Nil
February	32.0	March	30	66.9	1.090	36	Nil
March	32.0	April	30	Nil	Nil	Nil	Epiphytes, sedimentation low light intensity and turbid water.
October '88	32.0	November '88	45	3.0	Nil	Nil	Grazing by fishes
November	32.0	January '89	45	27.3	Nil	Nil	Epiphytes and epifauna
December	32.0	February	40	54.4	0.700	18	Nil
January '89	32.0	March	60	167.1	4.221	70	Nil
February	32.0	April	60	80.3	1.509	25	Nil
March	32.0	April	25	48.2	0.506	20	Nil

Table 2.
Growth and production of *G.edulis* on culture nets in Palk Bay

Month of Planting	Seed material introduced (kg)	Month of harvest/ removal of nets	Growth period (days)	Crop harvested (wet wt in kg)	Increase in yield (kg/m^2)	Rate of production ($g/day/m^2$)	Reasons for failure of crop
May '87	32.0	May '87	7	Nil	Nil	Nil	Sudden change in the quality of water due to phytoplankton bloom.
June	32.0	July	40	Nil	Nil	Nil	Epiphytes and sedimentation
July	20.0	October	75	6.5	Nil	Nil	- do -
August	32.0	October	45	14.4	Nil	Nil	Epiphytes and epifauna
April '88	32.0	June '88	45	32.2	0.006	0.1	- do -
May	32.0	July	55	1.5	Nil	Nil	- do -
June	32.0	August	60	32.8	0.025	0.4	- do -
July	32.0	August	50	36.6	0.143	3.0	- do -
August	16.0	September	55	0.650	Nil	Nil	Grazing by fishes, epiphytes and epifauna
September	32.0	October	40	1.9	Nil	Nil	- do -

Table 3. Environmental and hydrological data collected from the seaweed culture site at Gulf of Mannar

Month	Water clarity	Water Movement (D.F.)	Sedimentation (g/24hrs)	Temperature (°C) A.T.	S.W.T.	Salinity (%)	Dissolved oxygen (ml/l)	Nutrients Phosphate (µg/l)	Silicate (µg/l)	Nitrite (µg/l)	Nitrate (µg/l)
October'86	Clear	15.023	1.274	30.1	29.7	33.76	5.62	0.05	27.00	-	0.50
November	-do-	14.170	1.415	29.5	28.7	34.19	3.88	0.26	22.75	-	0.66
December	-do-	6.321	1.220	29.2	28.2	30.53	4.46	0.17	30.30	-	2.50
January'87	-do-	6.697	1.179	29.7	27.2	30.22	4.73	0.12	43.40	0.84	1.00
February	Turbid	5.961	4.031	31.2	29.5	30.30	4.42	0.23	33.70	0.21	0.58
March	-do-	7.958	1.383	30.7	29.7	32.58	5.12	0.09	20.25	0.21	1.38
April	-do-	8.060	5.810	30.0	29.2	33.10	5.60	0.05	44.00	0.21	0.25
November	Clear	4.844	1.496	28.0	27.7	32.83	4.60	0.17	28.33	0.06	1.00
December	-do-	4.960	1.190	27.1	27.6	29.50	5.42	0.10	12.50	0.08	1.34
January'88	-do-	4.391	1.494	27.2	26.3	28.00	6.20	0.10	24.66	0.15	2.13
February	-do-	6.314	3.168	28.1	27.6	29.50	6.66	0.22	14.50	0.06	3.00
March	Turbid	7.607	4.128	31.8	30.4	32.80	6.06	0.24	35.30	0.17	3.15
October	Clear	7.398	1.364	29.5	28.7	35.16	4.97	0.08	29.66	0.21	2.25
November	-do-	5.914	0.801	29.2	26.9	30.14	5.25	0.12	24.25	0.24	3.66
December	-do-	4.780	0.832	28.8	27.2	29.13	5.47	0.08	23.00	0.02	1.44
January'89	-do-	4.572	1.367	27.7	26.5	30.40	4.50	0.21	35.00	0.08	2.12
February	-do-	5.109	1.461	29.1	27.1	32.00	5.01	0.18	22.22	0.05	1.94
March	-do-	5.456	1.948	32.6	28.4	32.17	4.41	0.19	42.50	0.22	2.25

Table 4. Environmental and hydrological data collected from the seaweed culture site at Palk Bay

