Evaluation of Relationship between Light Intensity (Lux) and Growth of Chaetoceros muelleri

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Abstract

Microalgae have the most significant contribution towards the global environment, oxygen production and carbon cycle consequently understanding marine microalgae is vital. Hence the factors that affect the growth should be considered and studied in advance before the culturing of these algae. Photosynthesis is most important in plant growth. Thus this study tries to find out the optimum light intensity (Lux) required for achieving maximum yield of Chaetoceros muelleri in a laboratory culture.

The inoculation of the algae was done under controlled environment where the cells were counted and assumed to be the same for all. The pure strand of C. muelleri with f2 media (8 sets of 3 flasks) were placed in front of the light source at lux values of 0 lux, 500 lux, 1000 lux, 1500 lux, 2000 lux and 2500 lux. The cell count was the basic result that was collected. At every 24 hours cells were counted and readings were recorded.

The experiment lasted 7 days. The result showed that there was significant growth that is the number of cells increased exponentially as the Light intensity (lux) increased till the culture was exposed to a 1000 lux where maximum cells were counted during the culture period (168 hours). From previous studies it was evident that the optimum light intensity for flask culture in laboratory was 1000 lux. However, results from the experiment show that the cell growth with 1500 lux is very close and similar to 1000 lux. Some recommendations after the experiment are; that there is very little literature on the above topic and that this area requires a lot more attention as Fiji’s Aquaculture Industries are blooming thus there is a need for further research and study around the same area.

Keywords: Microalgae; Lux; Chaetoceros muelleri

Introduction

Microalgae are defined as minute photosynthetic plants and can be found in both seawater and freshwater [1]. These have similar properties as land based plants but they have to be submerged in an aqueous environment where they have efficient access to water, carbon dioxide and other nutrients.

Nowadays, there are several marketable applications of microalgae; some of which include (i) they are used to enhance the nourishing value of food and animal feed owing to their chemical composition, (ii) they play a crucial role in aquaculture and (iii) they can be assimilated into cosmetics. Moreover, they are cultivated as a source of highly valuable molecules [2]. Microalgae are also used in the production of pharmaceuticals, diet supplements, pigments and biofuel [3] and represent the largest, yet one of the most poorly understood groups of microorganisms on earth [4]. A handful of microalgae species out of the many that have been found are mainly cultivated for live aquaculture feed and Chaetoceros muelleri [5] is one of them.

The hypothesis for this experiment is to find whether light is required to culture Chaetoceros muelleri. Secondly to examine the amount of light required to give the maximum yield of the product. Also show the relationship between the amount of light required and the growth rate of Chaetoceros muelleri.

Microalgal culture has to be conducted under specialised conditions as explained by Coutteau [6]; the most important parameters regulating algal growth are nutrient quantity and quality, light, pH, turbulence, salinity and temperature. Concentrations of cells in phytoplankton cultures are generally higher than those found in nature. Algal cultures must therefore be enriched with nutrients to make up for the deficiencies in the seawater. Macronutrients include nitrate, phosphate and silicate. Here the paper describes the general set for culturing Microalgae: Temperature 16-27°C, Salinity 12-40g/l and Light Intensity (lux) 1,000-10,000 lux depending on the volume of culture.

As with all plants, microalgae photosynthesize, i.e., they assimilate inorganic carbon for transformation into carbon-based matter. Light is the source of energy which drives this reaction and in this regard intensity, spectral quality and photoperiod need to be considered. Light intensity plays an vital role, but the necessities fluctuate critically with the culture penetration and the density of the algal culture: at higher depths and cell concentrations the light intensity must be increased to penetrate through the culture 1,000 lux is suitable for Erlenmeyer flasks, 5,000-10,000 lux is required for larger volumes [6]. Light may be natural or supplied by fluorescent tubes. Too high light intensity (e.g. direct sun light, small container close to artificial light) may result in photo-inhibition. Also, overheating due to both natural and artificial illumination should be avoided. The duration of artificial illumination should be minimum 18h of light per day, although cultivated phytoplankton develops normally under constant illumination [7].

Background

Chaetoceros is probably the largest genus of marine planktonic
Materials and Methods

The experiment was carried out in the laboratory of the School of Marine Studies, University of the South Pacific (USP), Suva, Fiji.

