



Effect of photon irradiance and temperature on growth in four species of *Trentepohlia* (Trentepohliales, Chlorophyta)

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Abstract

Four different species of *Trentepohlia* (*T. diffracta*, *T. abietina*, *T. arborum* and *T. umbrina*) were cultured in modified BBM medium at different light intensity (20, 40, 80 and 120 $\mu\text{mol photons m}^{-2} \text{sec}^{-1}$) and at different temperature (5°C, 15°C, 25°C, 30°C and 35°C). Evaluation of growth was done through dry weight basis which was measured every week after inoculation. Optimum growth (mg/L) was observed at irradiance of 40 $\mu\text{mol photons m}^{-2} \text{sec}^{-1}$, and at 25°C temperature while the lowest growth rate was noted at 120 $\mu\text{mol photons m}^{-2} \text{sec}^{-1}$ and 5°C. In all the four species of *Trentepohlia* log phase started in the third week after inoculation and the growth continued till the sixth week. Comparing amongst the four species growth rate was found to be highest in *T. diffracta* than the other three species. At 40 $\mu\text{mol photons m}^{-2} \text{sec}^{-1}$ in the sixth week, the dry weight of *T. diffracta* was 250 mg/L.

Keywords: *Trentepohlia*, photon irradiance, temperature and growth

Introduction

Microalgae are autotrophic organism that absorbs light energy and inorganic nutrients and produces biomass rich in lipids, carbohydrates, proteins and pigments (Markou and Nerantzis, 2013)^[1]. The growth of microalgal population depends on three abiotic factors *viz.* sufficient light, favourable temperature and inorganic nutrients such as nitrogen, phosphorus and carbon (Bold and Wynne 1978)^[2]. Among these factors, the light that directly influences photosynthesis mechanism is an important factor in defining optimal conditions for the culture (Falkowski *et al* 1985)^[3]. In the presence of non-limiting nutrients, the efficiency of microalgal culture remained controlled mainly by the intensity of light and favourable temperature (Bouterfas *et al* 2006)^[4]. In addition to light, temperature also affected the photosynthetic activity and the growth of microalgae (Coles and Jones 2000)^[5].

East Khasi Hills District is the central parts of Meghalaya with Shillong as its state headquarter. It covers a total area of 2,748 km² and lies approximately between latitudes 25°07' to 25°41' N and longitude 91°21' to 92°09' E. East Khasi Hills District experiences a subtropical highland climate, where summer is cool and rainy with an average total rainfall of more than 2100 mm annually, while winter is usually cold and dry. This region harbour luxuriant growth of subaerial algae the dominant genera being *Trentepohlia*, hence orange yellowish coloured patches are seen on tree barks, cemented walls and rocks. Species of *Trentepohlia* had been widely studied for its taxonomy, but very less was concentrated on its physiology and behaviour in culture. A few reports are available on growth and development of different species of *Trentepohlia* in culture (McCoy 1977^[6]; Lee *et al* 1990^[7]; Abe *et al* 1998^[8]; Chen *et al* 2014^[9]). Hence this work was carried out to study the growth pattern and biomass production of four different species of *Trentepohlia* grown at different light intensity and temperature.

Materials and Methods

Collection of Algal samples

Four dominant species of *Trentepohlia* were collected in Shillong, which lies approximately between latitudes 25°07' to 25°41' N and longitude 91°21' to 92°09' E from four different substrata *viz.* *Trentepohlia diffracta* (Krempelhuber) Hariot from cemented wall, *Trentepohlia arborum* (C. Agardh) Hariot from rock surface, *Trentepohlia umbrina* (Kützinger) Bornet from iron electric pole (since it was difficult to segregate *T. umbrina* from other groups of algae growing along with it on bark of trees, hence it was collected from an electric pole where the growth of other groups were negligible) and *Trentepohlia abietina* (Flotow) Hansgirg was collected from bark of *Eucalyptus* tree.

