

Note

Growth and pigment constituents of the red alga *Gracilaria edulis* (Gmelin) Silva, grown at different depths

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ABSTRACT

Chlorophyll-a, phycoerythrin, phycocyanin and allophycocyanin of the red alga, *Gracilaria edulis*, cultured in outdoor tanks under natural light at different depths were estimated. Crop growth rate and pigment contents in relation to varying light intensities (depth) were observed. An inverse relationship between pigment content and the light intensity was noted. But growth rate was more at higher light intensities.

The level of irradiance needed for optimum growth of a species shows some correlation with its habitat (Luning, 1981). Submerged plants generally respond to low light conditions by increasing their pigment content as well as accessory pigment/chlorophyll ratio (Waaland *et al.*, 1974; Rhee and Brigg, 1977; Lapointe, 1981). Studies on *Gracilaria* sp., an important agar-yielding red alga, have indicated that growth depends mainly on temperature, light, nutrients and to lesser degree, on salinity (Jones, 1959; Kim and Humm, 1965; Kim, 1970). According to Lapointe and Duke (1984), light in the marine environment varies as much over short time scales as seasonally, that, seaweeds like *Gracilaria* sp. constantly respond to changes in ambient light fields by altering biochemical constituents and this acclimation is used to achieve balanced growth (Laws and Bannister, 1980).

The present experiment was aimed to find out the effect of light intensities on growth and pigment constituents of *Gracilaria edulis* cultivated at varying depths.

Vegetative plants of *Gracilaria edulis* were collected from Thonithurai (9°16'N and 79°10'E) near Mandapam, southeast coast of India and transported to the laboratory at Field Mariculture Centre of CMFRI, Narakkal in enriched seawater. Enrichment of seawater was done by the standard procedure of Conway and Walne (1976). Two fibreglass tanks were set outdoor for vegetative cultivation of *G. edulis*, one of 250 l capacity, tank I, which was coated by white enamel paint on the inner surface and the other of 500 l capacity, tank II which was coated with blue enamel paint. Both the tanks were of different depths. Tank I was having water depth of 35 cm. Tank II was

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divided into two compartments by a nylon mesh frame at 10 cm water column. Considering the water holding capacity, 200 g of fresh healthy fragments were put in tank I and 350 g each were kept in two layers, one on the top at 10 cm depth and the other in the bottom at 65 cm depth in tank II. Biomass of the plants was taken at regular intervals of 15 days. Exchange of water in the tank was also carried out at an interval of 15 days during the observation period.

A few healthy fragments of *Gracilaria edulis* were collected from the culture tanks of varying depth. Apical portion of the plants were cleaned, washed thoroughly in sterilised seawater, blotted, weighed and ground in 90% acetone for the extraction of chlorophyll-a. Water soluble pigments such as phycoerythrin, phycocyanin and allophycocyanin were extracted in 0.5 M phosphate buffer of pH 6.8. Estimation of pigments was carried out by standard procedure of Jeffrey and Humphrey (1975).

Of the four pigments analysed, phycoerythrin was found to be more at all depths (10, 35 and 65 cm water column) followed by allophycocyanin, phycocyanin and chlorophyll-a. Plants that were kept at a greater depth were found to contain higher amount of all the pigments estimated. The pigment content showed an inverse relationship with the light intensities or a positive correlation with depth (Table 1). It was also observed that all the pigment contents were less in tank I having 35 cm water depth than in the shallower depth (10 cm) of tank II. It may be explained here that the tank I, which was painted white in the inner surface, reflected more light than tank II which

TABLE 1. Correlation matrix

Depth/ days	CGR	CHL	PE	PC	APC
CGR	1.000	-0.937*	0.674	0.730	-0.151
CHL	0.999*	1.000	0.891	0.923*	0.204
PE	0.972	0.962*	1.000	0.997*	0.626
PC	-0.143	-0.179	0.094	1.000	0.564
APC	-0.287	-0.322	-0.053	0.989*	1.000

CGR - crop growth rate, CHL - chlorophyll, PE - phycoerythrin, PC - phycocyanin, APC - allophycocyanin, *-highly significant.

was painted blue. Beer and Levy (1983) found that *Gracilaria* sp. required low photon fluence rates for optimal growth and photosynthesis and showed low light compensation point. Waaland *et al.* (1974), Lapointe (1981), Lapointe and Ryther (1979), Lapointe and Duke (1984) and Levy and Friedlander (1990) also reported that pigment contents of red algae were inversely proportional to light levels and under limiting light, nitrate uptake is relatively fast compared to the rate of carbon fixation and results in low C:N ratio and accumulation of N-reserves such as r-phycoerythrin and tissue nitrate.

