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EFFECT OF LIGHT INTENSITY ON THE PERFORMANCE PROFILE OF SPIRULINA PLATENSIS CULTIVATED IN FCBATMOSPHERIC PHOTOBIOREACTORS 2022

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ABSTRACT

This research was carried out at the Limnology and Water Resources Research Center, National Research and Innovation Agency (BRIN KST Sukarno Bogor). The research was carried out in August-October 2022. This research was intended to determine the optimal light intensity to produce maximum Spirulina platensis biomass, with culture conditions using Zarouk medium modified for trace elements and cultured in a hybrid photobioreactor (combination of flat panel and bubble column) , the light source used is an LED lamp with the light intensity used in this study is 300 µmol/(m^2.s) and 200 µmol/(m2.s), the light photoperiod is 24 bright. The parameters studied were Optical Density, biomass concentration, specific growth rate of biomass, biomass productivity, Total Nitrogen (TN) of Biomass and Medium, and Total Phosphate (TP) of Biomass and medium. Cultivation lasted for 11 days, after the data was obtained the Paired T analysis test was used using Microsoft Excel 2019 with a confidence level of 95%. The results showed that the light intensity treatment of 300 µmol/(m 2.s) was the best under conditions of supporting parameters pH ± 9, DO ± 9, and temperature ± 25oC, resulting in an average biomass concentration of 0.208 g/L, an average Optical Density of 0.232, an average rate of specific biomass growth 0.393 divisions/day, average biomass productivity 0.05 g/l/d, the average TN Biomass is 63,508 mg/g, TP Biomass is 8,757 mg/g. Meanwhile, the absorption of TN Medium 0.876 g/L and TP Medium 4.258 g/L showed higher results at a light intensity of 200 µmol/(m 2.s).

Keywords: Spirulina platensis, Light Intensity, Photobioreactor, Optical Density, Biomass Concentration, Biomass Productivity, TN, TP.

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1. INTRODUCTION

Spirulina platensis is the oldest algae on earth that lived around 3.6 billion years ago (Soni *et al.* 2017). *Spirulina platensis* was first discovered by Spanish scientist Hernando Cortez and the Conquistadors in 1519 during research at Lake Texcoco in the Valley of Mexico. Meanwhile, the first person to suggest that *Spirulina platensis* had benefits in the world of health was Pierre Dangeard by researching flamingos which were able to survive by consuming blue-green algae, which was then commercialized by a botanist named Jean Leonard with the first spirulina processing factory in France in 1969 (Ugwu et al. 2008; Soni et al. 2017). *Spirulina platensis* is generally found in sea water, fresh water and brackish water. This microalgae has high adaptability with its resistance to salt concentrations reaching 30 g/L and alkaline lake conditions with a pH reaching 11 (Silke *et al. Spirulina platensis* has the ability to survive and grow under quite extreme pressure and conditions, with a multitude of potential, of course this makes S platensis a commodity that should be developed in the future (Barka and Blecker, 2016).

Spirulina platensis is currently used in various aspects of biotechnology development such as biofuels, biostimulants, food crops and waste water treatment. In the world of production, *S. platensis* is used as a functional food product referring to its contents as listed in table 1 and other contents such as pigments, fatty acids and lipids which are generally widely used as cosmetics, medicines and fuel production (Soni *et al.* In recent years, *Spirulina platensis* has had great opportunities in the world of algae products which are generally used as medicines, food supplements and natural feed for several aquatic organisms. The annual demand for *Spirulina platensis* has increased by 5.8% from 2017 until it is predicted that it will continue to increase in 2026 (Silke *et al.* Therefore, development in the field of *Spirulina platensis* culture must continue to be developed considering its enormous and promising potential in the future. Spirulina is a microalgae that is widely cultivated in the world, accounting for more than 30% of world microalgae biomass production (Costa et al. 2019). *Spirulina platensis* cultivation can be done by paying attention to several optimal conditions for its cultivation such as temperature, light intensity, nutrients, pH, and the presence of carbon dioxide. Choosing the right light intensity in research is also an important thing to pay attention to, namely by paying attention to the light flux and wavelength range that is suitable for carrying out the photosynthesis process. Some specific organisms will have conditions for the optimal amount of light intensity, how long the light exposure is, and what range of light wavelengths to use. During the growth period, *Spirulina platensis* requires a light intensity range of 20,000 – 30,000 lux with a photoperiod of 12 hours to 16 hours per day. 24 hour light exposure to *Spirulina platensis* cultures will be dangerous because this condition will disrupt several chemical reactions, including protein synthesis and the *Spirulina platensis* respiration process, which takes place during the dark period (Soni *et al*. 2017). Several studies have proven that light intensity affects the growth rate of microalgae. Research conducted by Padang *et al.* (2013), that treatment with a light intensity of 15,000 lux gave the highest peak cell density in cultivating Navicula sp. compared to light intensity treatments of 10,000 lux and 5000 lux. Sinaga et al. (2020), stated that the higher the light intensity will result in the growth rate of Nannochloropsis sp. which is getting lower. According to Peri *et al.* (2009), light intensity that is too high (11,700 lux) will reduce cell density compared to light intensity of 7,400 lux and 3,400 lux, this is because light intensity that is too high will affect the increase in temperature and salinity so that phytoplankton have problems in growth which results in at low cell population density.

Therefore, this research aims to find out and determine the best light intensity used in the *Spirulina platensis* cultivation process, both biomass production and Total Nitrogen (TN) and Total Phosphate (TP) uptake.

2. RESULT / EXPERIMENTAL (MATERIALS AND METHODS)

2. 1. Materials and Methods

This research is a collaboration between the Department of Chemical Engineering ITB and Pusris Limnology and Water Resources BRIN KST Soekarno, with the aim of obtaining optimal and cheap growing media for maximum production of Spirulina platensis. This research was carried out in August – October 2022 at the Research Center for Limnology and Water Resources National Research and Innovation Agency (NRIA) KST Soekarno, Bogor Regency.

This research uses the t-test, which is a hypothesis testing method where one research object is subjected to 2 different treatments, the data is processed using Microsoft Excel, with the final conclusion being that one is the best treatment. This research was carried out with 2 treatments and 4 repetitions (2 sampling times each and carried out in duplicate). The design is as follows:

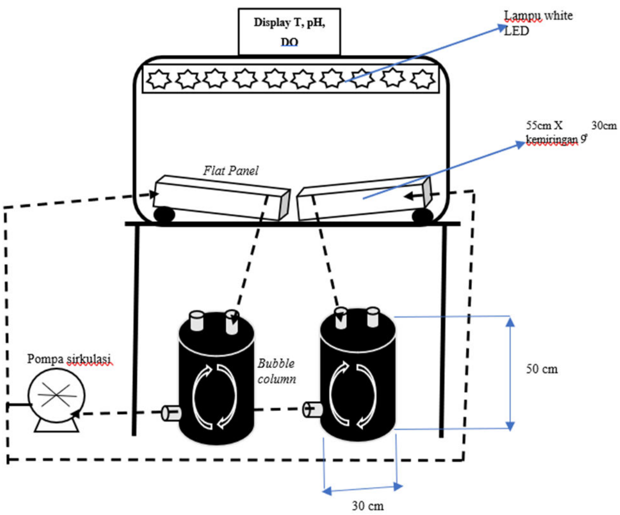
Treatment 1: Irradiance 300 μmol/(m 2.s)

Treatment 2: Irradiance 200 μmol/(m 2.s)