Month	Water clarity	Water Movement (D.F)	Sedimentation (g/24 hrs)	Temperature (°C) A.T.	Temperature (°C) S.W.T	Salinity (%)	Dissolved oxygen (m1/1)	Nutrients			
								Phosphate (µg/1)	Silicate (µg/1)	Nitrite (µg/1)	Nitrate (µg/1)
May '87	Turbid	1.904	2.049	31.5	30.0	33.37	5.58	0.13	15.50	6.83	1.53
June	-do-	3.217	2.167	31.2	29.5	33.50	4.96	0.14	24.75	2.22	2.94
July	-do-	2.918	2.046	31.1	29.5	34.40	4.70	0.15	33.00	0.02	0.56
August	Clear	2.480	1.711	28.2	28.5	35.00	5.65	0.17	21.33	0.07	1.08
September	-do-	1.974	1.951	29.9	29.1	35.11	5.68	0.16	31.00	0.19	5.17
April'88	-do-	4.742	1.364	30.5	30.8	30.16	4.84	0.10	30.50	0.07	1.38
May	-do-	4.179	1.830	30.0	29.7	31.36	4.86	0.13	28.50	0.16	0.44
June	-do-	3.501	1.479	29.0	28.5	32.51	4.60	0.22	41.50	0.40	0.94
July	-do-	3.815	1.675	29.0	27.9	33.06	5.47	0.25	45.00	0.04	0.80
August	-do-	3.119	1.380	28.8	28.1	34.20	4.65	0.16	43.75	0.08	1.06
September	-do-	3.836	1.334	29.1	27.5	35.80	5.73	0.19	35.75	0.06	0.75
October	-do-	2.558	0.785	30.0	28.6	35.00	4.81	0.10	13.00	0.04	1.25

robusta, Hypnea valentiae, Ceramium tenerrimum, Centroceras claculatum, Roschera glomerulata and Laurencia papillosa (red algae) and *Lyngbya majuscula* (blue-green alga).

The different animals attached to the nets were *Aplysia*, sponges, ascidians, bryozoans, *Sepia* and other molluscan egg mass. The fishes which grazed on *G. edulis* were *Siganus javus, S. canaliculatus* and *Psammoperca waigiensis.* The plants of G. edulis introduced in Palk Bay during May '87 degenerated due to sudden change in the quality of water caused by phytoplankton bloom of *Trichodesmium thiebautii* and *Nitzschia sigma* var. *indica* which also caused mass mortality of fishes in Palk Bay.

The data collected on ecological and hydrological parameters from the seaweed culture sites at Gulf of Mannar and Palk Bay are given in Table 3 and 4 respectively. In Gulf of Mannar water was turbid from February to April '87 and March'88. The values for water movement (D.F) varied from 4.391 to 15.023 with slightly low values during the months of good growth when compared with other months of the particular season. The values for sedimentation ranged from 0.801 to 5.801 g/24 hrs with high values from February to april '87 and March '88. The atmospheric temperature varied from 27.1 to 32.6°C and surface water temperature from 26.3 to 30.4°C. The salinity ranged from 28.00 to 35.16% and dissolved oxygen from 3.88 to 6.66 ml/l. The values for phosphate varied from 0.05 to 0.26, silicate from 12.50 to 44.00, nitrite from 0.02 to 0.84 and nitrate from 0.25 to 3.66 μg/l.

In Palk Bay the water was turbid only during May to July '87. The values for water movement (D.F) varied from 1.974 to 4.742. The values for sedimentation ranged from 0.785 to 2.167 g/24 hrs. with high values between May to July '87. The atmospheric temperature ranged from 28.2 to 31.5°C while the surface water temperature ranged from 28.1 to 30.8°C. The ranges of salinity and dissolved oxygen were 30.16 to 35.80% and 4.60 to 5.73 ml/l respectively. The phosphate content varied from 0.10 to 0.25, silicate from 13.0 to 45.0, nitrite from 0.02 to 6.83 and nitrate from 0.44 to 5.17 μg/l.

