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The Effect of Dosing Liquid Organic Fertilizer on the Growth Rate of Seaweed Caulerpa Racemosa (J. Agardh, 1873)

Habib Muhammad Raihan[1], Ria Azizah Tri Nuraini[2], AB Susanto[3]*
Diponegoro University
Corresponding Author: AB Susanto abe09092019@gmail.com

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A B S T R A C T

Caulerpa racemosa is one of the most widespread green seaweeds in marine waters. Caulerpa racemosa is a seaweed that is a popular commodity. In addition to being a food ingredient, Caulerpa sp. is used as a substance that provides an anesthetic effect and as a mixture for anti-fungal drugs. The demand for this seaweed continues to increase, but its production cannot be fulfilled, this is because its production is seasonal and still relies heavily on natural products. Therefore, it is necessary to increase the production of Caulerpa sp. through engineering with the addition of fertilizers in its cultivation. This seaweed cultivation pays attention to several parameters such as temperature, dissolved oxygen, salinity, and nutrients. This study aims to examine the effect of giving various doses of liquid organic fertilizer on the growth (wet weight) of C. racemosa seaweed. This study used an experimental method using a completely randomized design (CRD). This method consists of 4 treatments and 3 repetitions. The doses or treatments given were treatment K (no dose of liquid organic fertilizer), A (liquid organic fertilizer dose of 2.5 mL), B (liquid organic fertilizer dose of 3.5 mL) and C (liquid organic fertilizer dose of 4.5 mL). The results of this study showed that the application of liquid organic fertilizer significantly affected the biomass and specific growth rate of C. racemosa ($p<0.05$). Treatment A (liquid organic fertilizer dose of 2.5 mL) gave the best results of all treatments with a specific growth rate of 1,33 ± 0,16%/day.

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INTRODUCTION

Caulerpa racemosa is one of the most widespread green seaweeds in marine waters. This type of green seaweed can adapt quickly to its environment, besides having a high level of survival. *Caulerpa racemosa* is a seaweed that is a commodity that is quite popular and is often consumed by coastal communities.

This seaweed has content such as vitamin A, vitamin C, iron, iodine, calcium, and amino acid content dominated by L-threonine, L glysine, L-glutamic acid, and L-lysine (Palawe *et al*., 2021). *Caulerpa* sp. seaweed also contains minerals, protein, carbohydrates, high fiber, and low fat. Realizing the high nutritional content of latoh, countries such as Japan and the Philippines have looked at it. Unfortunately, there are no serious cultivators in Indonesia. In addition to its good nutritional composition, *Caulerpa* sp. is known to be rich in bioactive compounds with various biological activities. These properties make it potentially used as a functional food. *Caulerpa racemos*. has anti-microbial compounds due to its content of bioactive compounds known as: caulerpin, sterol, and caulerpicin (Nofiani *et al*., 2018). Demand for this seaweed continues to increase, but its production cannot be fulfilled, this is because its production is seasonal and still relies heavily on natural products. Therefore, it is necessary to increase the production of *Caulerpa* sp. through engineering with the addition of fertilizers in its cultivation.

LITERATURE REVIEW

Caulerpa sp is one of the macroalgae of the class Chlorophyceae. Generally, *Caulerpa* sp. grows in shallow seas and in calm water streams. The *Caulerpa* clan has approximately 60 species. *Caulerpa* sp. distribution is widely spread on the coast of the tropics to subtropics with the greatest diversity is in the tropics (Saptasari, 2010). In eastern Indonesia, *Caulerpa racemosa* is used as food. However, the *Caulerpa* macroalgae group has never been cultivated for commercial purposes.

Cultivation of Caulerpa racemosa is generally in ponds using brackish water. This seaweed cultivation pays attention to several parameters such as temperature, dissolved oxygen, salinity, and nutrients. Nutrients are elements needed by plants as a source of energy that is used to organize various cell components during the growth process. The addition of nutrients serves to increase the amount of dissolved nutrients in water so that they can be absorbed by seaweed to support the growth process (Pradhika *et al*., 2019). One of the efforts that can increase algae growth and help production is fertilization or the addition of nutrients. According to Suniti and Suada (2012), fertilization is one of the efforts to increase plant production because the provision of fertilizer is an effort to add nutrients (N, P, K) to the plant for its survival. Enough nutrients are used by seaweed to perform growth through the process of photosynthesis. Giving fertilizer must use a certain dose, if excessive fertilization it can affect the growth of seaweed. Nitrogen (N) is used to stimulate the growth of a plant so that it can grow rapidly. While phosphorus (P) plays an important role in plants as a limiting factor in the process of photosynthesis and potassium (K) is used by plant cells during the process of assimilation of energy produced by the photosynthesis process (Ginting *et al*., 2015).

