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Effect of environmental factors on spore shedding in *Gracilaria corticata* J.Agardh

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ABSTRACT

Gracilaria corticata is an agarophyte which occurs abundantly throughout the year in the intertidal rocky surfaces of Visakhapatnam coast, India. Spore shedding experiments such as effect of environmental factors on spore shedding and on diurnal periodicity of spore shedding were conducted during 2007 and 2008. Maximum numbers of tetraspores were released when fronds were in submerged condition, exposed to dark condition and at 30 ‰ salinity. Neither acceleration nor delay in the peak shedding of tetraspores in *G. corticata* was found even after exposure to various periods of desiccation, salinities and different light intensities.

1. Introduction

Seaweeds are commercially valuable for the sources of food, fodder, fertilizer and extraction of important phycocolloids and biofuels. Spores in seaweeds are single celled reproductive bodies and are capable of growing into new plants. Studies on sporulation play a vital role in the field of mariculture to generate the algal populations in the natural habitats. Several authors have studied the spore shedding from marine algae of tropical waters (Katada, 1955; Srinivasa Rao, 1971; Umamaheswara Rao and Kaliaperumal, 1983; Subba Rangaiah, 1983, 1984, 1985; Umamaheswara Rao and Subba Rangaiah, 1986; Narasimha Rao and Subba Rangaiah, 1991. In the present investigation studies were made on the spore shedding from *G. corticata* in different environmental conditions.

2. Material and methods

Visakhapatnam is situated on the east coast of India between the latitude 17^0 40' 30'' and 17^0 45' N longitudes 83^0 16' 25" and 83^0 21' 30"E. The coastline is sandy with outcrops of rocky boulders in different regions. Materials for this study were collected during the spring tide periods from VUDA park regions where large accessible boulders occur with dense growth of algae. *Gracilaria corticata* J.Agardh was collected for carrying the laboratory experiments during the years 2007 and 2008. Experiments were conducted on the effect of environmental factors such as desiccation, salinity and light intensity on spore shedding and diurnal periodicity of spore shedding from the above candidate. In the experiments conducted to study the exposure to air, the tetrasporophytic fronds were blotted to remove the water on the surface of the fronds and exposed to air in the laboratory and also in the open air during the day time. At the time of conducting these experiments, the temperature in the laboratory was $32 \pm 2\ ^0C$ and the relative humidity varied from 62 to 67%. In the open air where these experiments were conducted, the temperature was $34 \pm 2\ ^0C$ and relative humidity ranged from 58 to 63%. At 15 minute intervals the materials thus exposed to air were transferred to Petri-dishes filled with seawater and the spore output was estimated after 24 hours as mentioned in the earlier works (Subba Rangaiah, 1983). Seawater collected from the inshore area was adjusted to 80‰ salinity by exposing to sun light to make up the stock solution. Lower grades were prepared from this stock solution by the addition of requisite quantity of distilled water. Spore output was estimated at

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0‰ to 70‰ salinities, maintaining the Petri-dishes at room temperature (32±2) ^{0}C under 8 hours day length with 9 µ E/ m^2 s day light fluorescent illumination. Effect of light intensity on spore output were investigated at room temperature using light intensities of 0 (dark) to 36 µ E/ m^2 s. Based on the changes observed in the spore output per day, experiments on diurnal periodicity were conducted selecting certain periods of exposure to air (0 to 60 minutes), salinities (10 to 60 ‰) and light intensities (0 to 36 µ E/ m^2 s).

3. Results

3.1 Factors influencing spore output

Changes were observed in the tetraspore output of *Gracilaria corticata* , in control (i.e., in fronds submerged for 2 hours), maximum spore output was observed and with increase in the time of exposure the quantity of spores liberated gradually decreased. The spore output declined rapidly from 15 to 45 minutes of exposure to air at room temperature in air (Figs. 1). In general the spore production was less in the fronds exposed to open air (Fig.1 A) when compared to shade condition. There was no spore discharge in the fronds exposed after 75 minutes (Fig.1B).