The pigment constituents of *Gracilaria edulis* at different depths showed variation, which reflect on the appearance. Plants grown at low light (65 cm depth) appeared red than that grown under higher light (10 cm depth) which looked more greenish in colour. According to Brody and Brody (1962) and Rhee and Briggs (1977), red alga changes its colour in relation to the chl/PE ratio. But Beer and Levy (1983) opined that plants grown at 60 and 140 $\mu\text{Em}^{-2}\text{s}^{-1}$ had same Chl/PE ratio, but definitely appeared differently coloured. In the present experiment the

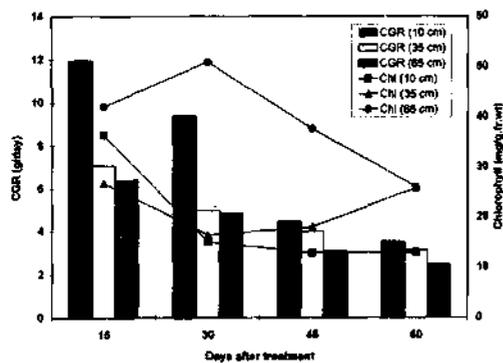


Fig. 1. Crop growth rate and chlorophyll content of *Gracilaria edulis* cultured in different depths of water.

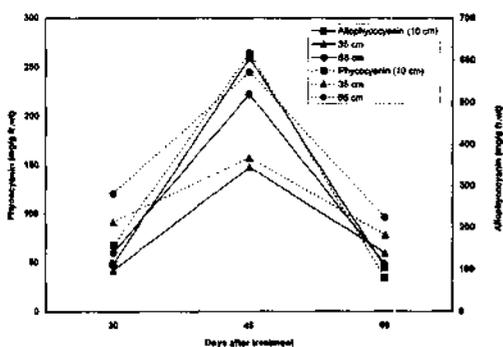


Fig. 2. Phycocyanin and allophycocyanin content of *Gracilaria edulis* cultured in different depths of water.

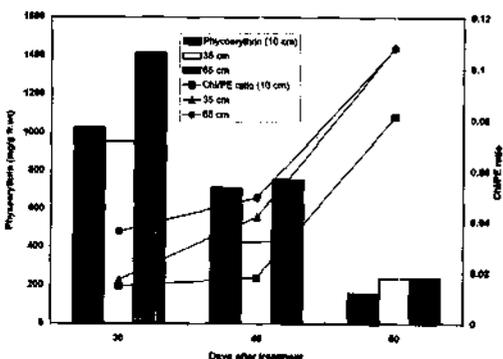


Fig. 3. Phycocyanin content and the ratio of chlorophyll and phycocyanin of *Gracilaria edulis* cultured in different depths of water.

chl/PE ratio increased gradually over a period of time under different treatments (Fig. 3). The increase was more pronounced at 10 cm depth due to marked decline in the phycoerythrin content on 60 days of growth. At 35 and 65 cm depth, the ratio of chl/PE showed almost a similar value although the pigment constituents are different. The Chl/PE ratio showed a pronounced increase from 45-60 days of treatment in all the cases.

It was also noted that the chlorophyll content showed significant positive correlation with CGR over the period of treatment ($r = 0.997$). The crop growth rate and the chlorophyll content declined gradually from 15 to 60 days of treatment (Fig. 1). It was also observed that the chlorophyll content increased at a greater depth showing a negative correlation with growth ($r = -0.937$). The accessory pigment, phycoerythrin also exhibited an initial decline of 30.7% within 45 days of treatment and further to 77% in 60 days. This again showed significantly positive correlation with CGR and chlorophyll content under different days of growth (Table 1). Phycocyanin and allophycocyanin showed a different trend. The pigments increased in 45 days of growth and declined by 60 days (Fig. 2). No significant correlation was established between these two pigments and growth rate. It seems that the adaptation of the plants to low light in terms of increasing pigments is related to growth response or to interact with decline in growth (Lapointe, 1981; Beer and Levy, 1983).

In the present experiment it was observed that although the pigment content increased markedly at higher

depth, the growth rate was found to be more when the plants were incubated at high light intensity (10 cm deep) and gradually declined as the depth increased. It was observed that the growth rate was more at 10 cm depth which may be hypothesised that the light intensity received at this depth might have been sufficient to saturate photosynthetic oxygen evolution of *Gracilaria* species. The availability of dissolved carbon was efficiently utilised for proper growth of the plant. The crop growth rate of *Gracilaria edulis* declined gradually over a period of incubation under all the treatments. Beer and Levy (1983) opined that, if plants were not cut and the biomass was allowed to increase throughout the whole growing period, the relative growth rate would decline to about half the initial after four weeks. Similar results were obtained in the present experiment.

It may be explained here that limitation of carbon, nutrients and other factors might have influenced to reduce the growth rate when the plants were cultivated in stagnant seawater. To overcome this stress, the pigment contents increased to optimise the photosynthetic activity which may be indicative of a strategy aimed at maximising light harvesting process to maintain a balanced growth. These results are similar to those observed by Sagert *et al.* (1997). Laing (1989) observed that, *G. sordida* grown under limiting PFD when transferred to high PFD showed increase in growth by 30% and they hypothesised that the algae were capable of storing nutrients growing under low light was unable to utilise the available nutrients due to low PFD.

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