Inoculation of algal samples

Equal colony of the alga from pure culture was inoculated in the conical flasks (triplicates) containing modified BBM medium (Abe *et al* 2008)^[10]. These were then kept in the culture rack at 20, 40, 80 and 120 $\mu\text{mol photons m}^{-2} \text{sec}^{-1}$ provided by cool fluorescence light and photoperiod of 16:8 light and dark periods to examine the effect of photon irradiance on growth of each species of *Trentepohlia*. Similarly in order to study the effect of temperature on four species of *Trentepohlia* the conical flasks (Triplicates) were kept in an incubator at different temperature (5°C, 15°C, 25°C, 30°C and 35°C) at 40 $\mu\text{mol photon m}^{-2}\text{s}^{-1}$ and photoperiod of 16:8 light and dark periods.

Measurement of algal growth

To evaluate the growth of the four species of *Trentepohlia* at different light intensities and temperatures dry weight was measured every week after inoculation till the 5th week. At the end of each week the cultures were filtered on pre-weighted filter papers and washed with distilled water. Then the filter papers were oven dried at 100°C for 2 h and their weight was again taken. The mean dry weight of triplicate samples was reported in milligrams.

$$\text{Growth (mg/L)} = W_2 - W_1$$

Where, W_1 = weight of filter paper and W_2 = weight of filter paper with algae.

Results

Effect of photon irradiance on growth in four species of *Trentepohlia*

The four species of *Trentepohlia* showed optimum growth at irradiance of $40 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$, while the lowest growth rate was noted at $120 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$. In all the four species of *Trentepohlia* log phase started in the third week after inoculation and the growth continued till the sixth week. Growth rate was highest in *T. diffracta* compared to the other three species. At $40 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$ in the sixth week, the dry weight of *T. diffracta* was 250 mg/L and in *T. abietina* it was 200 mg/L. Minimum growth in culture was observed in *T. arborum* (Figure 1.1 to Figure 1.4).

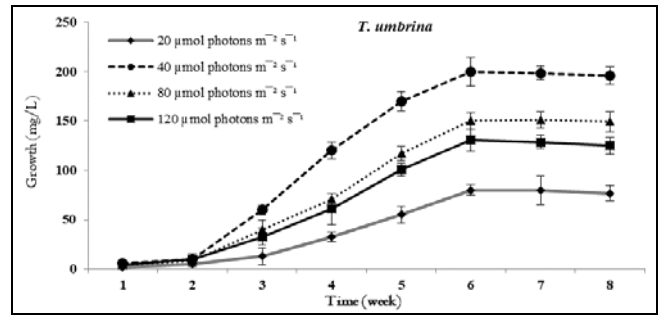


Fig 4: Effect of different photon irradiance on growth of *Trentepohlia umbrina*

Effect of temperature on growth in four species of *Trentepohlia*

Growth (mg/L) in four species of *Trentepohlia* was optimum at 25°C , by increasing and decreasing the temperature beyond 25°C , growth of *Trentepohlia* decreased significantly. Log phase started in the third week after inoculation and the growth continues till the sixth week in all the four species and lower growth rate was observed at lowest temperature of 5°C . Comparing amongst the four species, *T. diffracta* showed better growth rate at different temperature and followed by *T. abietina*. Lowest growth rate was exhibited by *T. arborum* (Figure 2.1 to Figure 2.4).

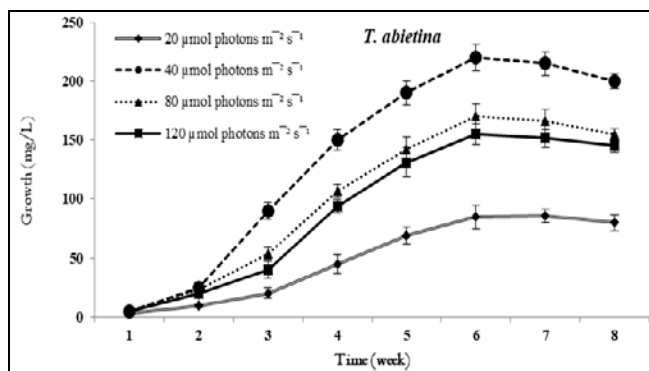


Fig 1: Effect of different photon irradiance on growth of *Trentepohlia abietina*

