



Light And Nutrient Factors In The Growth Rate Of Microalgae: A Review

Anshah Silmi Afifah¹, Gita Prajati², Yosef Adicita³, Yura Witsqa Firmansyah⁴.

^{1,2,3} Environmental Engineering Study Program, Faculty of Engineering, Universal University, Indonesia
Corresponding autor: Email : anshah.silmi@gmail.com

⁴ Environmental Health Master Study Program, Faculty of Public Health, Diponegoro University, Indonesia.
Corresponding autor: Firmansyahyura@gmail.com

Article details:

Received: 13th September 2020

Revision: 18th September 2020

Accepted: 21th September 2020

Published: 30th September 2020



Abstract

Microalgae have the highest efficiency in capture and exploit sunlight in the process of photosynthesis. The use of microalgae is very good in replacing raw materials for motorized vehicles and is useful for mitigating global warming problems. Because of this potential, the

growth rate of microalgae must be considered properly for population stability. Factors such as light and nutrient provision are important components that must be considered in the growth rate of microalgae. This study aims to determine the light and nutrient factors that affect the growth rate of microalgae. This study uses a literature review method with a narrative approach, secondary data obtained from articles, journals, or scientific papers accessed through an online database. The results of this study, light factor and nutrients have an important role in the growth rate of microalgae

Keywords: microalgae, light, nutrient

To cite this article :

Anshah Silmi Afifah, Gita Prajati, Yosef Adicita, Y. W. F. (2020). Light And Nutrient Factors In The Growth Rate Of Microalgae: A Review. *International Journal of Health, Education and Social (IJHES)*, 3(9), 72–80.



Introduction

Microalgae are one of the plants that have the highest efficiency in capturing, utilizing solar energy and CO₂ in the photosynthesis process (Kimball, 1983). Microalgae are included in a group of small plants, both uni-cellular or multicellular and living in colonies, which can be found in freshwater or marine waters. Microalgae can be classified into several phyla including Cyanobacteria (blue green), Chlorophyta (green), and Chrysophyta (brown-gold) (Mety, 2013).

Microalgae have good potential as raw material for bioenergy production as well as being an alternative solution that can be used to mitigate global warming by substituting engineered vehicle raw materials. Microalgae have a source of biomass with the components contained therein which have high benefits such as protein, carbohydrates, fatty acids, etc. The main component of microalgae that can be used as biofuel is triglycerides, 14 species of microalgae have the potential to produce biodiesel with oil contained in them ranging from 15-77% dry weight (Christi, 2007). Triglycerides in microalgae can be converted into biodiesel or fatty acid methyl ester (FAME) through a transesterification reaction with methanol using acid, base or enzyme catalysts. This reaction can be carried out in two ways,

The growth rate of microalgae is influenced by several factors, including light, and nutrients. Light becomes a source of energy in the photosynthetic process which is useful for the formation of organic carbon. Exposure and light intensity determine the growth rate of microalgae based on the length of exposure and the type of wavelength used for photosynthesis. Light plays an important role in the growth rate of microalgae, but the needs vary based on the level of culture depth and density.

The nutrients in microalgae are very dependent on the conditions in which they live. Nutrients from seawater contain elements that are quite complete for microalgae, but are different from microalgae that live in fresh water. Freshwater and seawater nutrients have different nutrient content. The purpose of this study was to determine the factors that affect the growth rate of microalga.

Methods

This study uses a literature review method with a narrative approach. Secondary data sources used come from journals, articles, scientific papers accessed from online databases such as Google Scholar, Garuda Dikti Journal Portal, Science Direct, Pubmed, etc.