The fixed variables in this research are: Temperature, pH, and DO

The research procedures carried out are:

- Making modified Zarrouk culture medium. The composition of the medium used is: $NaHCO_3$ 16.8 g/L, K_2HPO_4 0.5 g/L, $NaNO_3$ 2.5 g/L, K_2SO_4 1 g/L, NaCl 1 g/L, $MgSO_4.7H_2O$ 0.2 g/L, $Na_2EDTA.2H_2O$ 0.08 g/L, $CaCl_2.2H_2O$ 0.04 g/L, $FeSO_4.2H_2O$ 0.01
  a. Solution A5 (trace element): H_3BO_3 2.86 g/L, $MnCl_2.4H_2O$ 1.81 g/L, $ZnSO_4.7H_2O$ 0.22 g/L, Na_2MoO_3 0.01 g/L, and $CuSO_2.5H_2O$ 0.07 g/L
  b. Solution B6 (trace element): NH_4VO_3 22.86 g/L, $KCr(SO_4)_2.12H_2O$ 192 g/L, $NiSO_4.6H_2O$ 44.8 g/L, $Na_2WO_4.2H_2O$ 17.94 g/L, $TiOSO_4.8H_2O$ 61.1 g/L, and $Co(NO_3)_2.6H_2O$ 43.98 g/L.
- Arrangement of the framework for the photobioreactor culture container along with hoses and sensors to measure water quality in real time. This reactor consists of a bubble column reactor for the dark reaction process and a flat panel for the light reaction process. The light intensity is regulated. The 2022 atmospheric FCB Photobioreactor instrumentation arrangement can be seen in Figure.



- Mixing *S. platensis* with the medium. *S. platensis inoculum* stock of 10% (v/v) of the total working volume was put into the 2022 atmospheric FCB photobioreactor container along with medium with a distribution of 20 L in the flat panel section (10 L each because there are 2 flat panels) and 40 L in the bubble columns (20 L each because there are 2 bubble columns) so that the total working volume of biomass is 60 L, cultivate for 11 days, then on the 11th day the biomass is harvested. Samples were taken on day 0 (t0), day 2 (t2), day 3 (t3), day 5 (t5), day 7 (t7), day 9 (t9) , and day 10 (t10). Put it in a sample bottle.
- After sampling, the sample is then stored in the refrigerator until the 11th day (harvest).
- After sampling until the 10th day of sampling, all samples are tested and measured at their wavelengths according to the respective parameter procedures using a UV-Vis spectrophotometer. Summary data on the results of measuring growth medium quality parameters was obtained from the data set of thesis research results Ika Atman Satya.
- Test result data is stored in Excel and analyzed according to the specified formulas and conditions.
- Obtain research results and conclusions. After analysis, you will get the calculation results and conclusions can be made.

2. 2. Result

Based on treatment 1 with a light intensity of 300 μmol.m-².s $^{-1}$ the lowest temperature occurred on day 0, namely 24.42°C and the highest temperature occurred on day 3, amounting to 25.82°C, the average temperature for treatment 1 was 25.39°C. whereas in treatment 2 at a light intensity of 200 μmol.m-².s $^{-1}$ the lowest temperature was 25.05°C recorded on the 8th and 11th days, while the highest temperature occurred on the 7th day, namely 25.08°C with an average the temperature is 25.06°C can be seen in **Figure 1**. This is in line with research conducted by Bangun et al. (2015) who researched the effect of using different temperatures on the growth of Spirulina platensis, used temperatures of 25°C, 30°C and 35°C using Walne fertilizer which had been enriched with vitamin B12 as the growth medium with a salinity level of 20 ppt, resulting in maximum growth. occurs at a temperature of 25°C and shows the success of *Spirulina platensis* production in maintaining the longest exponential phase with the highest cell production.

Generally, the pH is in a constant condition. In treatment 1, the light intensity was 300 μmol.m-².s^{1}. The pH at the beginning of cultivation was 7.90 and the highest pH occurred on the last day of observation, namely on the 11th day with a pH of 8.68. The average pH in treatment 1 was 8.48. Meanwhile, in treatment 2 with a light intensity of 200 μmol.m-².s1, the initial pH of cultivation was 8.22 and reached the highest pH of 8.96 on the 5th day of observation; the average pH in treatment 2 was 8.71 this result can be seen in **Figure 2** . Previous research was conducted on Spirulina fusiformis which was cultivated with several different light intensities of 2000 lux, 4000 lux, 6000 lux, 8000 lux and 10,000 lux using a bubble column photobioreactor, the pH at the time of culture initiation ranged from 8.72 – 8.84 (Satya et al., 2021)

The results of research using different light intensities of 300 μmol.m-².s1 and 200 μmol.m-².s1 which were cultivated using the FCB Atmosphere 2022 photobioreactor showed results, for the light intensity of 300 μmol.m-².s1 the lowest DO was recorded on the day 0th cultivation, namely 7.90 mg/L and the highest DO on the 11th day was 8.84 mg/L, the average DO for treatment 1, namely with a light intensity of 300 μmol.m-².s1, was 8.57, while for treatment 2 at a light intensity of 300.

The lowest μmol.m-².s1 DO was recorded on day 0 of cultivation, namely 7.98 mg/L and the highest DO value occurred on day 11 of cultivation, 8.73 mg/L, with the average DO value for treatment 2 being 8.50 mg/L, These results can be seen in **Figure 3**.

The results of this research are in accordance with previous research conducted by Buwono et al., (2018), examining the cultivation of *Spirulina platensis* at different culture scales. The research results showed that *Spirulina platensis* cultivated on a laboratory scale ranged between 7.9 – 8.9 mg/L, lower than *Spirulina platensis* cultivated on a semi-mass scale outdoors, 9.7 mg/L.