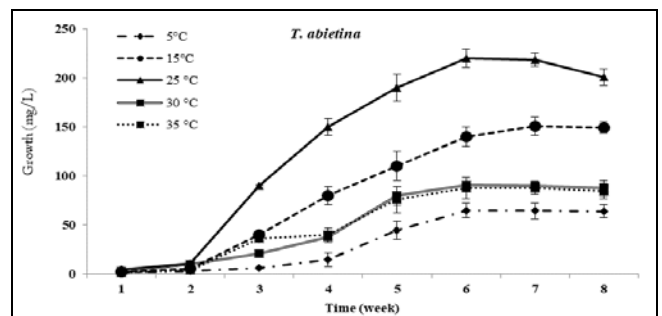


Fig 5: Effect of different temperature on growth of *Trentepohlia abietina*

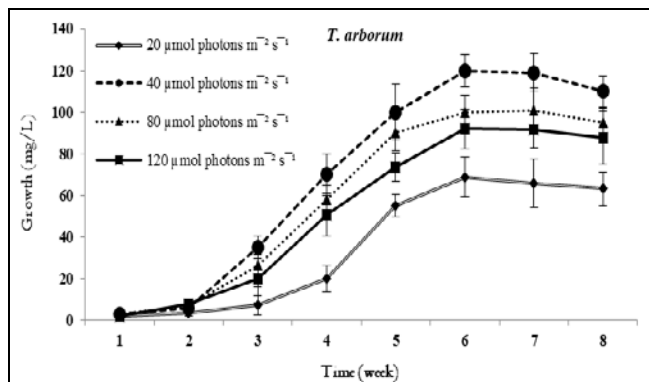


Fig 2: Effect of different photon irradiance on growth of *Trentepohlia arborum*

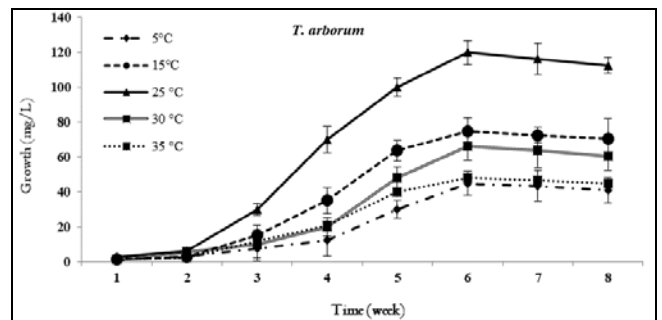


Fig 6: Effect of different temperature on growth of *Trentepohlia arborum*

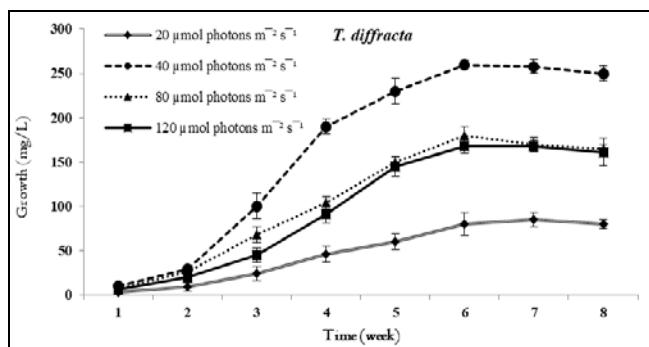


Fig 3: Effect of different photon irradiance on growth of *Trentepohlia diffracta*