Results and Discussion

Factors that Affect Microalgae Growth Rate

Light

Table 1. Literature review used in light factors

Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine 2009	Specific Growth Rates of Chlorella sp. And Dunaliella sp., Based on Differences in Nutrients and Photoperiod
Rivi Febriani, Saberina Hasibuan, and	Effect of Different Light Intensities on



Syafriadiman 2019	Density and Carotenoid Content of Dunaliella salina
Doni Putra Pradana, Berta Putri, Siti Hudaiah 2017	Effect of Light Intensity on Growth and Carotenoid Content of Dunaliella sp. in Leaf Extract Media of Lamtoro Leucaena leucocephala

The first research from Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine 2009 with the title "Specific Growth Rate of Chlorella sp. And Dunaliella sp, Based on Differences in Nutrients and Photoperiod" (5) with the following research results:

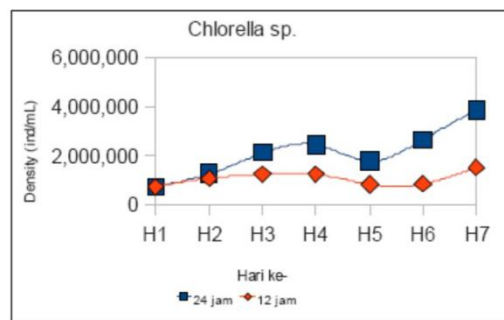


Figure 1. Graph of Chlorella sp. in Different Photoperiod Treatments (Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine, 2009)

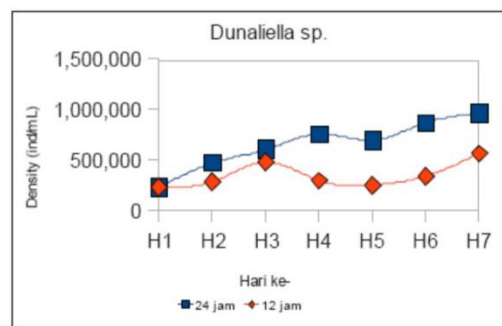


Figure 2. Growth Graph of Dunaliella sp. in Different Photoperiod Treatments (Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine, 2009)

Figure 1 shows that the highest final density of Chlorella sp. There was a 24-hour light treatment with a value of 3 859 747 ind / mL with an average k value of 0.39 / day. The final density at 12 hours light treatment was 1,498 930 ind / mL with an average specific growth rate of 0.171 / day. Meanwhile, Figure 2 shows that the highest final density is Dunaliella sp. In this study, there was a 24 hour light treatment with a value of 971 805 ind / mL and an average specific growth rate of 0.329 / day. The final density obtained in the 12-hour light treatment was 573 799 ind / mL and the average specific growth rate was 0.206 / day. (5)



The study explained that light is a factor that influences the growth rate of microalgae, although in the process of a time period of 12 hours of exposure, light intensity still experiences microalgae growth, although not as large as a 24 hour period. In this study, there should be a control variable, namely microalgae that are not treated with light exposure so that later they have a difference between the light intensity of the 24-hour, 12-hour period and without light. The study also did not explain the wavelengths used in the experiment, and there was no known cause for the decrease on the fifth day.

The second study by Rivi Febriani, Saberina Hasibuan, and Syafridiiman 2019 entitled "The Effect of Different Light Intensities on Density and Carotenoid Content of *Dunaliella salina*" with the following research results:

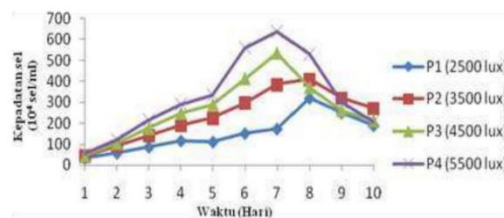


Figure 3. Graph of Average *D. salina* at Peak Density. (Rivi Febriani, Saberina Hasibuan, and Syafridiiman, 2019)

Figure 3 explains that the results of observations of cell density for 10 days show that the highest average density of *D. salina* cells is found on day 7 with light intensities of 4,500 lux (P3) and 5,500 lux (P4). This is because high light intensity takes a short time to reach peak density. Whereas at P1 (2,500 lux) and P2 (3,500 Lux) the peak density occurs on the 8th day, this is because low light causes a slow growth rate which results in low density (Rivi Febriani, Saberina Hasibuan, and Syafridiiman, 2019)

The study did not describe how the *D. salina* microalgae had a difference in the highest peak growth of cell density P1 and P2 experienced the highest growth peak on the seventh day, while P3 and P4 experienced the highest growth peak on the eighth day with the same light intensity treatment.