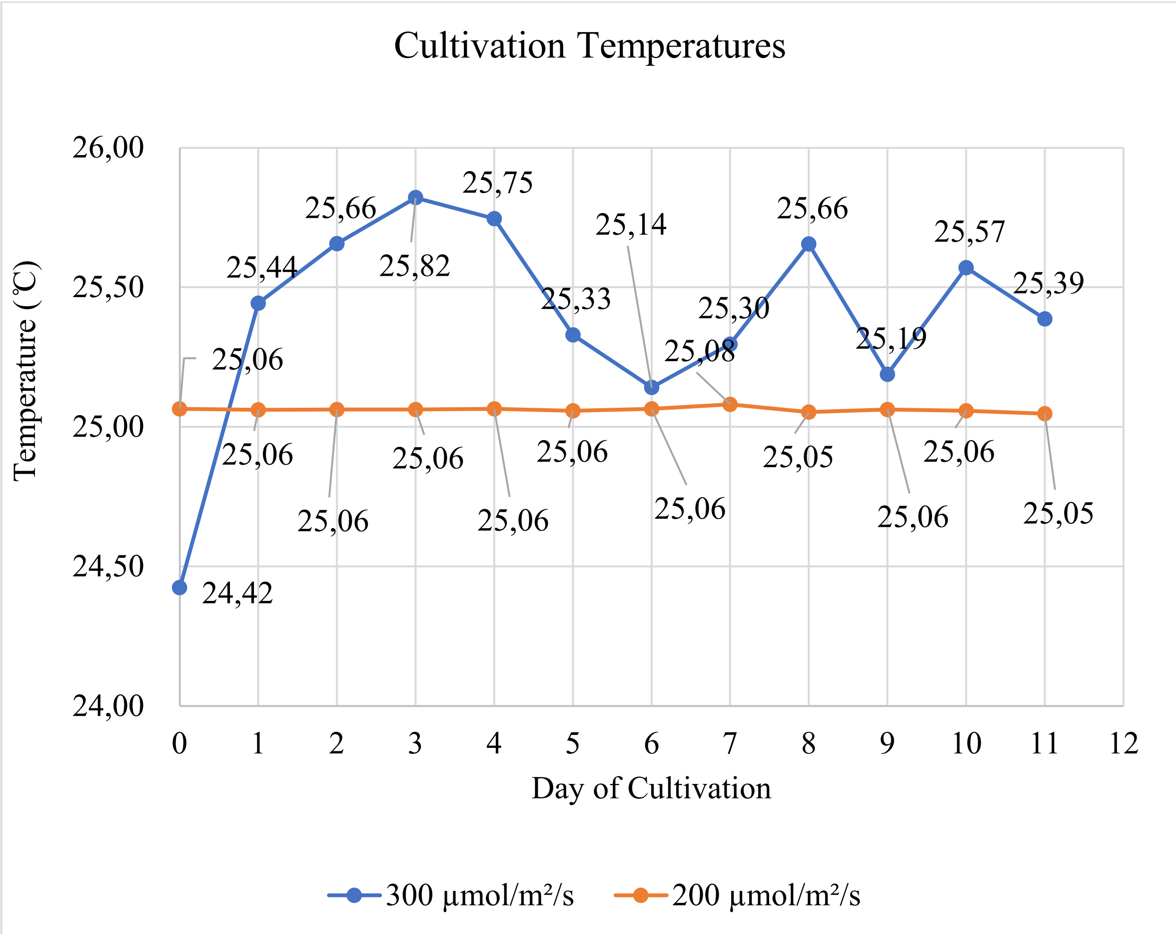


Figure 1. Cultivation Temperatures

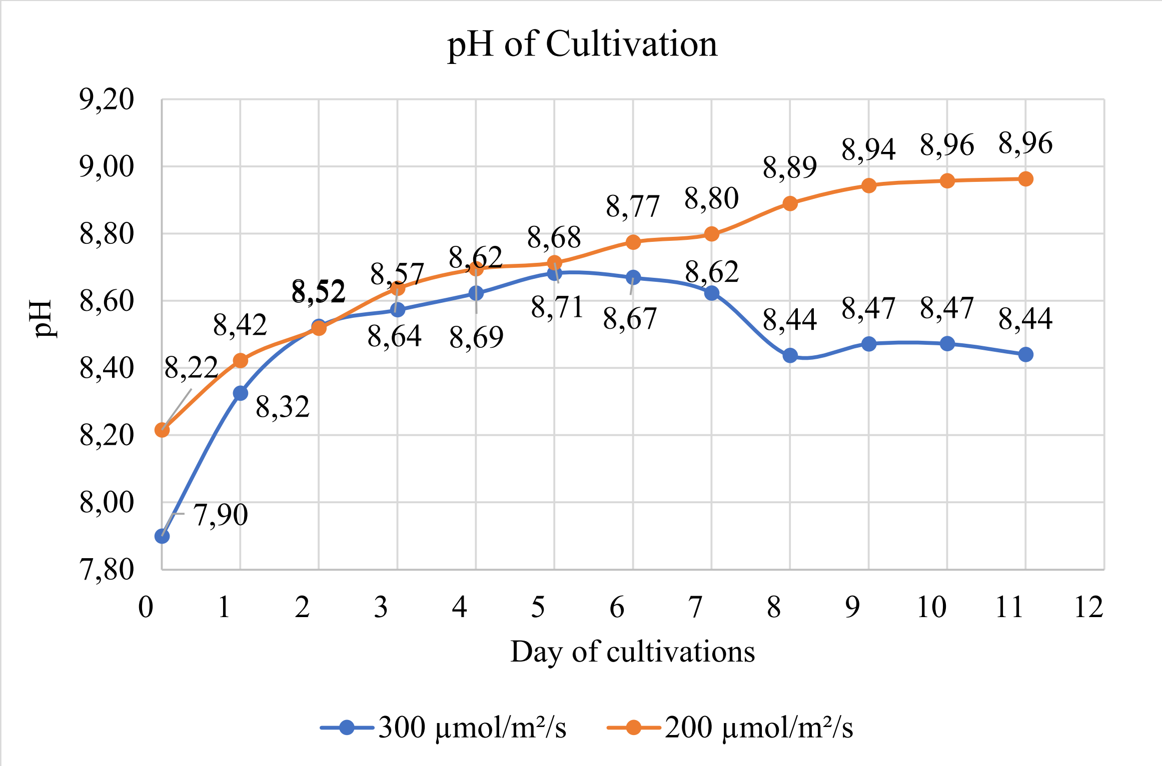


Figure 2. pH of Cultivation

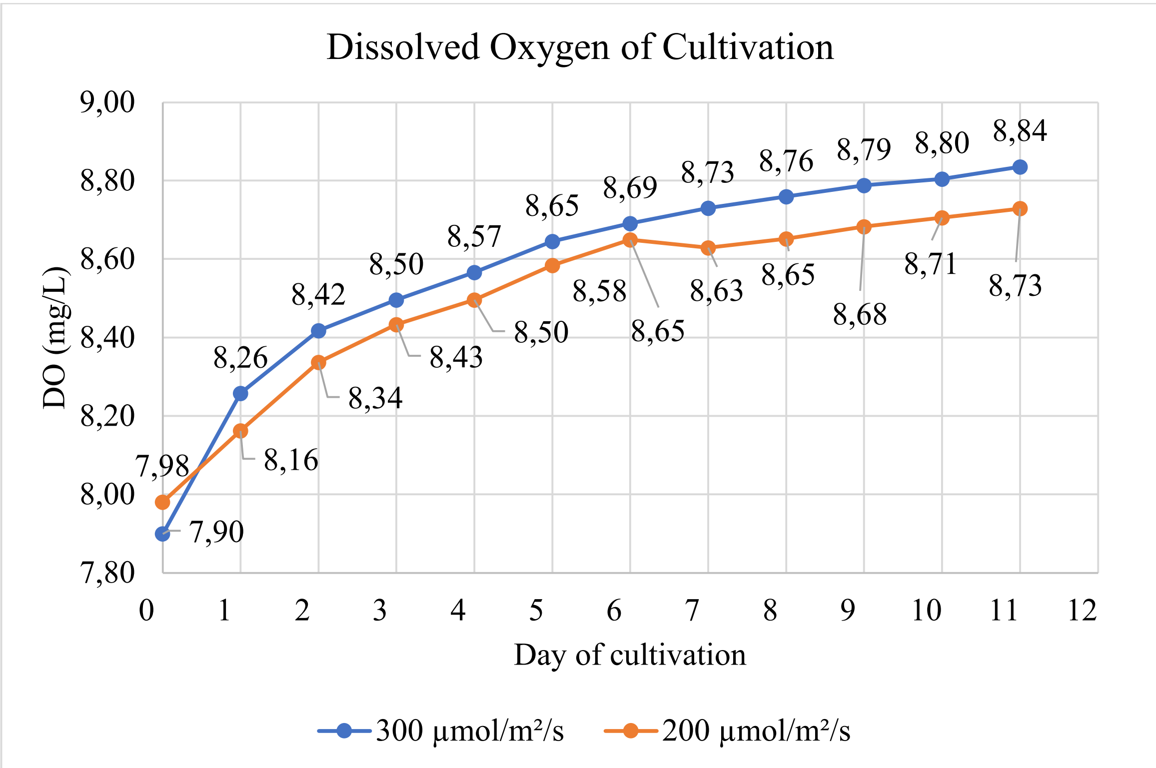


Figure 3. Dissolved Oxygen of Cultivation

2.3. Specific Growth Rate

The growth curve of *Spirulina platensis* tends to experience a linear phase at the beginning of the observation and begins to experience an exponential phase on the 3rd day of observation and tends to experience a lag phase and experiences a decreasing phase on the 8-10th day of observation. Fluctuations in Optical Density values in this study were influenced by several things, including differences in the growth period of the microalgae being cultivated. The facts are in accordance with Chandra and Rai's (2008) statement that the factors that influence Optical Density include the density of microalgae, namely the presence of adequate nutrition in the growth of microalgae, environmental stress which is usually caused by extreme temperatures in the growing medium or the presence of minimal nutrients in the cultivation medium, Apart from that, the presence of toxins can also result in a decrease in Optical Density values.

