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# EFFECTS OF EMERGENCE AND SALINITY ON THE PHOTOSYNTHETIC AND RESPIRATORY ACTIVITIES OF *ULVA FASCIATA* DELILE (CHLOROPHYTA).

MUSTAFA SHAMEEL

*Department of Botany, University of Karachi, Karachi-32, Pakistan.*

**Abstract**

The rates of photosynthesis and dark respiration were measured in a littoral seaweed, *Ulva fasciata* Delile. Gross photosynthesis and respiration initially increased during emergence, reached to a maximum at 20% desiccation and then gradually declined but the net photosynthesis constantly declined with the rise in the intensity of desiccation.

A pretreatment of *U. fasciata* with salinities between 40 and 60°/00 increased the gross photosynthesis, which however decreased after exposure to salinities below 30°/oo and higher than 70°/oo. Treatment with fresh water reduced respiration, which increased over the control on exposure to 10 – 40°/oo. Pretreatment with 50°/oo S and higher steadily decreased the respiratory activity. A 4 min exposure in distilled water reduced the gross photosynthesis to almost zero, which was nullified after a pretreatment for 6 min or higher durations.

## Introduction

Intertidal algae are usually exposed to periodic desiccation during emergence. Photosynthetic and respiratory activities of algae occupying different positions in the littoral belt are affected by desiccation (Brinkhuis *et al.*, 1976; Qadir *et al.*, 1979; Shameel, 1980b). Changes in salinity may also cause considerable influences on the photosynthetic and respiratory rates of intertidal algae (Ohno, 1976; Lehnberg, 1978; Shameel, 1980a). Apart from thallus growth, salinity also indirectly affects the distribution of seaweeds (Norton & South, 1969; Ogata & Schramm, 1971; Munda, 1978). The effects of these ecological determinants in the marine environment on intertidal algae are little known. Similarly the cellular changes in direct responses of the photosynthetic system have not been investigated. The present paper deals with study of the influences of desiccation and salinity (S) on the rates of gross and net photosynthesis and dark respiration in *Ulva fasciata*, a green intertidal alga growing commonly on the coast of Pakistan.

## Materials and Methods

Clean, healthy and non-reproductive thalli of *Ulva fasciata* Delile, about 10 cm long were collected from the littoral belt of the rocky ledge at Manora and Paradise Point near Karachi. They were dried in blotting sheets and cleaned of epiphytes by mild scraping. The release and uptake of $CO_2$ in emerged condition were measured by an infra-red Beckman gas analyser (Model 215), using a closed system at 0% humidity and 20°C. Young thalli were hung in a plexiglass chamber of 3 l capacity which was illuminated from both sides by light intensity of 1.5 x $10^3 \mu Em^{-2} sec^{-1}$ for photosynthesis. For dark respiration it was covered with strong black plastic. The incubation period was 2 hour.

Dry air was passed over the thalli in the closed system for desiccation. The algae were removed every 15 min, quickly weighed and replaced in the plexiglass chamber. The algae on 70% desiccation were removed and the dry weight (dw) determined by drying at 70°C for 48 h.

Algal thalli were pretreated in complete darkness with either sea water of various salinities (10 – 80 °/oo) or fresh water (0°/oo S) for 1 h. A set of them were initially kept in emergence for 1 h and then treated with distilled water for 2 - 18 min durations. They were then brought back into normal sea water (36°/ooS). These were kept in sunlight or in darkness for 1 h to measure the rate of gas exchange at 28°C. The amount of $O_2$ production or uptake was determined by the Winkler Method according to Grasshoff (1976) and the rates of gross photosynthesis and dark respiration