This study was conducted to determine the effect of different doses of organic liquid fertilizer on the growth of *Caulerpa racemosa* seaweed. The right dose of fertilizer will be easily used to maximize seaweed yields. Providing additional nutrients in the form of fertilizer can increase the production of *Caulerpa racemosa* seaweed.

METHODOLOGY

The material in this study was *Caulerpa racemosa* with an initial weight of 25 g obtained from Jepara waters. The liquid organic fertilizer used in this study is NASA liquid organic fertilizer. The liquid organic fertilizer contains macro elements C- Organic: 9,69%, N: 4,15%, P_2O_5: 4,45%, K_2O: 5,66%, Trace elements or micro elements (Cu, B, Mo, Mn, Zn and Co) and various growth stimulating hormones (Cytokinin, Auxin and Gibberellin).

This research uses an experimental method. This method consists of 4 treatments and 3 repetitions. The treatments were K (no dose of liquid organic fertilizer), A (2,5 mL dose of liquid organic fertilizer), B (3,5 mL dose of liquid organic fertilizer) and C (4,5 mL dose of liquid organic fertilizer) which refers to the research of Ginting *et al*. (2015). This research used a completely randomized design (CRD). This method is used to investigate cause and effect by imposing one or more treatment conditions and then comparing them with one or more control groups that are not subjected to treatment (Dini *et al*., 2021). This study used 3 repetitions. This study used NASA liquid organic fertilizer as a treatment with different doses in each treatment applied to *C racemosa*. The control variable (no fertilizer) was used as a comparison treatment between seaweed given liquid organic fertilizer with seaweed without fertilizer. Before being given to the media as a liquid fertilizer dose treatment, the fertilizer treatment was first diluted into a stock solution. Treatment stock solution A was made by mixing 2.5 mL of liquid organic fertilizer into 1 liter of water, so that the fertilizer concentration in the solution became 2500 ppm (1μL/L = 1ppm, then 2,5 mL/L = 2500 ppm).

During the 30-day research period, water quality parameters were checked. Measurement of water quality parameters in C. racemosa media includes temperature, pH and salinity. This measurement will be done every 6 days and salinity will be adjusted when it exceeds the salinity limit for seaweed life, which is 29-35 ppt.

Weighing the Wet Weight of Caulerpa Racemosa

The growth rate of C. racemosa in this research was observed in the form of specific growth rate of seaweed. Specific growth rate of seaweed is calculated from the results of wet weight measurements measured every 6 days for 30 days. Specific growth rate of C. racemosa is strongly influenced by salinity, pH, temperature and dissolved oxygen so that seaweed can experience good growth. C. racemosa seaweed can generally be harvested around 30 days (Firda *et al*., 2022).

Specific Growth Rate of Caulerpa Racemosa

On the 30th day, the final wet weight of Caulerpa racemosa seaweed was weighed in each aquarium. After weighing, the growth rate of the seaweed will be calculated. According to Hung et al. (2009) this growth rate is calculated as the main parameter of the effect of different treatments on the condition of Caulerpa racemosa seaweed planted. Specific growth rate is often called Specific Growth Rate (SGR) and can be calculated using the formula:

$$SGR=((Wt - Wo) / t) \times 100\%$$

Description:
SGR= Specific Growth Rate per day (% weight/day)
Wt= Average mass at time t (g)
Wo= Initial average mass (g)
T= Time (days)

Data Analysis

The data obtained, in the form of SGR, were analyzed statistically using the Anova test. This analysis is used to determine differences between treatment groups. Before Anova analysis, data normality and homogeneity analysis were carried out first as a condition for Anova test. After the Anova test is carried out, if there is a significant difference, then the Post Hoc Test is carried out with the Tukey test to determine where the differences are (Riadi *et al.*, 2020).

RESULT AND DISCUSSION

The results of research conducted for 30 days resulted in *Caulerpa racemosa* wet weight data which can be seen in Table 1. wet weight data of Caulerpa racemosa for 30 days can also be seen in Figure 1.