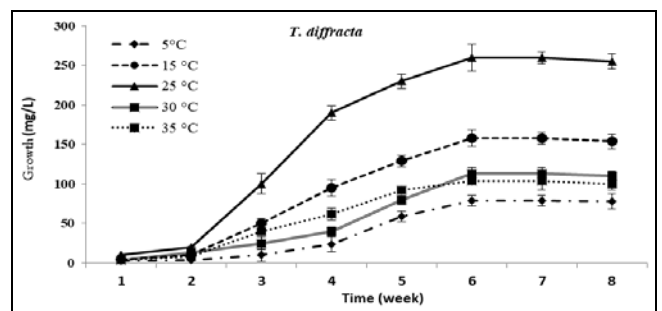


Fig 7: Effect of different temperature on growth of *Trentepohlia diffracta*

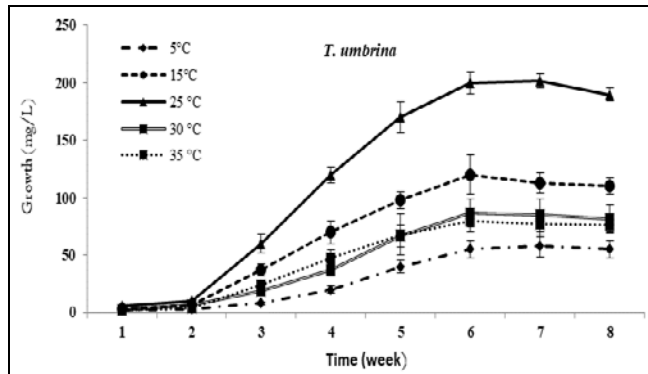


Fig 8: Effect of different temperature on growth of *Trentepohlia umbrina*

Discussions

Effect of different photon irradiance and temperature could be observed on growth of four species of *Trentepohlia*. Optimum growth rate in this study was observed on culture kept at $40 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$ irradiance and 25°C temperature. With increase in photon irradiance and temperature growth of *Trentepohlia* decreased significantly, similarly low growth rate was observed at lower temperature and lower light intensity. This signifies that $40 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$ and 25°C are the optimum irradiance and optimum temperature for better growth of the four species of *Trentepohlia* in culture. The significant decrease in growth rate at highest photon irradiance could be due to photoinhibition which resulted in decreased rate of photosynthesis and consequently led to decline in biomass production and on the other hand lower light intensity led to lower light requirements essential for growth of *Trentepohlia*. In microalgae, low irradiance could limit photosynthesis (Dunstan 1973)^[11] but high irradiance caused photoinhibition (Neidhardt *et al* 1998)^[12]. In addition to light, temperature also affected the photosynthetic activity and the growth of microalgae (Coles and Jones 2000)^[5]. Optimum temperature of 25°C had been reported for many microalgae and some species of *Trentepohlia* as well. Abe *et al* (1998)^[8], reported that the optimum irradiance of *T. aurea* was at $43 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$ and optimum temperature to be 25°C . They also demonstrated significant decrease in growth rate by decreasing and increasing the temperature below and beyond 25°C in *T. aurea*. Similar trend could be observed in the present case as well. According to many authors, the negative effect of suboptimal growth temperature on algal metabolism and efficiency got strengthened when low temperatures were accompanied by high irradiances (Sorokin and Krauss 1962^[13]; Spearing and Karlander 1979^[14]; Vonshak *et al* 2001^[15]; Vonshak and Torzillo 2004^[16]). Similarly growth of all four species of *Trentepohlia* was inhibited at suboptimal temperature as well as at high temperature in this study. Magana and Villareal (2006)^[17], reported that the optimum temperature for growth in a dinoflagellate *Karenia brevis* as 15°C - 30°C , the growth rate increased when the irradiance was increased from 31 to $67 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$, and the growth rate reduced significantly at temperature below 15°C . Several workers demonstrated that biochemical processes are temperature-sensitive and at temperatures deviating far from the optimum, the absorbed light energy could not be converted into carbohydrates efficiently. Moreover at low temperatures the turnover of enzymes was reduced, and thus

the metabolic activity of the algae became lower which led to a lower growth rate and a reduced need of substrate (Dauta *et al* 1990; Huner *et al* 1998; Coles and Jones 2000)^[18, 19, 5].

Conclusion

Effect of different photon irradiance and temperature could be observed on growth of four species of *Trentepohlia*. Optimum growth rate in this study was observed on culture kept at $40 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$ irradiance and 25°C temperature. This signifies that $40 \mu\text{mol photons m}^{-2} \text{sec}^{-1}$ and 25°C are the optimum irradiance and optimum temperature for better growth of the four species of *Trentepohlia* in culture. Overall, *T. diffracta* and *T. abietina* showed better growth rate compared to *T. umbrina* and *T. arborum*.

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