

BRIEF COMMUNICATION

Inhibition of pigments and phycocolloid in a marine red alga *Gracilaria edulis* by ultraviolet-B radiation

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Abstract

Vegetative fragments of the subtidal macroalga *Gracilaria edulis* (Gmel.) Silva cultured under field conditions at Thonithurai were subjected in the laboratory to UV-B radiation (280 - 320 nm). UV-B inhibited the accumulation of chlorophyll and phycobiliproteins, and lowered agar yield (23 to 43 %) and its gel strength (22 to 36 %) under 12 to 72 h exposure. The longer the exposure to UV-B radiation the more significant impact on pigments and phycocolloid properties of *Gracilaria edulis* was observed.

Additional key words: agar, chlorophyll, phycobiliproteins, phycocyanin, phycoerythrin

Depletion of ozone layers in stratosphere is linked to disintegration of anthropogenic chlorofluorocarbons, resulting in an increase in the amounts of ultraviolet radiation reaching the earth's surface (Frederick 1993). Ultraviolet-B radiation (UV-B, 280 - 320 nm) is an important environmental factor affecting marine ecosystems. UV-B penetration in the sea is considerably reduced by plankton and dissolved organic matters (Hojerslev and Aas 1991). UV-B greatly reduces the marine primary productivity through the disruption of photosystem (PS) 2 (Worrest 1983), DNA damage (Karentz *et al.* 1991), and inhibition of ribulose-1,5-bisphosphate carboxylase activity (Lesser *et al.* 1994). According to Grossman *et al.* (1993) heat, cold, high irradiance, and UV-B may alter the composition of thylakoid membranes in aquatic organisms. There is no information on the variation in the thylakoid membrane components and agar yield of *Gracilaria edulis* subjected to different levels of UV-B.

Gracilaria edulis (Gmel.) Silva was cultured by Single Raft Floating Technique (SRFT) (Subbaramaiah and Thomas 1995) at Thonithurai, Gulf of Mannar

(9°17'N, 79°11'E). Algae that reached their full growth after 90 d were harvested and separated into two groups: the control group was irradiated by three 20 W *Philips* fluorescent tubes, and the experimental group was exposed to the combination of two 20 W fluorescent tubes and one 20 W (TL 20/12) sun lamp (280-320 nm, *Philips*) for 12 to 72 h. The algae were well spread in trays to get maximum surface absorption. The samples were analyzed at different time intervals for biochemical composition, agar yield, and agar properties. Chlorophyll (Chl) concentration was quantified spectrophotometrically according to Arnon (1949). Room temperature absorption spectra of Chl and phycobilisomes were recorded directly using a DU-7 UV-VIS spectrophotometer (*Beckman*, Irvine, USA). Protein content was estimated according to Lowry *et al.* (1951). Concentration of phycobiliproteins was estimated following the method of Kremer (1988). Extraction of agar and determination of gel strength, gelling and melting temperatures were carried out according to Thomas and Krishnamurthy (1976).

Received 23 January 2001, accepted 19 June 2001.

Acknowledgements: The authors thank Dr. P.K. Ghosh, Director, CSMCRI - Bhavnagar for his encouragement, and Prof. G. Kulandaivelu, Madurai Kamraj University, Madurai, for helpful comments and suggestions. Department of Science and Technology, New Delhi is gratefully acknowledged for financial support to K. Eswaran.

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Table 1. Changes in pigments and protein contents [g kg^{-1} (d.m.)] in *Gracilaria edulis* exposed to UV-B radiation for different periods. Means \pm S.D., $n = 3$.

| Treatment [h] | Chl α | Protein | Phycoerythrin | Phycocyanin |
|---------------|-----------------|-----------------|-----------------|-----------------|
| 0 | 2.38 \pm 0.10 | 3.90 \pm 0.20 | 18.1 \pm 0.79 | 27.2 \pm 0.64 |
| 12 | 1.83 \pm 0.78 | 3.00 \pm 0.17 | 82.0 \pm 0.92 | 14.6 \pm 0.36 |
| 24 | 1.64 \pm 0.36 | 2.65 \pm 0.21 | 52.2 \pm 0.99 | 12.7 \pm 0.16 |
| 36 | 1.46 \pm 0.30 | 2.59 \pm 0.14 | 47.6 \pm 0.55 | 12.0 \pm 0.21 |
| 48 | 1.25 \pm 0.21 | 1.73 \pm 0.10 | 28.1 \pm 0.11 | 11.0 \pm 0.27 |
| 60 | 1.03 \pm 0.15 | 1.52 \pm 0.17 | 25.7 \pm 0.18 | 9.9 \pm 0.17 |
| 72 | 0.97 \pm 0.35 | 1.07 \pm 0.80 | 13.4 \pm 0.25 | 7.7 \pm 0.13 |