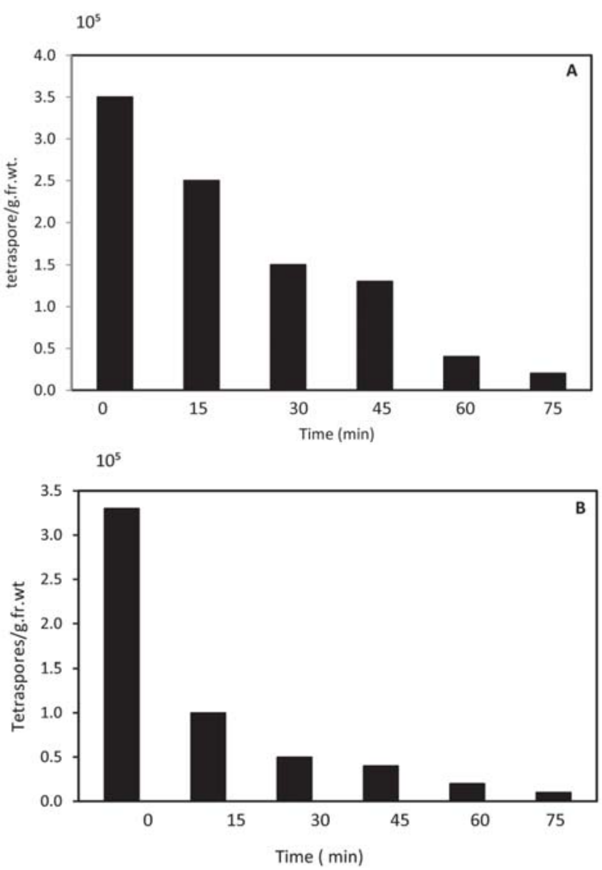

Fig.1. Rate of the spore output of gracillaria corticata at ambient (A) outdoor and (B) indoor temperature on exposure to air

Effect of salinity on spore shedding was shown in Fig. 2. There was no spore shedding at 0 ‰ and 70 ‰ salinities. Spore liberation was seen in salinities from 10- 60 ‰ and maximum spore shedding was observed at 30 ‰ followed by 20 ‰ and 40 ‰ salinities. Minimum spore shedding was seen in salinities at 10 ‰ and 60 ‰.

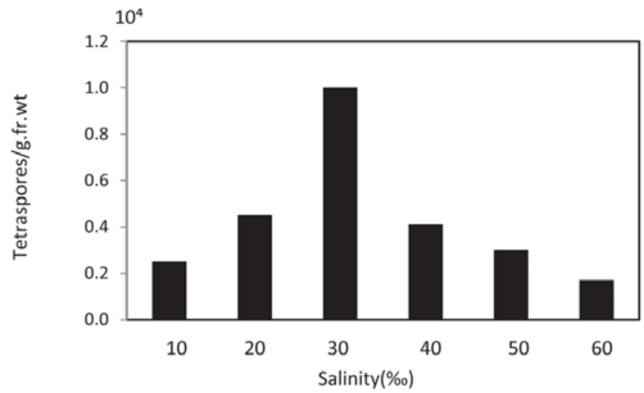

Fig.2. Rate of spore output *Gracilaria corticata* at different salinities

Fig.3 shows the quantity of spores liberated in darkness and at three different light intensities ranging from 9 µE/ m^{2}s to 36 µ E/ m^2 s. In *Gracilaria corticata* spore output was observed in complete darkness. The values obtained at 9 µ E/ m^{2}s were slightly less than those obtained in darkness

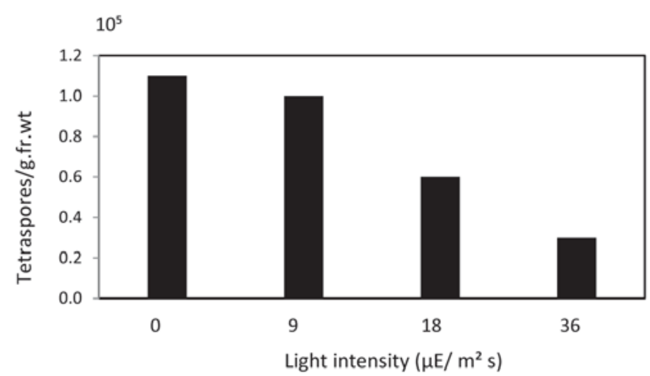

Fig.3. The effect of irradiance on spore output of *Gracilaria corticata*

and the spore output decreased gradually with increasing light intensity staring from 18 ì E/ m^{2}s.

3.2 Factors influencing diurnal periodicity

Diurnal periodicity curves obtained on *Gracilaria corticata* exposed to air for 0 (control), 15, 30, 45 and 60 minutes are shown in Fig.4. The diurnal periodicity of tetraspores did not vary in *Gracilaria corticata* in control and in the fronds exposed to air for a period of 15 to 60 minutes. Since exposure of the fronds to air affect the spore shedding, the quantity of spores liberated at different times of the day also decreased from control to 60 minutes exposure but the diurnal periodicity curve did not change (Fig.4).