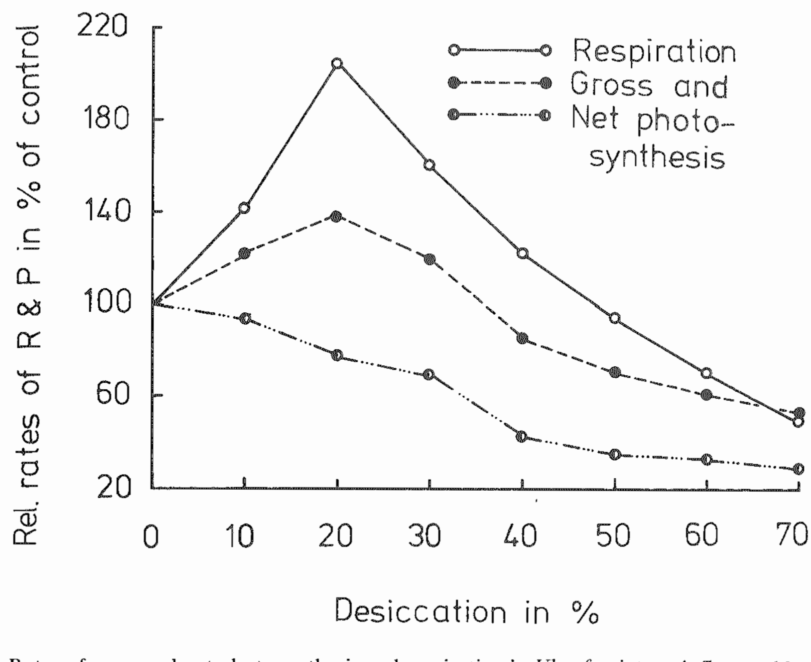


Fig.1. Rates of gross and net photosynthesis and respiration in *Ulva fasciata* as influenced by desiccation, measured in mg $CO_2$. g $(dw)^{-1}$..$h^{-1}$ at 20°C and 1.5 x $10^3$ $\mu E$ $m^{-2}$ $sec^{-1}$.

calculated. The values of photosynthesis and respiration obtained in terms of mg $CO_2$. g $(dw)^{-1}$. $h^{-1}$ (for emergence experiments) and mg $O_2$. g $(dw)^{-1}$. $h^{-1}$ (for salinity and distilled water experiments) are expressed in terms of control percentage. Each measurement reported is an arithmetic mean of 8 replicates.

## Results and Discussion

### *1. Effect of emergence*

The effect of emergence was an increase in desiccation as the thalli were exposed to air, this may have a direct bearing on the gas metabolism of seaweeds. Gross photosynthetic and respiratory activities of *U. fasciata* initially increased with increasing desiccation, reaching to a maximum at 20% desiccation and then steadily declined (Fig. 1). The net photosynthesis constantly decreased with increase in desiccation. The rate of gross photosynthesis was highest at 20% desiccation, and upto 70% *U. fasciata* was able to maintain a positive net photosynthetic rate suggesting that the seaweed is physiologically well adapted to the intertidal zone. Net photosynthesis of *U. fenestrata* in emerged state was about 3 times more than that of *Iridaea cordata* (Qadir *et al.*, 1979). *I. cordata* is low intertidal seaweed and is better adapted to submergence than emergence. *Ulva* when emerged thus appears to tolerate water loss for longer periods.

Although gross photosynthesis reached to a maximum value at 20% desiccation

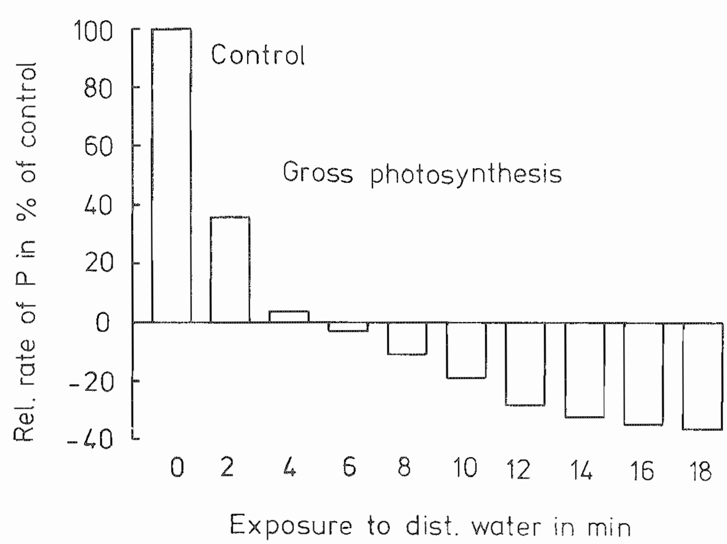


Fig.2. Rates of gross photosynthesis and respiration in *Ulva fasciata* measured in normal sea water ($36^{o}$/oo/ S) after emergence of 1 h and a pretreatment with dist. water for various durations (measured in mg $O_2$. g $(dw)^{-1}$. $h^{-1}$ at $28^{o}$C).

but the rate of respiration simultaneously increased and this caused a sharp fall of net productivity in *U. fasciata*, between 10 – 20 % desiccation. Similar fall in the rate of net photosynthesis was observed between 30 – 40%, which may be due to a sudden retardation of gross photosynthesis and a steady increase in dark respiration over the control values. *U. indica,* an upper littoral alga exhibited a similar change in its photosynthetic and respiratory activities as affected by increasing desiccation (Shameel, 1980b). *U. pertusa,* a mid littoral seaweed survived during spore stage for 16 h at 80% relative humidity under desiccation (Ohno, 1969). *U. fenestrata,* a low to mid intertidal alga showed lesser gross and net photosynthetic values in the emerged condition than in the submerged state. There seems to exist a clear relationship between algal habitats and the tolerance of desiccation during emergence.