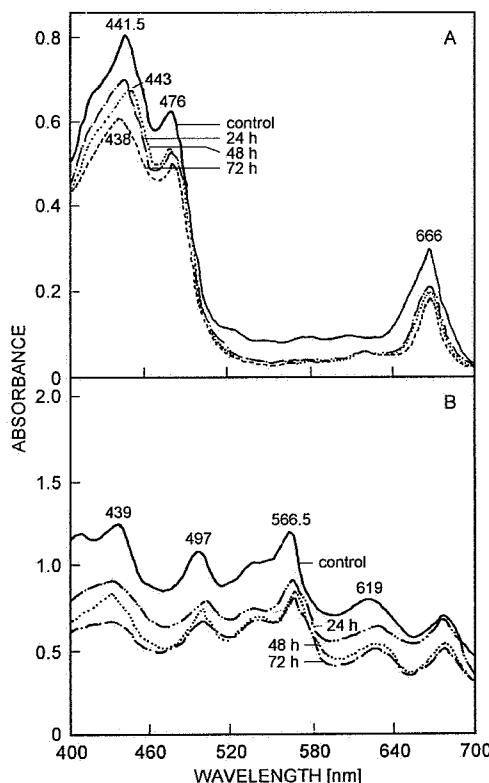


Fig. 1. Room temperature absorption spectra of chlorophyll (A) and phycobiliproteins (B) in control and UV-B treated *Gracilaria edulis*.

Exposure of algae fragments to UV-B caused drastic changes in pigment contents (Table 1). Prolonged exposure (more than 24 h) to UV-B reduced the quality and quantity of both Chl α and phycobilins. A gradual reduction in Chl α (17.2 to 46.4 %), phycoerythrin (47.5 to 86.0 %) and phycocyanin (43.8 to 52.4 %) was observed over the respective controls. Similar reduction in Chl content induced by UV-B was reported earlier in *Vigna* sp. by Nedunchezhian and Kulandaivelu (1991), and in cyanobacteria by Quesada *et al.* (1995). In *G. edulis* not only Chl but also phycocyanin and phycoerythrin concentrations were drastically reduced by UV-B. UV-B degrades polypeptides of molecular mass of 55, 47, 33, 27-28, and 10 kDa (Eswaran 1992). These proteins are associated with pigment-protein complexes of PS 1 and PS 2 reaction centre. In our experiment a reduction in pigment contents was observed also in control algae. This was due to high irradiance, similarly as in the experiments with *Ulva pertusa* (Muthuvelan *et al.* 1997/98).

Absorption spectra of Chl extracted from control algae (Fig. 1A) showed absorbance maxima at 441.5, 476, and 666 nm. The UV-B treated samples showed similar peaks, but shifted by 2 - 3 nm and the absorbance was less pronounced. The low absorption and the variation in absorption spectra indicate UV-B induced changes in thylakoid organization (Kulandaivelu *et al.* 1989). Absorption maxima of phycobilisomes were at 439, 497,

Table 2. Changes in agar yield and 1.5 % agar properties of *Gracilaria edulis* after UV-B treatment. Means \pm S.D., $n = 3$.

| Treatment [h] | Agar yield [%] | Gel strength [g cm^{-2}] | Gelling temperature [$^{\circ}\text{C}$] | Melting temperature [$^{\circ}\text{C}$] |
|---------------|------------------|-------------------------------------|--|--|
| 0 | 58.78 \pm 0.65 | 125.49 \pm 4.64 | 41.50 \pm 2.38 | 77.89 \pm 3.04 |
| 12 | 40.72 \pm 2.04 | 92.43 \pm 4.12 | 36.80 \pm 1.96 | 61.25 \pm 1.56 |
| 24 | 34.73 \pm 0.95 | 84.12 \pm 3.07 | 35.48 \pm 3.49 | 57.09 \pm 3.51 |
| 36 | 28.08 \pm 1.46 | 79.70 \pm 1.66 | 33.56 \pm 3.33 | 53.80 \pm 3.35 |
| 48 | 24.46 \pm 1.42 | 73.64 \pm 2.68 | 30.42 \pm 2.38 | 50.60 \pm 1.21 |
| 60 | 16.61 \pm 0.81 | 68.78 \pm 2.33 | 28.56 \pm 2.37 | 43.14 \pm 4.34 |
| 72 | 12.54 \pm 1.10 | 46.19 \pm 3.18 | 26.55 \pm 3.23 | 34.66 \pm 3.30 |

656.5 (phycoerythrin), and 619 nm (phycocyanin) (Fig. 1B). There was a drastic decline in absorbance of phycobilisomes with increasing UV-B exposure time. A similar absorbance decrease of phycobilisomes with increasing UV-B was reported by Sinha and Hader (1996). Total soluble protein concentration in *G. edulis* was drastically reduced in UV-B treated plants. This may be related to the damage of DNA and other macromolecules (Giese 1964). Decrease in content of total soluble protein under various stresses including radiation quality was reported by Muthuvelan *et al.* (1997/98).

The enhanced UV-B induced a drastic reduction in

agar yield (23.4 - 43.4 %). On increasing the UV-B exposure from 12 to 72 h the gel strength was also decreased by 22.5 to 36.1 % over the respective controls (Table 2). No such experimental evidence of the effect of UV-B on agar yield and its properties was reported earlier. The agar composition of *Gracilaria* is species dependent (Lahaye *et al.* 1988). Variations in radiation quality and photoperiod affect the agar content of *Gracilaria* sp (Christiaen *et al.* 1987) and high gel strength is correlated with proper irradiation. Ekman and Pedersen (1990) reported that photon irradiation and day-length seriously alter the agar yield and gel strength in *Gracilaria sordida* and *Gracilaria verucosa*.

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