Table 1. Average *Caulerpa Racemose* Wet Weight (Grams) for 30 Days

Treatment	**Seaweed Wet Weight (gram) ± SD**					
	Day-0	**Day-6**	**Day-12**	**Day-18**	**Day-24**	**Day-30**
K	25 g ± 0	32,1 ± 3,27	38,7 ± 9,11	48,2 ± 9,82	52,9 ± 9,11	58,6 ± 4,33
A	25 g ± 0	33,8 ± 2,86	44,0 ± 5,05	53,0 ± 7,05	60,0 ± 5,01	65,0 ± 4,72
B	25 g ± 0	24,6 ± 8,18	31,2 ± 9,82	38,7 ± 5,91	45,4 ± 2,84	42,6 ± 2,54
C	25 g ± 0	27,0 ± 6,61	30,7 ± 7,02	34,4 ± 5,28	38,4 ± 3,81	33,0 ± 2,40

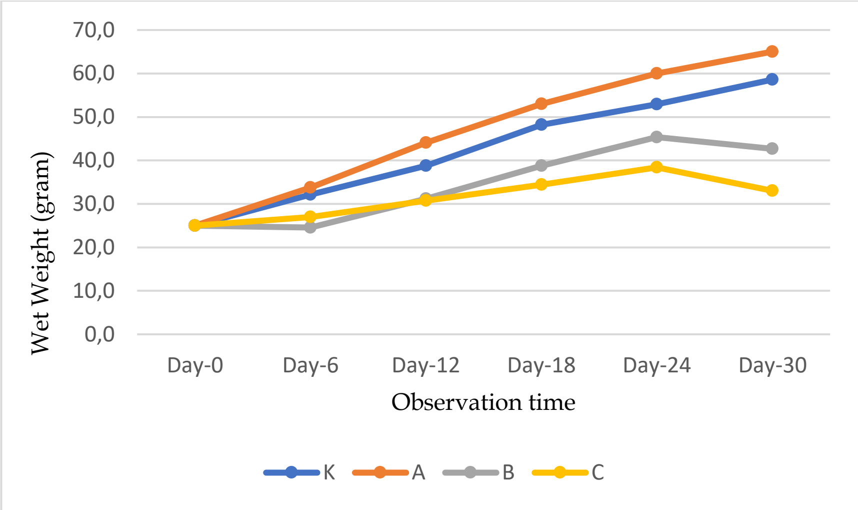

Figure 1. Histogram of *Caulerpa racemosa* Wet Weight Line for 30 Days

The specific growth rate of C. racemosa for 30 days is presented in Table 2, showing the SGR value for Control = 1.12% per day, A = 1.33% per day, B = 0.59% per day, while C = 0.27% per day.

Table 2. Average Specific Growth Rate (SGR) of *Caulerpa racemosa* 30 Days

Treatment	**SGR % ± SD**
K	1,12 ± 0,15
A	1,33 ± 0,16
B	0,59 ± 0,09
C	0,27 ± 0,08

The results showed that the growth of *Caulerpa racemosa* seaweed for 30 days increased in weight every week (Table 1). The results of the achievement of the average weight of seaweed for 30 days, in the control treatment (58,6 g), treatment A (65 g), treatment B (42,6 g), and treatment C (33 g). The highest average weight gain of *C. racemosa* was obtained in treatment A with the provision of liquid fertilizer containing N, P and K elements at different doses. According to Nasmia *et al*. (2020), mentioned that the provision of liquid organic fertilizer can increase cell metabolic activity in liquid organic fertilizer nutrients that can increase weight growth and followed by the resulting production.

Nitrogen is a macro element that serves to stimulate plant growth, so that plants can grow rapidly. Lack of N element will inhibit the growth of seaweed because it is an element used in the photosynthesis process. according to Kushartono *et al*. (2012), seaweed requires N levels around 5,44%. Liquid organic fertilizer used contains the element N of 4,15%. N levels in liquid organic fertilizer used although not in accordance with the needs of the element N seaweed *Caulerpa* sp, but can still help seaweed to sustain life. This can be seen from the observation of seaweed weight gain (Table 1). Nitrogen is needed as a building block of plant proteins, chlorophyll, nucleic acids and produce thin cell walls, so as to spur maximum plant production.

According to Sahir *et al*. (2022), that element P is an important element for all aspects of life, especially in the transformation of metabolic energy. The element P plays an important role for cell division. This P element deficiency can cause slow growth. According to Kushartono *et al*. (2012), the need for seaweed to the element P by 2-3%. Liquid organic fertilizer used contains P element of 4,45%. P levels in liquid organic fertilizer used is sufficient to meet the needs of the element P seaweed unutk grow, it can be seen from the observations of seaweed weight (Table 1). Giving organic liquid fertilizer has a pretty good result for the achievement of the weight of seaweed that showed an increase in the weight of seaweed *C. racemosa*. Element P is part of the cell nucleus and is important for cell division. Lack of P element can cause stunted growth, small number of buds, and slow growth. Element P acts as a limiting factor in the process of photosynthesis (Cyntya *et al*., 2018).

