Pak. J. Bot., 12(2): 195-199, 1980.

INFLUENCE OF DESICCATION ON THE PHOTOSYNTHETIC AND RESPIRATORY ACTIVITIES OF A MARINE GREEN ALGA, *ULVA INDICA*.

MUSTAFA SHAMEEL

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

Abstract

Photosynthesis and respiration rates were measured in an intertidal green alga, *U. indica* Anand under different stages of desiccation (0 - 70%) at 20°C. Gross photosynthesis and respiration were initially enhanced and reached a maximum at 20% desiccation, however they steadily decreased with increasing percentage of desiccation. Net photosynthesis constantly declined with increasing duration of emergence.

Introduction

Stocker & Holdheide (1938) observed that in emerged condition the rate of photosynthesis in intertidal algae was higher than in submerged state. Later observations, however, showed that photosynthetic and respiratory activities of emerged seaweeds were either lower or nearly equal to those of submerged ones (Ogata, 1968; Imada *et al.*, 1970; Kremer & Schmitz, 1973). Recent investigations pointed out that in upper and mid-littoral algae the gross photosynthesis increased and respiration decreased with desiccation, resulting in an enhancement of net photosynthesis. In lower littoral seaweeds, however, net photosynthesis decreased due to retarded gross photosynthesis and enhanced respiration with increasing water loss under emerged condition (Johnson *et al.*, 1974; Brinkhuis *et al.*, 1976; Qadir *et al.*, 1979).

Our studies on the effect of salinity on rate of O_2 exchange have indicated that *Ulva indica*, a green alga endemic to the coast of Pakistan provides an ideal material for the study of photosynthetic and respiratory activities (Shameel, 1980). This is an intertidal seaweed and grows in the upper to mid-littoral region, where it undergoes desiccation during long periods of emergence. It, therefore, appeared interesting to examine the relationship between desiccation and such physiological parameters as photosynthesis and respiration in this alga.