Satya *et al.* (2021) in their research examining *Spirulina fusiformis* at different light intensities, the results showed that at 10,000 lux applications had a higher biomass productivity value than other light intensity treatments. Therefore, it can be concluded that high light intensity can accelerate the growth of *Spirulina fusiformis* cultivation (Moshenpour Willoughby, 2016; Satya *et al.,* 2021). The same can happen with *Spirulina platensis* because it is still in the same genus. This statement is supported by the results of this study which uses different light intensities (300 μmol.m^{-2}.s1 and 200 μmol.m^{-2}.s1) the average concentration of biomass in treatment 1, namely at 300 μmol.m^{-2}.s1 light, is higher than treatment 2, namely at light intensity 200 μmol.m^{-2}.s1. The average biomass concentration in treatment one with a light intensity of 300 μmol.m^{-2}.s1 was 0.208 g/L, while in treatment 2 the light intensity of 200 μmol.m^{-2}.s1 was 0.179 g/L.

Spirulina platensis was treated with different light intensities of 300 μmol.m-^{2}.s1 and 200 μmol.m-^{2}.s1. The research results show that high light intensity tends to produce a high specific growth rate of biomass, at a light intensity of 300 μmol.m-^{2}.s1 the specific growth rate of biomass is 0.393 divisions/day, whereas at a light intensity of 200 μmol.m-^{2}.s1 biomass growth rate 0.164 divisions/day. This results supported by Soni *et al.* (2019) examined the cultivation of *Spirulina platensis* in different culture media (standard Zarrouk medium and modified Zarrouk medium with changing nitrogen sources (urea), the light intensity used was around 1500-4500 lux, the results Research shows that the modified Zarrouk medium produces a higher specific biomass growth rate and biomass productivity compared to cultivating *Spirulina platensis* biomass which is cultivated in standard Zarrouk medium. The maximum specific biomass growth rate reaches 0.9 g/L/d.

At a light intensity of 300 μmol.m-^{2}.s1, biomass productivity reaches 0.05 g/l/d, while at a light intensity of 200 μmol.m-^{2}.s1, biomass productivity reaches 0.034 g/l/d. The results of this research are in accordance with previous studies conducted. Many studies have been carried out regarding biomass productivity, one of which is research conducted by Satya et al., (2021) who examined Spirulina fusiformis in bubble column photobioreactors, the biomass productivity produced in this study ranged from 14.19-24.95 mg/L/d. Similar studies using column photobioreactors have biomass productivity ranging from 40-140 mg/L/d (Orais and Costa 2007).

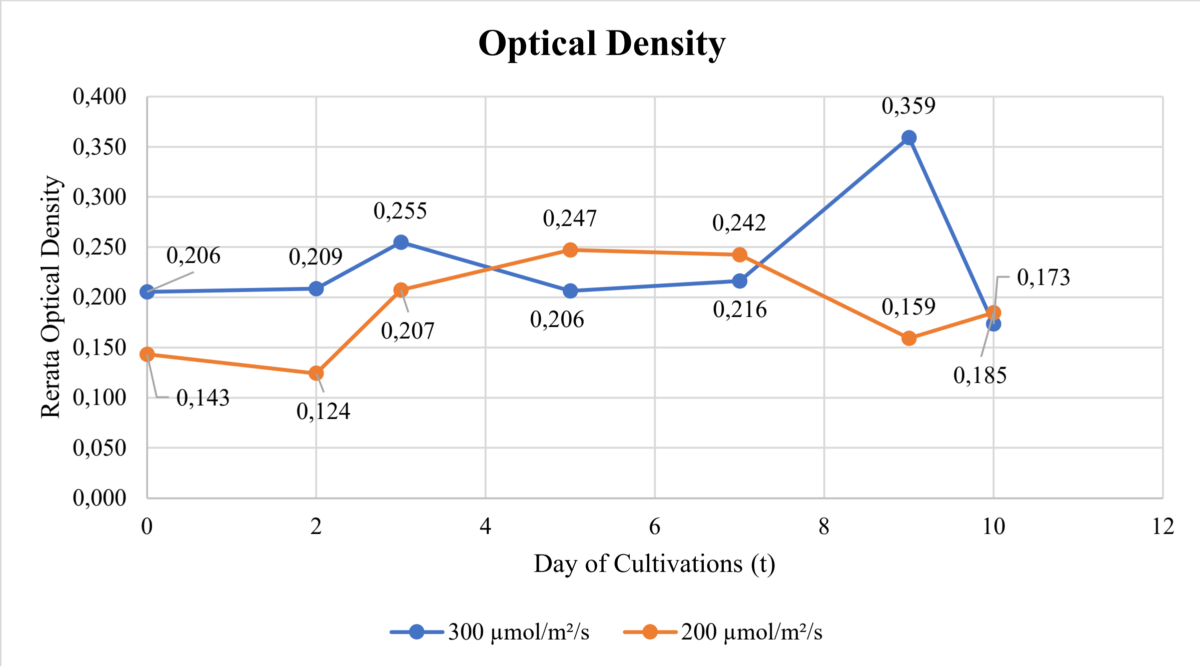


Figure 4. Optical Density

The results of the study on the cultivation of *Spirulina platensis* in a photobioreactor using a light intensity of 300 µmol/m²/s and 200 µmol/m²/s. Behavior 1 with a light intensity of 300 µmol.m^{-2}.s1 showed that the result on the first day of cultivation was 0.206, the smallest OD occurred on the 10th day or during the harvest period, which was 0.173, and the average OD of treatment 1 with a light intensity of 300 µmol/m²/s was 0.2321. Meanwhile, treatment 2 with a light intensity of 200 µmol/m²/s OD on the first day was 0.143, the lowest OD was found on the 2nd day of observation of 0.124, the highest OD on the 5th day of observation with an OD of 0.247, and the average OD studied in the 2nd treatment with a light intensity of 200 µmol/m²/s was 0.186. If seen in **Figure 4**, the growth curve *of Spirulina platensis* tends to experience a linear phase at the beginning of observation and begins to experience an exponential phase on day 3 of observation and tends to experience a lag phase and a decline phase on day 8-10 of observation. The fluctuation of *the Optical Density* value in this study is influenced by several things, including the difference in the growth period of the cultivated microalgae, anomalous conditions during the culture also affect fluctuations, especially on the 9th day, several supporting components experience error *conditions*, one of which causes the aerator to stop operating. The same thing happened in the research of Tambunan *et al.* (2022) which researched the growth of *Spirulina platensis* on acidic, neutral, and alkaline mediums on a laboratory scale, the results showed that there was an anomaly in the population density curve *of Spirulina platensis* which originally increased on the 2nd day, and the low population on the 4th day then there was a population surge on the 5th day, one of the indications is The aeration condition is less stable, so that sampling tends not to be stirred perfectly, so there may be a surge in biomass density in the sampled part which has a direct effect on the increase in density.