Experimental organisms (C. muelleri)

A pure 20 ml sample of C. muelleri was purchased from Australian National Algae Culture Collection (ANACC), CSIRO in Tasmania, Australia with the assistance of the USP Laboratory Technician.

Glassware preparation

The glassware used in this experiment was cleaned and washed with detergent and autoclaved on programme A (121°C and 20 psi) as provided on the autoclave for 15 minutes.

Water treatment

Seawater was strained using 1 µm (micro meter) cartridge filter and used for the preparation of the Media and Stock solution. After filtration the water was passed a Life Guard Ultra Violet Steriliser (Model no. - QL 40) that uses a 40 watt UV sterilizer bulb. All the above was done in the Aquaculture Laboratory (Wet Lab).

F/2 media preparation and modification

The procedures used to prepare the F/2 Media and also the Modification of F/2 media were followed from Guillard [11]. 75 g of NaNO3 and 5g of NaH2PO4 H2O were dissolved in 1 litre of filtered sea water and this was labelled as Solution A. Trace Metals was labelled Solution B, Silicates was labelled solution C. 1 ml of solution B and C was used for every litre of media. Vitamins were labelled Solution D and 0.5 ml of this solution was used for every litre of media.

Inoculation

A sample of pure C. muelleri is placed in a controlled environment for it to grow or reproduce. For this experiment the procedure used was adapted from Probert and Klaas [12] was followed. 100 ml of the F/2 media that was prepared earlier was filled into 250 ml Conical culture flasks which were covered using corks and aluminium foil. The prepared flasks were autoclaved under Programme A. After the Autoclave the flasks were removed and left overnight to cool in the algae room. All the flasks were inoculated with 10% of inoculum (C. muelleri) in the Laminar Flow cupboard. The cabinet was cleaned with 70% ethanol. The pippttes and micro pipettes were also autoclaved [13]. The Nitrile hand gloves used are to be sprayed with 70% ethanol and will be worn while inoculating. The mouth of the culture flask was sterilised by moving over a Bunsen burner flame.

Experimental setup

After the inoculation the rubber corks were bored to make holes and the glass tubing were inserted for the inlet (3-4 mm) and exhaust (2-3 mm) were placed to seal the mouth. The above setup was prepared in the laminar flow cabinet to avoid contamination. Once the inlet and exhaust lines are fixed the flasks were ready for setup in the algae room. Some of the parameters that were kept constant were; temperature at 18°C, preferred pH of 7-9 with reference to FAO, Instrumental Paper, 1999, salinity was between 20-35 ppt, Aeration was controlled by opening or closing the switch valves linked to the inlet line and the cell starter culture the cells were calculated in terms of cells/ml.

The variable

The variable in the experiment is the lux that is a standardized unit of measurement of the light intensity (which can also be called “illuminance” or “illumination”) - as an example for reference purposes. One lux is equal to one lumen per square metre [14]:
The average cell count for the three treatments.

<table>
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<th>Cell Count T1</th>
<th>Cell Count T2</th>
<th>Cell Count T3</th>
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<td>0.2</td>
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<td>2.483333</td>
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</tbody>
</table>

Table 1: The average cell count for the three treatments.
the other necessary factors that were kept constant. This experiment showed the effect of light on the growth of \( C. \) \textit{muelleri} which was only one factor. There are further studies required in the similar areas. Once there is a better understanding of the culture of microalgae at a small scale, this could be used in the mass culture and used in the developing aquaculture industry in Fiji and the Pacific Islands.

### Conclusion

This study examined the amount of light intensity required to give the best yield of \( C. \) \textit{muelleri} in a laboratory culture. From the experiment carried out and the data analysis it may be concluded that the 1000 Lux is the optimum lux to produce the best yield. This is supported by the literature. It was noticed that as light intensity increased the growth of \( C. \) \textit{muelleri} increased significantly to a limit at 500 lux, 2000 lux and 2500 Lux where the growth rate slowed. This could be due to the either the decrease in the nutrient level in the flask or due to too less or over heat of the flask.

The relationship between light intensity required and the growth rate of \textit{Chaetoceros muelleri} was also studied (Figure 1). Light is required for the growth of microalgae on the other hand too much light and too little light can slow the growth rate [17,18]. Thus the experiment indicated that 1000 lux to 1500 lux is the best light intensity in order to produce maximum yield.

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### References