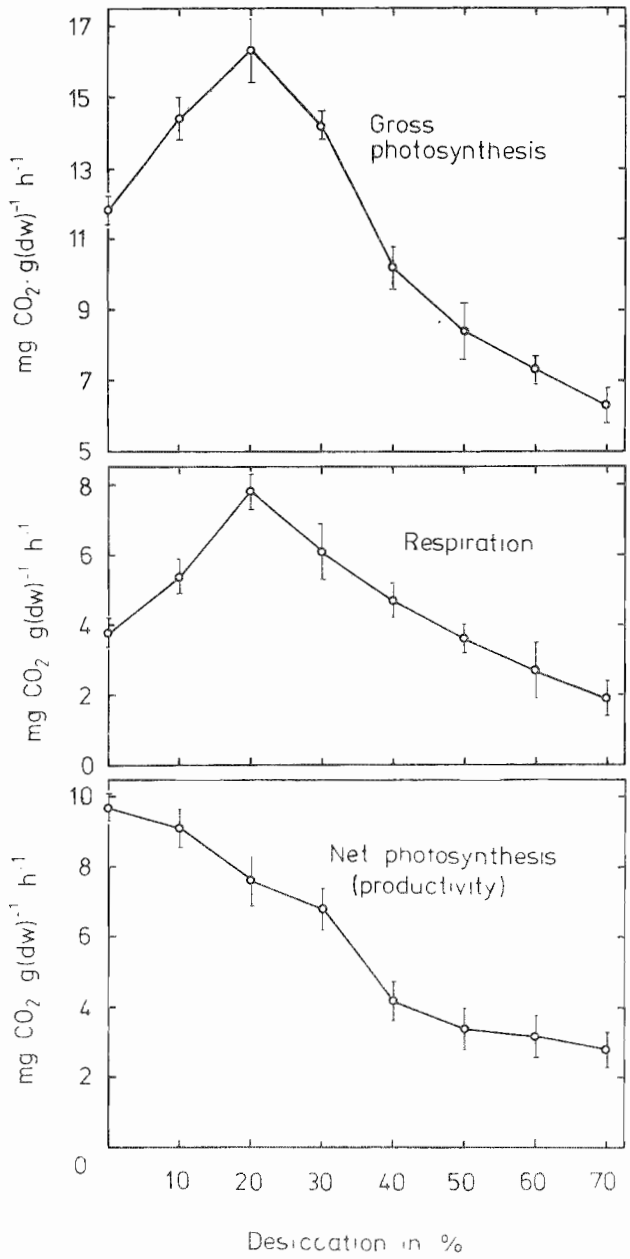

Fig. 1. The rates of gross photosynthesis, respiration and net photosynthesis in *Ulua indica* as affected by increasing desiccation, measured at 20°C with or without 1.5×10^{3} μE m^{-2} sec^{-1} light intensity.

Materials and Methods

Ulva indica Anand was collected from the ledge of conglomerate rocks on the western side of Manora Island, situated in the northern Arabian Sea near Karachi during low tides in the months of February to May, 1979. Young, healthy, non-reproductive and approx. 1 cm long thalli were selected, gently dried by blotting, scrapped mildly to remove the epiphytes and were immediately used for experimentation. Complete thalli were suspended by means of a thread in a plexiglass chamber of 3 l capacity and desiccated by passing dry air over the algae in the closed system. The seaweeds were carefully removed every 15 min, quickly weighed, replaced in the plexiglass chamber and the rate of desiccation calculated. When the algae reached 70% desiccation, they were removed and the dry weight (dw) was determined by drying at 70°C for 48 h.

In one set of experiment the plexiglass chamber was illuminated from both sides by flourescent tubes with a light intensity of 1.5×10^3 μE m^{-2} sec^{-1} for photosynthesis. In another set the chamber was covered with heavy black plastic for respiratory measurements. These were incubated for 2 h at 20°C. The release and uptake of CO_2 were measured by an infra-red Beckman gas analyser of model 215, using a closed system at 0% humidity. Each measurement reported is a mean of 8 replicates, standard deviation has also been calculated and expressed diagrammatically.

Results

Ulva indica exhibited a high photosynthetic activity. Rate of gross photosynthesis initially increased with increasing desiccation, reached a maximum at 20% desiccation and thereafter gradually decreased (Fig. 1). At 30% the gross photosynthesis was still higher than the initial value (at 0%), but it suddenly fell to a low level at 40% and then declined slowly with further increase in desiccation of upto 70%.

Respiratory activity was similarly affected by desiccation. It increased rapidly showing a sharp peak at 20% desiccation and then gradually declined (Fig. 1). Upto 40% the rate of respiration remained higher than the value at 0%. At 50% it was slightly lower than the initial value and decreased further with rise in the intensity of desiccation.

The productivity of *U. indica* always decreased under emerged condition correlated with increase in desiccation, since the alga showed a high photosynthetic activity it exhibited a positive net photosynthesis even at 70% desiccation (Fig. 1). The decrease in the rate of net photosynthesis was rapid upto 40% and thereafter it slowed down. Net productivity however suddenly fell to a low value between 10 and 20% and another similar fall was found between 30 and 40% desiccation.

Discussion

Gross photosynthesis of *U. indica* was maximum at 20% desiccation and upto 70% it was able to maintain a positive net photosynthetic rate. This indicates that the alga is physiologically well adapted for its position in the intertidal zone. In similar experiments with *U. fenestrata,* Qadir *et al.* (1979) also found that net photosynthesis in emerged condition was 3 times more than for *Iridaea cordata,* which is a low intertidal alga and is better adapted for submergence than emergence. This may be due to the intertidal stress as the algae growing in the intertidal region display physiological differences from subtidal seaweeds (Liddle, 1975).