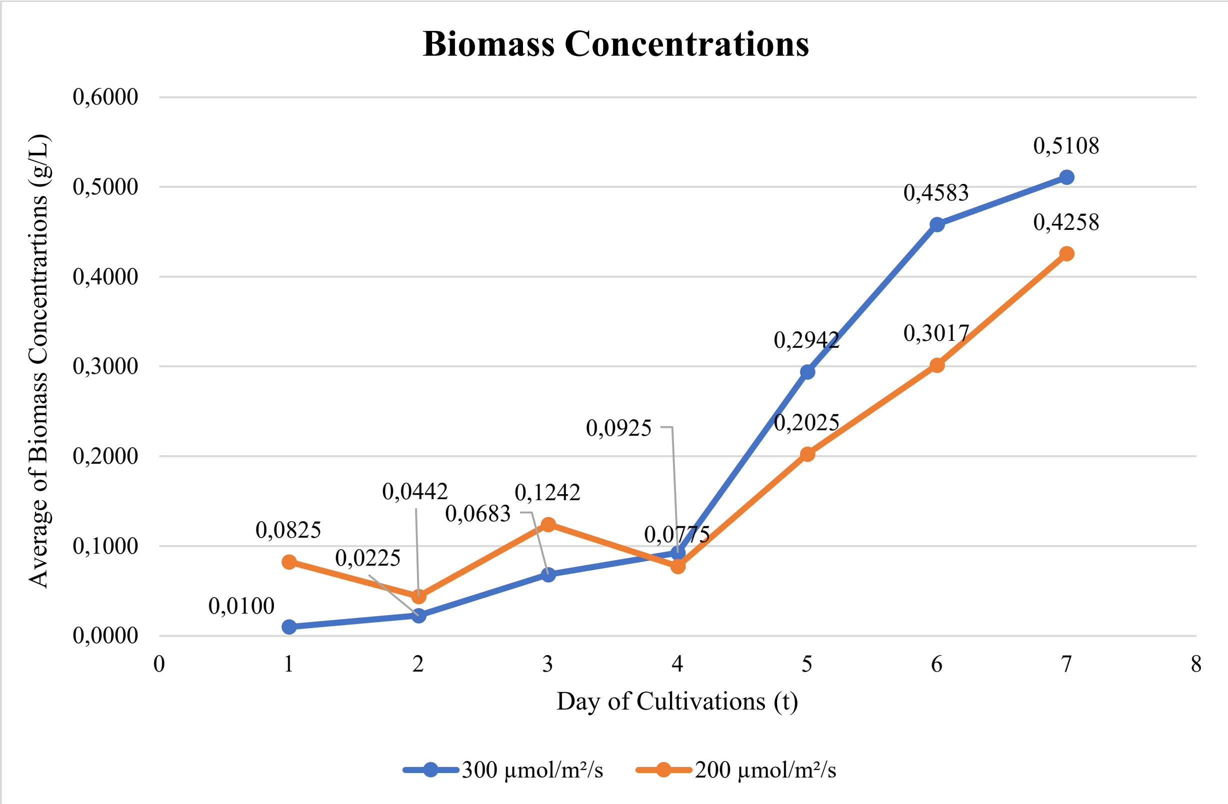


Figure 5. Biomass Concentrations

Satya *et al.,* (2021) in their research examining *Spirulina fusiformis* at different light intensities, the results showed that at 10,000 lux applications had a higher biomass productivity value than other light intensity treatments. Therefore, it can be concluded that high light intensity can accelerate the growth of *Spirulina fusiformis* cultivation (Moshenpour Willoughby, 2016; Satya *et al.,* 2021). The same can happen with *Spirulina platensis* because it is still in the same genus. This statement is supported by the results of this study which uses different light intensities (300 µmol/m²/s and 200 µmol/m²/s) the average concentration of biomass in treatment 1, namely at 300 µmol/m²/s light, is higher than in treatment 2, namely at light intensity. The 200 µmol/m²/s average curve of biomass concentration can be reviewed in **Figure 5** . The average concentration of biomass in treatment 1 with a light intensity of 300 µmol/m²/s was 0.208 g/L, while in treatment 2 the light intensity of 200 µmol/m²/s was 0.179 g/L.