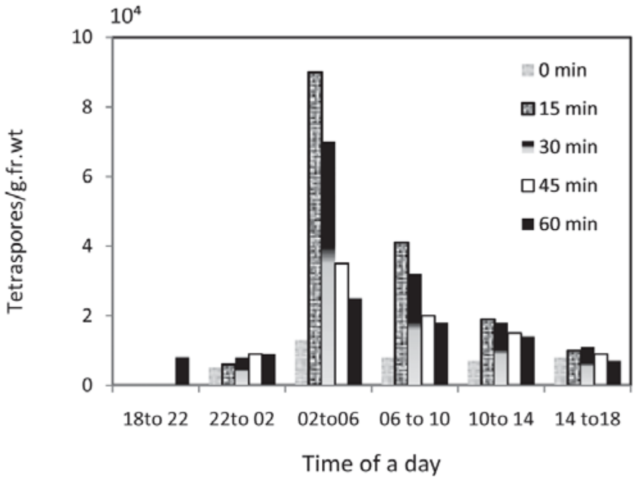

Fig.4. Diurnal periodicity in the spore output of *Gracilaria corticata* on exposure for different duration (min) to air.

Maximum liberation of spores was observed in all five different exposures with peak output between 02. 00 hour and 06.00 hour in the morning.

In order to show the effect of salinity on the diurnal periodicity, data collected at five different salinities (10 to 50‰) showed similar rhythm in the daily liberation of spores in all the selected salinities with peak output between 02.00 h and 06.00 h (Fig.5). As observed in the total spore output per day, the quantity of spores liberated varied in different salinities in the diurnal periodicity experiments also. Peak output was obtained in *Gracilaria corticata* at 30 ‰ (Fig. 5).

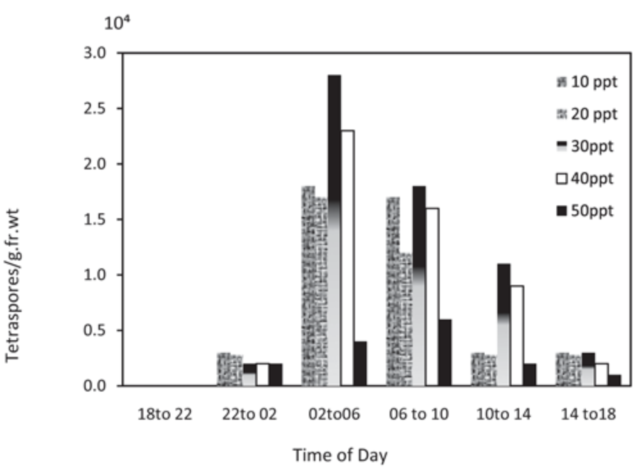

Fig.5. Diurnal periodicity in the spore output of *Gracilaria corticata* on incubation in water with different salinities (ppt)

Diurnal periodicity curves obtained at 0, 9 $\mu E/m^2s$ and 18 μ E/ m^2s light intensities are shown in Fig. 6. In these experiments also the diurnal periodicity of spores was not affected either in the dark or in the two light intensities used. The maximum shedding was observed between 02.00 h and 06.00.h (Fig.6).

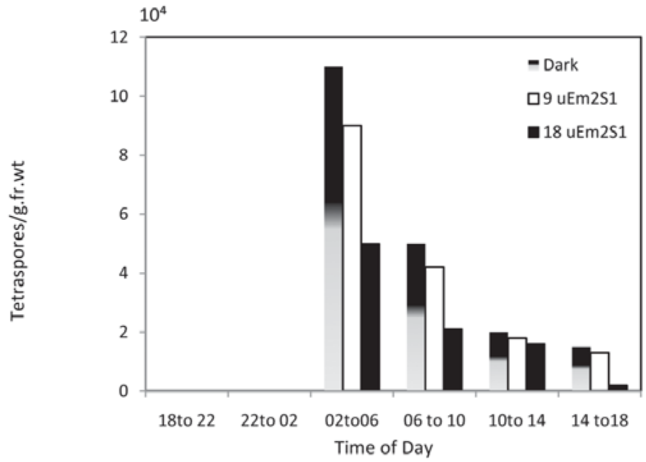

Fig. 6. Diurnal periodicity in the spore output of *Gracilaria corticata* at different irradiance ($\mu E/m^2s$).