The third research from Doni Putra Pradana, Berta Putri, Siti Hudaiah 2017 with the title "The Effect of Light Intensity on Growth and Carotenoid Content of *Dunaliella* sp. in the Leaf Extract Media of *Lamtoro Leucaena leucocephala* ", with the following research results:

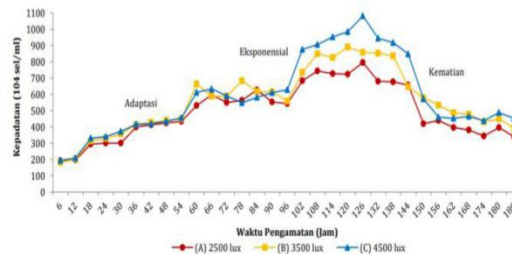


Figure 4. Graph of culture growth of *Dunaliella* sp. (Doni Putra Pradana, Berta Putri, Siti Hudaiah, 2017)

The results of statistical tests showed that the density of microalgae *Dunaliella* sp. During culture, there was no effect of light intensity treatment on the lamtoro leaf extract medium used. The results of statistical tests in the adaptation phase and the death phase had no effect, but in the exponential phase showed the effect of the light intensity treatment given, the LSD test results ($p < 0.05$) showed that the exponential phase during the treatment culture (A), treatment (B) and treatment (C) are different from each other.

This study has a good control variable with the application of three phases in observing microalgae growth. However, the death phase occurs in the absence of protection or security from disturbing variables, namely temperature, pH, and sanitation. In this study, based on statistical tests, in the adaptation and death phases, the absence of influence between the light intensity treatments provided did not explain the supporting theory of how this could happen.

The three studies are in line with the research of Ho et. al. 2012 biomass will continue to increase production of light intensity until it reaches a saturation point of about $420 \mu\text{mol} / \text{m}^2 / \text{second}$, with a maximum biomass production of $840.56 \text{ mg} / \text{L} / \text{day}$ and carbon absorption of $1435.90 \text{ mg} / \text{L} / \text{day}$. The formation of biomass and carbon fixation processes really need light, so light is the main component needed by microalgae to experience growth

Nutrients

Table 2. Literature Review used in nutrient factors

Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine 2009	Specific Growth Rates of <i>Chlorella</i> sp. And <i>Dunaliella</i> sp., Based on Differences in Nutrients and Photoperiod
Jin, HF, BL Ma, K. Lee. 2006.	Influence of nitrate feeding on carbon dioxide fixation by microalgae
Widianingsih, Retno Hartati, H. Endrawati, Ervia Yudiati, Valentina R. Iriani. 2011	The Effect of Reducing the Concentration of Phosphate and Nitrate Nutrients on the Total Lipid Content of <i>Nannochloropsis oculata</i>



The first research from Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine 2009 with the title "Specific Growth Rate of Chlorella sp. And Dunaliella sp., Based on the difference between nutrients and photoperiod "(5) with the following research results:

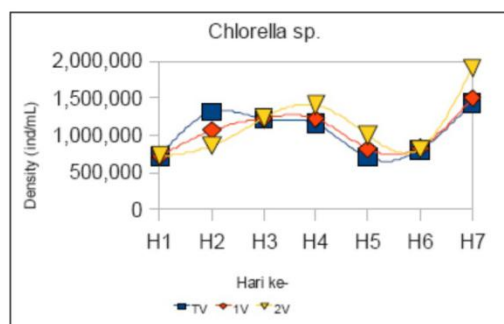


Figure 5. Growth Graph of Chlorella sp. on the Difference in Nutrient Concentration (Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine 2009).

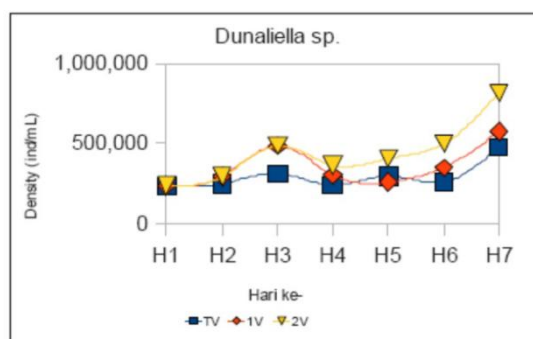


Figure 6. Growth chart of Dunaliella sp. at different nutrient concentrations (Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine 2009).