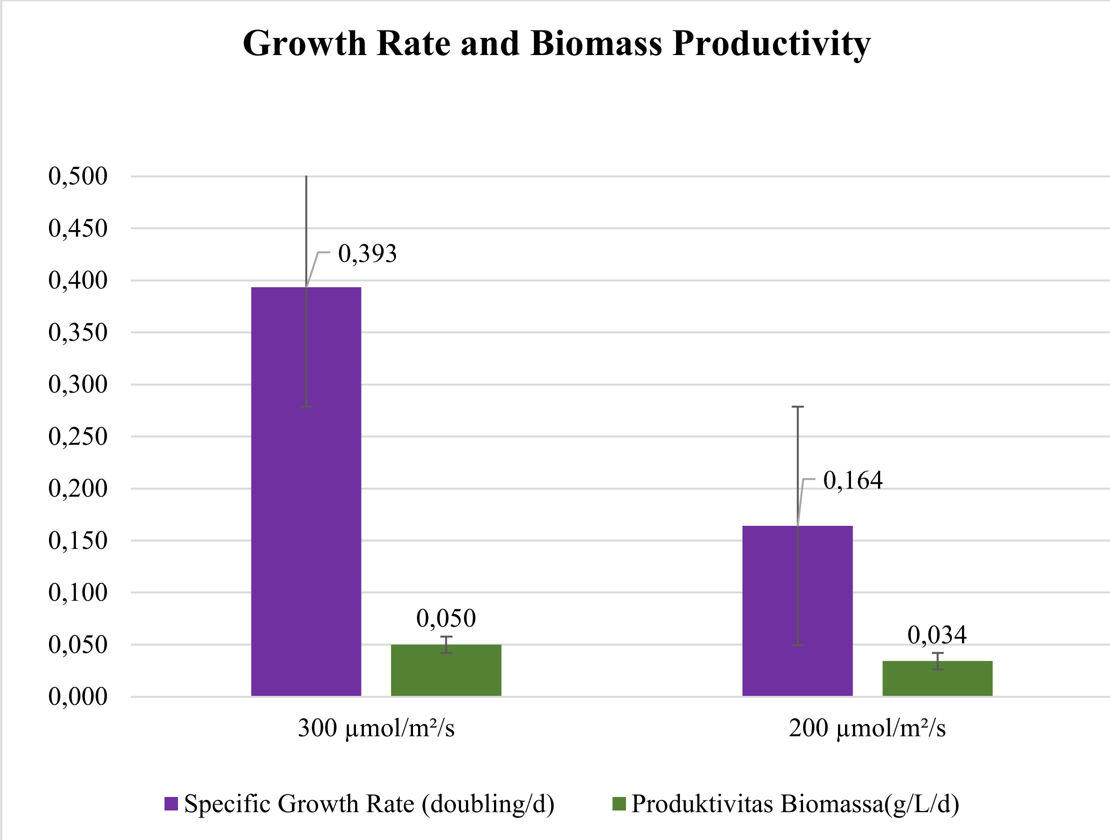


Figure 6. Growth Rate and Biomass Productivity

One of the factors that affect the specific growth of biomass is light intensity, a study conducted by Olaizola and Duerr (1990) which researched the influence of light intensity on the specific growth quality of biomass and *Spirulina platensis* pigments, in this study, fluorescent lamp light and Zarrouk medium were used with light intensity ranging from 66-1328 µmol/m²/s. The results showed that the maximum value of the specific growth rate of *Spirulina platensis* biomass was achieved at a light intensity of 465 µmol/m²/s, the growth rate increased rapidly to 2.7 doubling/day, while at higher light intensities, the specific growth rate tended to be close to a constant value of 2.6 doubling/day. This indicates that the higher the light intensity, the higher the specific growth rate of biomass in the culture medium, but at too high light intensity, the specific growth rate of biomass tends to be constant. This is according to **Figure 6** *of Spirulina platensis* which was given different light intensity treatments of 300 µmol/m²/s and 200 µmol/m²/s. The results showed that high light intensity tended to produce a high specific growth rate of biomass as well, at a light intensity of 300 µmol/m²/s the specific growth rate of biomass was 0.393 fission/day, while at a light intensity of 200 µmol/m²/s the growth rate of biomass was 0.164 fission/day.

2.4. Total Nitrogen (TN) Uptake

According to Munoz and Guieysse (2006), generally the level of microalgae uptake of Nitrogen and Phosphate to produce maximum protein ranges between 40-60% dry weight. Nitrogen is an important micronutrient that supports the growth of Spirulina platensis. Some sources of nitrogen that are generally used as an element of the *Spirulina platensis* growing medium are sodium nitrate.

Total Biomass Nitrogen (TN Biomass) Absorption of *Spirulina platensis* at different light intensities can be seen in Figure 12, at 300 μmol.m-2.s $^{-1}$ light on day 0 was 29.37 (mg/g), the highest content occurred on day 10th, namely 92.84 (mg/g). Meanwhile, the Total Biomass Nitrogen (TN Biomass) of *Spirulina platensis* light intensity 200 μmol.m-2.s $^{-1}$ on day 0 was 22.80 (mg/g), the highest content occurred on day 10, namely 50.82 (mg/g). The results of the paired sample T test show that the mean TN at a light intensity of 300 μmol.m-2.s $^{-1}$ > light intensity of 200 μmol.m-2.s $^{-1}$, the Pearson Correlation value is 0.77, meaning the relationship is very strong, the value of tcount > ttable meaning there is a difference, and the P value (two-tail) is 0.009 < 0.05 (significant α), which means it is not significant. So it can be concluded that different light intensities have a very strong relationship to the TN content in *Spirulina platensis* biomass, while the provision of light of 300 μmol.m-2.s $^{-1}$ and 200 μmol.m-2.s $^{-1}$ gives different biomass TN results. different but not significant. This result can be seen in **Figure 7**

Total Medium Nitrogen (TN Medium) *Spirulina platensis* at different light intensities can be seen in Figure 13, at 300 μmol.m-2.s $^{-1}$ light on day 0 is 0.5 (g/L) and is the highest TN medium content during cultivation period, while at a light intensity of 200 μmol.m-2.s $^{-1}$ on day 0 it was 0.99 (g/L), the highest content occurred on day 2, namely 1.02(g/L). The results of the paired sample T test show that the average TN of the medium at a light intensity of 300 μmol.m-2.s $^{-1}$ < light intensity of 200 μmol.m-2.s $^{-1}$, the Pearson Correlation value is 0.68, meaning the relationship is very strong, the t value > t table means there is a difference, and the P value (two-tail) is 0.009 < 0.05 (significant α), which means it is not significant. So it can be concluded that providing different light intensities has a very strong relationship to the TN content in the *Spirulina platensis* growing medium, while providing light of 300 μmol.m-2.s $^{-1}$ and 200 μmol.m-2.s $^{-1}$ gives TN results medium that is not significantly different. This result can be seen in **Figure 8.**

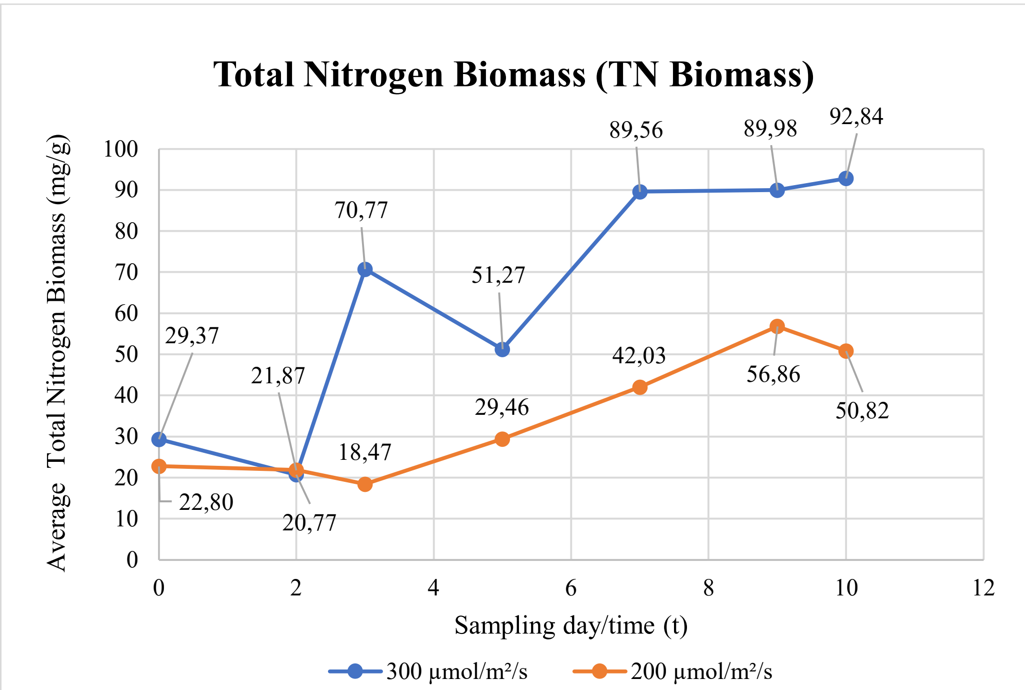


Figure 7. Total Biomass Nitrogen (Biomass TN)