Discussion

The present investigation reveals that sedimentation, light intensity, water turbidity, water temperature, water current, water quality, wave action, epiphytes, epifauna and grazing by fishes are the environmental factors which affect the growth of cultured *G.edulis*. This is in conformity with the earlier findings on the field cultivation of *G. edulis* (James *et al.*, 1986 and chennubhotla

et al., 1987) that sedimentation, epifauna and grazing by fishes affect the growth of *G. edulis*. The present study indicates that *G. edulis* can be successfully cultivated in the nearshore areas of Gulf of Mannar during the period November of March when the sea is calm. The rate of production of *G. edulis* was found to be high between December and February / March and it can be compared with the results obtained earlier by Umamaheswara Rao (1974) and chennubhotla *et al.*, (1978 and 1987). The coastal area near CMFRI Fish Farm in Palk Bay is not ideal for *G. edulis* cultivation as the growth of the plants was affected by various environmental factors such as epiphytes, epifauna, grazing by fishes and sedimentation. Hence culture attempts have to be made in other areas of Palk Bay during the calm season (April to September) in order to select the suitable culture sites and period of growth.

Acknowledgement

The authors wish to express their sincere thanks to Dr. P.S.B.R. James, Director, Central Marine Fisheries Research Institute, Cochin - 31 for suggesting this problem and for the facilities provided in carrying out this investigation.

Literature cited

Chennubhotla, V.S.K., N. Kaliaperumal and S. Kalimuthu, 1978. Culture of *Gracilaria edulis* in the inshore waters of Gulf of Mannar (Mandapam).*Indian J. Fish.*, **25**(1&2):228-229.

Chennubhotla, V.S.K., N. Kaliaperumal, S. Kalimuthu, J.R. Ramalingam, M. Selvaraj and M. Najmuddin. 1987. Seaweed culture. *CMFRI Bulletin*, **41** : 60-74.

Doty, M.S. 1971. Measurement of water movement in reference to benthic algal growth. *Bot. Mar.*, **14** : 32-35.

James, P.S.B.R., V.S. Krishnamurthy Chennubhotla and Joseph Xavier Rodrigo. 1986. Studies on the fauna associated with the cultured seaweed *Gracilaria edulis*. *Proc. Symp. Coastal Aquaculture*, MBAI, Cochin. pp.1193-1198.

Krishnamurthy, V., P.V.Raju and P.C. Thomas. 1975. On augmenting seaweed resources of India. J. Mar. Biol. Ass. India, **17** (2) : 181-185.

Krishnamurthy, V., P.V. Raju and P.C. Thomas. 1977. On augmenting seaweed resources c India, Seaweed Res. Utiln., **2** (1) : 37-40.

Paramasivam, M. and G.G.M. Devadoss. 1985. Effect of growth regulators in the field cultivation of *Gracilaria edulis* (Gmelin) Silva. *Indian J: Mar. Sci.*, **14** : 230-231.

Paramasivam, M. and G.G.M. Devadoss. 1987. Field cultivation of *Gracilaria edulis* (Gmelin Silva in Chinnapalam estuary, Pamban. *J.Mar.Biol. Ass. India*, **29** (1&2) : 360-362.

Patel, J.B., B.V.Gopal, V.R. Nagulan, K. Subbaramaiah and P.C. Thomas. 1979. Experimenta field cultivation of *Gelideilla acerosa* at Ervadi, India *Proc. Inst. Symp. Marine Algae of the Indian Ocean Region*, CSMCRI, Bhavnagar, India. pp. 24-25 (Abstract).

Patel, J.B., B.V.Gopal, V.R. Nagulan, K. Subbaramaiah and P.C. Thomas, 1979. Experimental field cultivation of *Gelidiella acerosa* at Ervadi in India. Proc. Symp. Coastal Aquaculture, MBAI, Cochin. pp.1342-1343.

Raju, P.V., and P.C. Thomas. 1971. Experimental field cultivation of *Gracilaria edulis* (Gmel.) Silva. Bot. Mar. **14** (2) : 71 - 75.

Subbaramaiah, K., K. Rama Rao, P.C. Thomas, M.R.P. Nair, B.V. Gopal and V.R. Nagulan. 1975. Cultivation of *Gelidiella acerosa*. Salt Res. Ind., **11** (1) : 33-36.

Strickland, J.D.H. and T.R. Parsons. 1968. A practical handbook of seawater analysis. Bulletin 167, Fisheries Research Board of Canada, Ottawa.

Umamaheswara Rao, M. 1973. The seaweed potential of the seas around India. Proc. symp. on Living Resources of the Seas Around India. pp. 687-692.

Umamaheswara Rao, M. 1974. On the cultivation of *Gracilaria edulis* in the nearshore areas around Mandapam. Curr. Sci., **43** (20) 660-661