Figures 5 and 6 are the results of observing the effect of different nutrient concentrations on the growth of microalgae Chlorella sp. and Dunaliella sp. The highest final density observed in the treatment of nutrient concentrations on the growth of Dunaliella sp. contained in the provision of nutrients every two days (2V) with a final density of 817 321 ind / mL and an average growth rate of 0.289 / day. The lowest final density was found in the treatment without nutrients (TV), namely 476 900 ind / mL and an average growth rate of 0.163 / day (Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine, 2009).

This research is very good in providing nutrient treatment with control, namely without giving nutrients (TV). However, on the growth of microalgae Chlorella sp. and Dunaliella sp. with the provision of nutrients once a day (1V) the growth rate is smaller compared to the provision of nutrients every two days (2V), it is not described how the process and theoretical



support. The type of nutrient used is also not described as the elements needed for the growth rate of microalgae.

Jin et. al. in his research explained that giving nitrate in a concentration of 15-20 ppm can increase cell density and extend the exponential phase time for 3 days. Giving nitrogen and phosphorus nutrients are the two best elements in the growth rate of microalgae. Widianingsih et. al. In this study, the biomass productivity and total lipid levels in *N. oculata* were influenced by nutrient levels.

Conclusion and Recommendation

Light factor and nutrient provision are important components in the growth rate of microalgae. Light as an energy source can help the photosynthesis process of the sun for the formation of organic carbon. Provision of nutrients can increase biomass productivity and total lipid levels in microalgae.

Acknowledgments

Acknowledge to DIKTI (Ministry of Education and Culture of The Republic of Indonesia) who has been willing to finance this research.



International Journal of Health, Education and Social (IJHES)



References

- Kimball, JW 1983. Biology. Translated by Soetarmi. S. T and Sugiri, N. Jakarta: Gelora Aksara Pratama
- Mirojiah, Mety. 2013. "Classification of Microalgae by Phylum". (online) diakses on 25 May 2014
- Christi Y., 2007. Biodiesel from Microalgae. Institute of Technology and Engineering, Massey University. *Biotechnology Advances* 25 (2007) 294-306.
- Milano J., Ong HC, Masjuki H., Chong WT, Lam MK, Loh PK, Vellayan V., Microalgae Biofuels as an Alternative to Fossil Fuel for Power Generation. *Renewable and Sustainable Energy Reviews*, 2016, 5, 180–197.
- Mujizat Kawaroe, Tri Prartono, Adriani Sunuddin, Dahlia Wulan Sari, Dina Augustine. 2009. Specific Growth Rate of *Chlorella* sp. and *Dunaliella* s., Based on Differences in Nutrients and Photoperiod. *Surfactant and Bioenergy Research Center*, Bogor Agricultural University.
- Rivi Febriani, Saberina Hasibuan, and Syafriadiman. 2019. The Effect of Different Light Intensities on Density and Carotenoid Content of *Dunaliella salina*. *Journal of Fisheries and Marine Affairs* Volume 25 No. 1, February 2020: 36-43.
- Doni Putra Pradana, Berta Putri, Siti Hudaidah. 2017. The Effect of Light Intensity on Growth and Carotenoid Content of *Dunaliella* sp. in Leaf Extract Media of Lamtoro *Leucaena leucocephala*. *Scripta Biologica* Volume 4 Number 4 December 7 263–267.
- Ho, SH, CY Chen, and JS Chang. 2012. Effect of light intensity and nitrogen starvation on CO₂ fixation and lipid / carbo-hydrate production of an indigenous microalgae *Scenedesmus obliquus* CNW-N, *Biores. Technol.*, 113: 244–252.
- Jin, HF, BL Ma, K. Lee. 2006. Influence of nitrate feeding on carbon dioxide fixation by microalgae. *J. Environ. Sci. Health.*, 41: 2813–2824.
- Widianingsih, Retno Hartati, H. Endrawati, Ervia Yudiati, Valentina R. Iriani. 2011. The Effect of Reducing the Concentration of Phosphate and Nitrate Nutrients on the Total Lipid Content of *Nannochloropsis oculata*. *Marine Science* March 2011. Vol. 16 (1) 24-29
- of *Nannochloropsis oculata*. *Marine Science* March 2011. Vol. 16 (1) 24-29