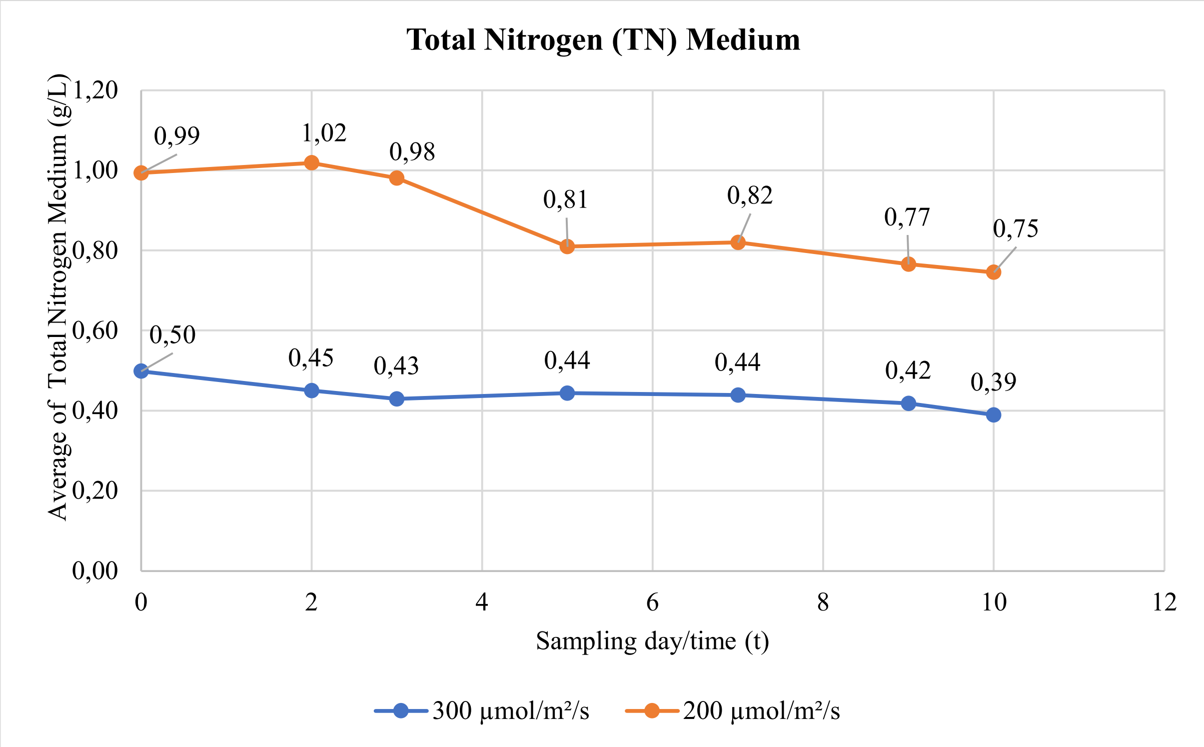


Figure 8. Total Nitrogen (TN) Medium

2.5. Total Phospate (TP) Uptake

The presence of the element P in nature is quite limited, in contrast to N, which is very abundant in the atomosphere. Previous research regarding several factors that can influence the cultivation process of Spirulina platensis, such as the element N which has an influence as well as a limiting factor for the growth of *Spirulina platensis* (Piorreck et al., 1984; Markou and Iordanis, 2012).

The results of research on phosphate uptake in *Spirulina platensis* cultivation can be viewed through two pathways, namely Total Biomass Phosphate (TP Biomass) and Total Phosphate Medium (TP Medium). Total Biomass Phosphate (TP Biomass) *Spirulina platensis* can be seen in **Figure 9** at intensity at light 300 µmol.m-2.s $^{-1}$ and 200 µmol.m-2.s $^{-1}$ can be seen in Figure 17, on day 0 it is 5.09 (mg/g), the highest content occurred on day 9, namely 14.55 (mg/g). Meanwhile, Total Biomass Phosphate (TP Biomass) for *Spirulina platensis* light intensity 200 µmol.m-2.s $^{-1}$ on day 0 was 3.89 (mg/g), the highest content occurred on day 10, namely 5.63 (mg/g). The results of the paired sample T test show that the mean TP at a light intensity of 300 µmol.m-2.s $^{-1}$ > light intensity of 200 µmol.m-2.s $^{-1}$, the Pearson Correlation value is 0.91, meaning the relationship is very strong, the value of tcount > ttable meaning there is a difference, and P value (two-tail) 0.01 < 0.05 (significant α), which means it is not significant. So it can be concluded that different light intensities have a very strong relationship to the TP content in *Spirulina platensis* biomass, while providing light of 300 µmol.m-2.s $^{-1}$ and 200 µmol.m-2.s $^{-1}$ gives different biomass TP results different but not significant.

Total Phosphate Medium (TP Medium) *Spirulina platensis* intensity at light 300 µmol.m-2.s $^{-1}$ and 200 µmol.m-2.s $^{-1}$ can be seen in Figure 18, on day 0 it is 0.5 (g/L) and is the highest TP content of the medium during the cultivation period, while at a light intensity of 200 µmol.m-2.s $^{-1}$ on day 0 it is 0.99 (g/L), the highest content occurs on day 2, namely 1.02(g/ L). The results of the paired sample T test show that the average TP of the medium at a light intensity of 300 µmol.m-2.s $^{-1}$ < light intensity of 200 µmol.m-2.s $^{-1}$, the Pearson Correlation value is 0.77, meaning the relationship is very strong, the t value < ttable means there is no difference, and the P value (two-tail) is 0.71 > 0.05 (significant α), which means it is significant. So it can be concluded that the provision of different light intensities has a very strong relationship with the TP content in the *Spirulina platensis* growth medium, while the provision of light of 300 µmol.m-2.s $^{-1}$ and 200 µmol.m-2.s $^{-1}$ gives TP results medium that is not significantly different. This result can be seen in **Figure 10.**

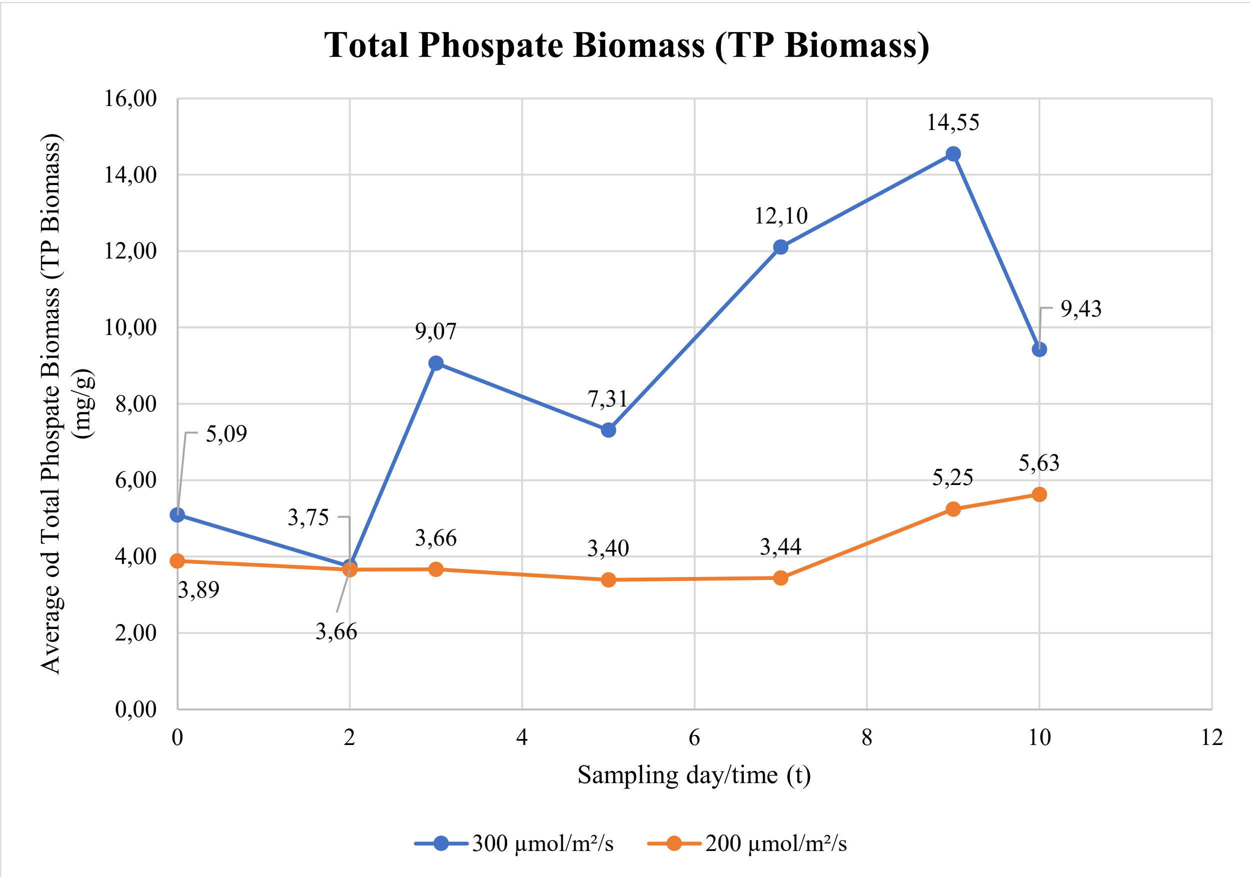


Figure 9. Total Phospate Biomass (TP Biomass)

