The effect of light and temperature on the photosynthetic rate of freshwater Cladophora thickly grown in an irrigation canal

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Abstract

To take the physiological natures of freshwater green alga Cladophora glomerata Kützing growing thickly in the irrigation canal, the photosynthesis in relation to the light intensity and the temperature was investigated. Photosynthesis and respiration were measured by gas-volumeter. The light saturation and the light compensation of photosynthesis at 20°C occurred mostly at about 5 klux and 140 lux, respectively. The optimum temperature for the photosynthesis was around 25°C. This alga showed a high photosynthetic rate within the wide temperature range of 10 to 30°C, and a tolerance to high temperature.

Key words: Cladophora -photosynthesis-respiration-temperature-light intensity

A great number of species in genus Cladophora (Chlorophyta, Cladophorales, Cladophoraceae) are marine algae, and these species vertically habitat segregation from the splash zone over the sublittoral zone, so that, the influence of environmental factors such as light, temperature, salinity, and emergence by ebb tide on the physiological activities of algae, are studied with ecological interest (Gordon et al. 1980, Katayama et al. 1985, Katayama and Saitoh 1989).

On the other hand, of genus Cladophora in freshwater, only a few species are known, except for the species known as Cladophora ball, and their physiological features have not been made clear. Cladophora glomerata Kützing, one of the freshwater Cladophora is growing thickly in canals of various district recently. The majority of this algae is growing in several places on the irrigation canal flowing through Towada City and Rokunohe Town of Aomori Prefecture, and has choked off the stream.

In the present report, to establish the fundamental aspects of an analysis of the mechanisms of this algal occurrence, the effects of light and temperature on the algal photosynthetic activity and respiratory activity were investigated.

MATERIALS AND METHODS

The filamentous materials of Cladophora glomerata used in the present investigation were collected from Sanbongi Trunk Canal at Rokunohe in Aomori Prefecture, in November, 1993. These algal samples were cleaned in running water of epiphytes and impurity before measurements.
The photosynthetic and respiratory rates of these algae were determined with a Productmeter, an improved differential gas-volumeter (Yokohama et al. 1986). Photosynthesis- and respiration-temperature curves were measured at various temperatures changed stepwise at intervals of five degree between 5°C and 40°C. In these measurements, photosynthesis was carried out under the illumination of 20klux. A photosynthesis-light curve was taken at seven different illuminations from 0 to 40klux, at the temperature of 20°C. Water temperature was regulated with a Coolnics Circulator (Yamato CTE82W). The light source for the measurement of photosynthesis was a Luminar Ace(Hayashi TKG-56-100) mounted with a halogen lamp(Hayashi JCR15V-150WBC).

RESULTS AND DISCUSSION

Photosynthesis-light relationships

The photosynthesis-light curve of an dry weight basis obtained at 20°C with Cladophora glomerata is shown in Fig. 1. The photosynthetic rate increased linearly at an illumination of less than 5klux, or when saturated by 5klux. Above 5klux, the rate increased gently up to 20 klux exhibiting the maximum rate, and then decreased slightly up to 40klux. The light compensation point was estimated at 140lux from the curve in Fig.1.

It is reported that the light compensation point is lower with green marine algae (Yokohama 1973) and phytoplankton in deep seawater than in shallow seawater. It is known also that within the same alga the light compensation point is lower when the growing temperature becomes low. From this point of view of the low saturation point in C. glomerata, it seems that the photosynthetic nature of this alga is similar to that of green algae growing in

![Graph](image)

Fig. 1. Photosynthesis-light curve at 20°C of Cladophora glomerata measured in November, 1993. The mean ± S.E. for 4 replicates.
deep seawater or at low temperature. But the vertical range in which C. *glomerata* grows in large quantities is a range of 0.5m in water depth where the light qualities do not vary. The optical environment of a place where C. *glomerata* grows is qualitatively and quantitatively different from that of deep seawater. Consequently, it is guessed that the physiological mechanism inducing the low saturation point of C. *glomerata* differs from that of green algae in deep seawater. The present result that this alga shows concerning the low saturation point and low compensation point perhaps signifies that the photosynthetic nature of this alga resembles rather the nature of the terrestrial shade plants.

*Photosynthesis-temperature and respiration-temperature relationships*

Figure 2 shows the net photosynthesis–temperature curve measured at 20klux and the respiration–temperature curve. These were obtained with C. *glomerata* in the temperature range of 5°C to 40°C. The net photosynthetic rate increased sharply in the temperature range between 5°C to 10°C. Above 10°C, the rate increased gently and reached maximum at 25°C. Above 25°C, the rate decreased, followed by linear decreasing up to 40°C where it showed about 0.

The respiratory rate in the dark increased according to the temperature rise within a range of 5°C to 35°C, and decreased slightly at 40°C.
The optimum temperature for photosynthesis of many marine green algae is around 25°C (Yokohama 1973). On the other hand, the optimum for aquatic plants in cold freshwater is 20°C, and that of the plants in shallow water such as *Cabomba caroliniana*, *Ceratophyllum demersum* and *Potamogeton crispus* is 30°C (Saitoh *et al.* 1970). The photosynthesis-temperature curves of these aquatic plants show the curves with sharp peaks at the optimum temperature. The optimum temperature for the photosynthesis of *C. glomerata* was 25°C. And the photosynthetic activity was high within the range of 10–30°C. These results suggest that this green alga in freshwater possesses a large capacity of acclimation over a wide temperature range. By studies on some species of marine *Cladophora*, the algae grown at higher temperature are tolerant to high temperature during its photosynthesis (Katayama and Saitoh 1989, Katayama *et al.* 1985). *C. glomerata* showed high photosynthetic rate at even 30°C, but the rate at 35°C decreased to about 60% of the maximum. It is thought, therefore, that this alga is tolerant to high temperature. It is concluded that large acclimation capacity and tolerance to high temperature of this alga is favorable for growth in an irrigation canal where the water temperature is changeable.

**REFERENCES**