## 2. *Effect of salinity*

An increased gross photosynthesis was observed in *U. fasciata,* when exposed to salinities between 40 – 60°/oo (Fig. 2). An exposure to 30°/oo had no effect, but lower salinities practically destroyed the photosynthetic mechanism. Salinities greater than 60°/oo steadily decreased the rate of gross photosynthesis. Respiration was greatly affected. On exposure to sea water (50 – 80°/oo S), the respiratory rate declined with the rise in salinity but a pretreatment with diluted sea water (10 – 30 °/oo S) increased the respiratory activity. The algae kept in fresh water exhibited a highly reduced rate of respiration.

The retarded gross photosynthesis observed after exposure to low salinities might have resulted from fast and extreme loss of ions due to extremely high ionic permeability as has also been observed in some other seaweeds (Gessner, 1969; Ohno, 1976; Shameel, 1980 a). A decline in the photosynthetic activity on pretreatment with very high salinities, may be due to osmotic stress. Gessner (1969) observed that the photosynthesis in *Fucus virsoides* was not influenced by a 1 h pretreatment with low and high salinities. *F. vesiculosus* is also resistant to high hydrostatic pressure as compared with other seaweeds (Shameel, 1979). *Fucus* has a thick thallus, from which ions are primarily washed out from the "free space" without affecting the vital system. On the contrary *U. fasciata* has a very thin thallus, in which ions are presumably thrown out by diffusion thus adversely affecting the vital system.

## 3. *Combined effects of emergence and salinity*

Intertidal algae are often exposed to fresh water during rainfall, when they emerge. A combination of these ecological determinants influences the gas metabolism more severely than a single ecofactor acting singly. A 1 h emergence and a pretreatment with distilled water for 2 min decreased the rate of gross photosynthesis to less than 40 % in *U. fasciata,* when measured in normal sea water, and a 4 min exposure was

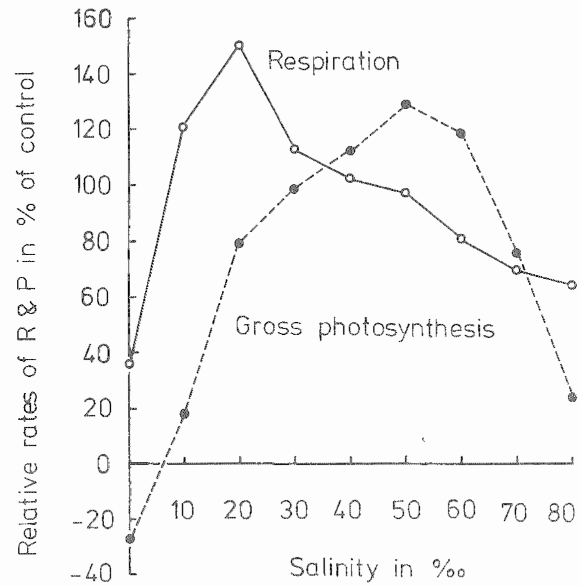


Fig.3. Rate of gross photosynthesis in *Ulva fasciata* measured in normal sea water (36°/oo S) after emergence of 1 h and a pretreatment with dist. water for various durations (measured in mg $O_2$. $g(dw)^{-1}$. $h^{-1}$ at 28°C).

enough to reduce the photosynthetic activity to almost zero (Fig. 3). After a 6 min treatment with distilled water the photosynthetic value became negative, which decreased further with the increase in duration of treatment. On an exposure for 10 min or more no regeneration took place, indicating the total break down of photosynthetic and respiratory activities. Since the rate of ion loss is maximum during first 5 min of osmotic stress, the irreversible metabolic depression is probably due to the fast ion loss.

*U. fasciata* is more resistant and better adapted to intertidal conditions than Dictyopteris *membranacea*, since 1 min exposure of *D. membranacea* to distilled water was enough to reduce the subsequent rate of photosynthesis to almost zero (Gessner, 1969). The high decline in rate of respiration in *U. fasciata* after exposure to fresh water (Fig. 2) speaks to the severity of this treatment. Although the thalli were replaced in sea water, no regeneration occurred. Long treatment with fresh water kills the alga. Gessner (1969) observed that several hours' pretreatment of *Fucus virsoides* with aerated distilled water did not affect its metabolism, which may be due to the construction of its thallus. Salinity not only acts via osmoconcentration but also affects through ionic influences due to which algae of different anatomical constructions show different behaviour.

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