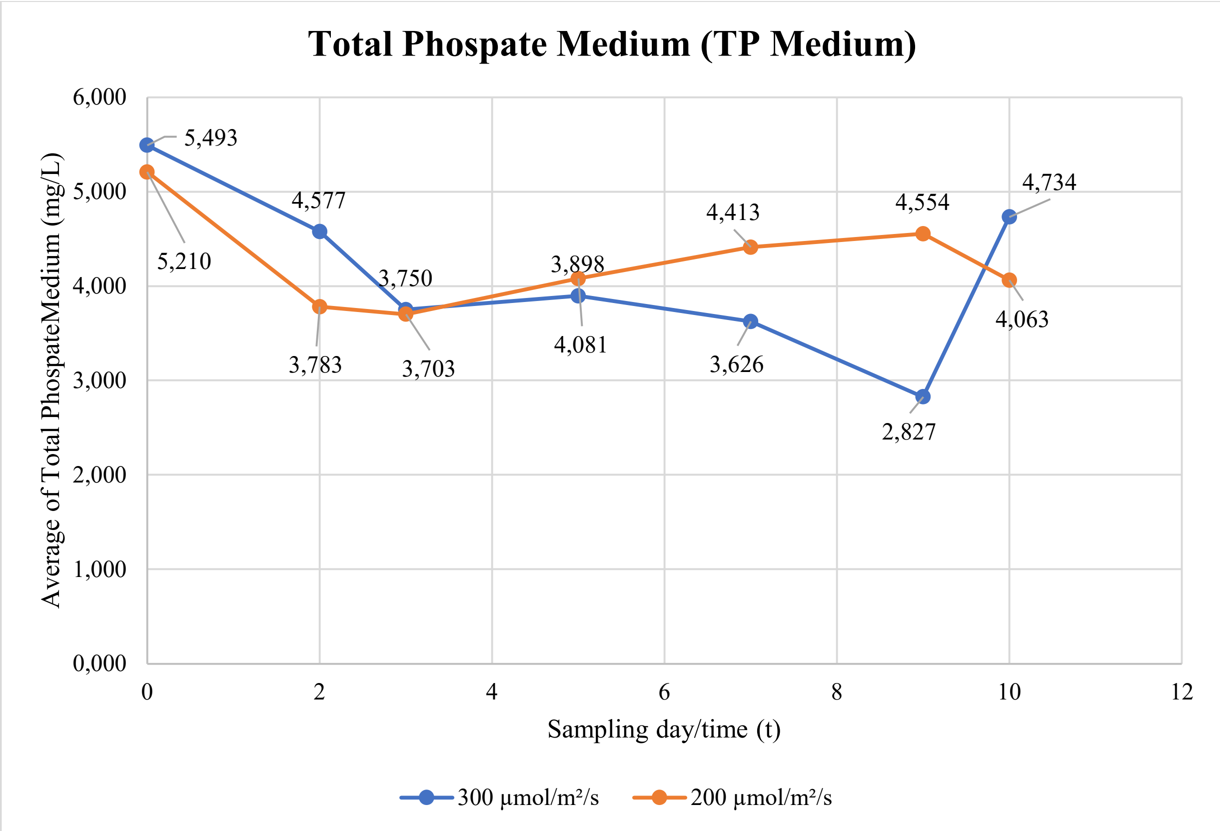


Figure 10. Total Phospate Medium (TP Medium)

3. CONCLUSIONS

Based on the research carried out, with the observation object *Spirulina platensis* which was cultivated in the FCB Atmosphere 2022 photobioreactor, the modified Zarrouk growth medium at a light intensity of 300 µmol.m-2.s $^{-1}$ and 200 µmol.m-2.s $^{-1}$, with quality conditions The average temperature of the growing medium is 25 ± 1 °C, the average pH of the medium ranges from 8.71-8.91, Dissolved Oxygen (DO) levels are 8.50-8.57 mg/l, giving the following results:

1) The average Optical density value at a light intensity of 300 µmol.m-2.s $^{-1}$ is 0.232 and the average Optical density value at a light intensity of 200 µmol.m-2.s $^{-1}$ is 0.143.
2) The average biomass concentration of *Spirulina platensis* at a light intensity of 300 µmol.m-2.s $^{-1}$ is 0.208 g/L, while at a light intensity of 200 µmol.m-2.s $^{-1}$ it is 0.179 g/L.
3) The average specific growth rate of *Spirulina platensis* biomass at a light intensity of 300 µmol.m-2.s $^{-1}$ is 0.393 divisions/day, while at a light intensity of 200 µmol.m-2.s $^{-1}$ it is 0.164 divisions/day.
4) The average value of *Spirulina platensis* biomass productivity in the light intensity treatment of 300 µmol.m-2.s $^{-1}$ was 0.05 g/L/d, while in the light intensity of 200 µmol.m-2.s $^{-1}$ it was 0.034 g/L/d.
5) The average uptake of Total Biomass Nitrogen (TN Biomass) by *Spirulina platensis* biomass in the light intensity treatment of 300 µmol.m-2.s $^{-1}$ was 63,508 mg/g, while in the light intensity treatment of 200 µmol.m-2.s $^{-1}$ the total biomass nitrogen uptake was 34,616 mg/g.
6) The average total medium nitrogen (TN Medium) at a light intensity of 300 µmol.m-2.s $^{-1}$ is 0.438 g/L, while at a light intensity of 200 µmol.m-2.s $^{-1}$, the Total Medium Nitrogen (TN Medium) is 0.876 g/L.
7) The average value of Total Biomass Phosphate (TP Biomass) absorbed by *Spirulina platensis* biomass in the light intensity treatment of 300 µmol.m-2.s $^{-1}$ was 8,757 mg/g, while in the light intensity treatment of 200 µmol.m-2.s -1 is 4.132 mg/g.

8) The average value of Total Phosphate Medium (TP Medium) in the 300 μmol.m-2.s $^{-1}$ light intensity treatment was 4,129 g/L, while in the 200 μmol.m-2.s $^{-1}$ light intensity treatment was 4,258 g/ L.

In general, high light intensity has a positive impact on increasing the average value of Optical Density, biomass concentration, specific biomass growth rate (SGR Biomass), biomass productivity, Total Biomass Nitrogen (TN Biomass), Total Medium Nitrogen (TN Medium), and Total Biomass Phosphate (TP Biomass). However, the influence of light intensity shows the opposite results for the Total Phosphate Medium (TP Medium) parameter.

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