4. Discussion

In the intertidal habitats, the environmental factors such as desiccation, salinity, temperature and light are considered as some of the important factors in controlling growth, reproduction and spore shedding of algae (Narasimha Rao and Subba Rangaiah, 2009, 2010). In the present study the effect of temperature on spore shedding was not conducted because of lack of proper facility. The eco-physiological aspect of spore discharge was studied on some Indian algae, viz. *G. corticata, G. textorii* and *Gracilariopsis sjoestedtii* (Subba Rangiah, 1983, 1984, 1985). In the present study, effect of environmental factors such as exposure to air on spore shedding of *Gracilaria corticata* showed a decreasing trend of tetraspores output when the algae were exposed to air and subjected to desiccation (Figs. 1). It is therefore; likely that exposure of fronds during low tides affects the quantity of spores produced. A similar response was reported in Gelidiales (Katada, 1955; Srinivasa Rao, 1971; Umamaheswara Rao and Kaliaperumal, 1983), Gigarinales (Umamaheswara Rao and Subba Rangaiah, 1986), Bangiales and Ectocarpales (Narasimha Rao and Subba Rangaiah, 1991). Some cultural studies showed that the release of spores /gametes in seaweeds is induced by desiccation and when wetting the fertile thalli (Luning, 1980; Sheath and Cole, 1980). In the present study the tetraspore shedding in *G. corticata* was observed for 75 min exposure in the outside and inside the laboratory which is almost coinciding the previous studies.

It was also observed that the degree of salinity of the seawater influenced spore shedding in *G. corticata*. The optimum salinity range observed for the maximum shedding in *G. corticata* was 30 ‰ (Fig. 2). Several studies recorded the influence of salinity on spore production and release in various algae of the Visakhapatnam coast and reported different optimum ranges (Subba Rangiah *et. al.*1975; Subba

Rangiah,1986; Umamaheswara Rao and Subba Rangaiah, 1986; Narasimha Rao and Subba Rangaiah, 1991. The tetraspore liberation occurred in *G. corticata* under photon flux densities raging from 0 to 36 $\mu E/m^2s$. The observations of the present study was in agreement with the previous studies made by Umamaheswara Rao and Subba Rangaiah (1986), where in the peak discharge of tetraspores in *G. corticata* was observed in complete darkness.

Environmental factors play an important role in the formation and liberation of spores from marine algae occurring in different vertical heights of the rocky substratum (Narasimha Rao and Subba Rangaiah, 2009; 2010). Like this, environmental factors influence the diurnal periodicity of spore shedding in the marine algal populations. In the present study neither acceleration nor delay in the peak shedding of tetraspores in *G. corticata* was found even after exposure to 60 minutes (Fig.4). The present study on *G. corticata* is in agreement with the observations made by Umamaheswara Rao and Kaliaperumal (1983) on Gigartinales. Variations in salinity did not affect diurnal periodicity pattern in the members of Gigartinales, Gelidiales and Cryptonemiales (Umamaheswara Rao and Subba Rangaiah, 1981; Umamaheswara Rao and Kaliaperumal, 1987). In this respect the present study on *G. corticata* agrees with the above findings. When the thalli of *the alga was* exposed up to 18 to 36 $\mu E/m^2s$ light intensities, there was no change in the peak period of shedding of tetraspores. Umamaheswara Rao and Kaliaperumal (1987) observed pre-ponement of the time of peak shedding of spores by 4 hours in *Gelidiopsis variabilis* at 3000 lux but not at 500 and 1400 lux and also in the dark. But in the present study, it seems that photon flux intensity did not have any effect on the diurnal periodicity of tetraspores shedding in *G. corticata*.

5. Conclusion

It is interesting to note that the quantity of spores liberated in *G. corticata* of the present study is almost less than half when compared to the studies made by Subba Rangaiah (1983) in the same alga almost 30 years back. This change may be due to increase in the temperature (2-3 ^{0}C) in the nature, and indiscriminate discharge of industrial effluents in to the sea. If this process continues, we do hope that in future there will be a drastic change in the seaweeds of Visakhapatnam towards decrease in the vegetation as well as in spore shedding capacities. So, we request the Government and NGOs to take necessary steps to conserve the seaweeds of Visakhapatnam by taking proper steps.

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