At 20% desiccation the gross photosynthesis of *U. indica* reached a maximum value but simultaneously respiration also increased to a sharp peak. This has caused a fall of net productivity between 10 and 20%. Another sudden fall in the rate of net photosynthesis was found between 30 and 40% desiccation. This may be due to a rapid decrease in the gross photosynthesis and gradual enhancement of respiratory rate *U. pertusa,* an alga of mid-littoral belt survived at spore stage for 16 h at 80% relative humidity under desiccation (Ohno, 1969). Similar observations have also been made by Qadir *et al.* (1979) on *U. fenestrata,* a low to mid-intertidal seaweed which exhibited lower gross and net photosyntheses in the emerged state as compared to submerged condition. This indicates a clear relationship between algal habitats and the tolerance of desiccation.

Fucus is a high intertidal seaweed and is, therefore, extremely resistant to desiccation and other ecofactors e.g. hydrostatic pressure in its rate of O_2 exchange (Gessner & Hammer, 1971; Shameel, 1973). Net photosynthesis of this alga when emerged reached a maximum at 20 – 35% desiccation due to increased gross photosynthesis and decreased respiration rates (Johnson *et al.,* 1974; Brinkhuis *et al.,* 1976; Qadir *et al.,* 1979). A comparison of these observations with that of present study indicates that *Ulva* is not so well adapted for prolonged emergence as *Fucus,* since the former occupies a position lower than the latter in the intertidal region when they occur together. Algae growing in higher belt on the shore have thicker cell membrance than those lower down, and a considerable amount of water must be retained in their cells (Ohno, 1969). Algal zonation could, therefore, also be explained in terms of relative net photosynthetic activity during emergence.

Acknowledgements

I would like to express my gratitude to Prof. A. Ghaffar and Mr. M.H. Hashmi for reading the manuscript and valuable comments.

References

Brinkhuis, B.H., N.R. Tempel and R.F. Jones. 1976. Photosynthesis and respiration of exposed salt-marsh fucoids. Mar. Biol., **34**: 349-359.

Gessner, F. and L. Hammer. 1971. Physiologische Untersuchungen Über die Toleranz von *Fucus virsoides* (Don.) J.Ag. Int. Revue ges. Hydrobiol., **56**: 581-597.

Imada, O., Y. Saito and S. Maeki, 1970. Relationships between the growth of *Porphyra tenera* and its culturing conditions in the sea. II. Influence of atmospheric exposure on photosynthesis, growth and others in *Porphyra* fronds. Bull. Jap. Soc. Sci. Fish., **36**: 369-376.

Johnson, W.S., A. Gigon, S.L. Gulmon and H.A. Mooney, 1974. Comparative photosynthetic capacities of intertidal algae under exposed and submerged conditions. Ecology, **55**: 450-453.

Kremer, B.P. and K. Schmitz. 1973. CO_2-Fixierung und Stofftransport in benthischen marinen Algen. IV. Zur ^{14}C-Assimilation einiger litoraler Braunalgen im submersen und emersen Zustand. Z. Pflanzenphysiol., **68**: 357-363.

Liddle, L.B. 1975. The effect of intertidal stress on *Padina sanctae-crucis* (Phaeophyta). J. Phycol., **11**: 327-330.

Ogata, E. 1968. Respiration of some marine plants as affected by dehydration and rehydration. J. Shimonoseki Univ. Fish., **16**: 89-102.

Ohno, M. 1969. A physiological ecology of the early stage of some marine algae. Rep. Usa Mar. Biol. Stat., **16**: 1-46.

Qadir, A., P.J. Harrison and R.E. De Wreede. 1979. The effects of emergence and submergence on the photosynthesis and respiration of marine macrophytes. Phycologia, **18**: 83-88.

Shameel, M. 1973. Untersuchungen Über den Einfluss des hydrostatischen Druckes auf den O_2-Gaswechsel mariner benthischer Algen. Int. Revue ges. Hydrobiol., **58**: 741-782.

Shameel, M. 1980. Influence of salinity on the rates of photosynthesis and respiration in *Ulva indica* Anand. Pak. J. Bot., **12**: 77-80.

Stocker, O. and W. Holdheide. 1938. Die Assimilation Helgolander Gezeitenalgen während der Ebbezeit. Z. Bot., **32**: 1-59.