According to Nani *et al*. (2023), the K element is a macro nutrient, which is a nutrient that is needed in large quantities by plants. Lack of K element in seaweed plants can cause plants to wither, thallus becomes not strong and susceptible to disease. In addition, the lack of K element can result in the slow process of photosynthesis and growth and increased respiration process. Liquid organic fertilizer used contains K element of 5,66%. Seaweed needs for K required 1.8%. Liquid organic fertilizer used for the study was sufficient to meet the needs of seaweed.

Water quality measurements in this study include temperature, salinity, pH and DO. The results of the water quality range measurements obtained for 30 days are presented in Table 3.

Table 3. Water Quality Parameters in Each Treatment for 30 Days

Parameters	**Treatment**				**References**
	K	**A**	**B**	**C**	
Temperature (°C)	31 - 32	30,4 - 31,3	30,4 - 31,5	30,2 - 31,6	26 - 30 °C [a)]
Salinity (ppt)	29 - 31	29,3 - 32,3	27,7 - 31	28,7 - 31,7	30 - 35 ppt [b)]
pH	7,1 - 7,3	7,1 - 7,3	7,1 - 7,3	7 - 7,3	6,8 - 9,6 [c)]
DO (mg/L)	6,5 - 7,5	6,5 - 7,6	6,4 - 7,6	6,4 - 7,6	5 mg/L [d)]

Description: a) Awaluddin *et al*. (2016); b) Kusmawati *et al*. (2018); c) Burdames dan Ngangi (2014); d) Ardiansyah *et al*. (2020)

The wet weight growth of a seaweed is influenced by the provision of good nutrients and is influenced by water parameters (Temperature, Salinity, pH and DO). Water parameters have an important role in the growth of seaweed, when the water parameters have a high enough value or less than the optimal value can cause the seaweed to delay its growth, even can cause death in seaweed. The average results of parameter measurements for each treatment showed temperatures ranging from 30,2 – 31,6 °C, salinity 27,7 – 32,3 ppt, pH 7 – 7,3 and DO 6,4 – 7,6 mg/L. According to Atmanisa (2020), the water quality can still support the life of seaweed because it is still in the normal range. The pH value in this study is quite good with a value of 7 – 7,3. According to Burdames and Ngangi (2014), the pH is suitable for seaweed growth is 6,8 – 9,6. The value of salinity in this study ranged from 27,7 to 32,3 ppt, at the value of salinity seaweed can still live. This is in accordance with Kusmawati *et al*. (2018), which states that the optimal salinity to support the cultivation of sea grapes (C. *racemosa*) ranges from 30 - 35 ppt. The temperature value in this study ranged from 31 – 31,6 °C, and at that temperature value seaweed can still live. This is reinforced by the statement Awaluddin *et al*. (2016) which states that seaweed can grow and develop well in waters that have a temperature range of 26 - 30°C. The value of dissolved oxygen (DO) in this study ranged from 6,4 – 7,6 mg/L, and at that DO value seaweed can still live. This is reinforced by the statement of Ardiansyah *et al*. (2020) which states that seaweed can grow and develop with the DO quality standard value for seaweed is more than 5 mg/L.

The specific growth rate of *C. racemosa* given several treatments of different doses of liquid fertilizer showed varying results. The highest SGR results were obtained by treatment A with an SGR of 1,33% per day, followed by SGR in the control treatment of 1,12%, treatment B of 0,59%, while treatment C had an SGR of 0,27%. The results of the Anova test of specific growth rate data show a Sig: 0,027 p value <0,05, so it is concluded that there are significant differences between treatments. This is as a result of the differences in each treatment on the dosing of liquid organic fertilizer. The results of the Post Hoc test showed that the location of the difference in the specific growth rate of C. racemosa seaweed due to the provision of different doses of liquid fertilizer is located in treatment A and treatment C. This is evident from the results of the Post Hoc test analysis. This is evident from the results of the analysis of Post Hoch test show significance value of 0,033 <0,05.

Specific growth rate of *C. racemosa* seaweed produced during the study as shown (Table 2), treatment A produced the best specific growth rate value of 1,33% / day (Table 2). The increase in weight of *C. racemosa* seaweed is due to the growth of thallus. This is due to the content of N, P, K in liquid fertilizer that helps in the process of seaweed growth and also meet the nutrient needs of seaweed. N content in liquid fertilizer is 4,15%, and P 4,45%, K 5,66%. The addition of liquid organic fertilizer can be absorbed well by seaweed so as to increase growth during the maintenance period. Results in several studies such as Ginting *et al*. (2015) and Pradhika *et al*. (2019) showed that the provision of fertilizer in liquid form can affect the growth rate of seaweed. Another thing that affects is the amount of nutrients contained in liquid fertilizer so that it affects the initial absorption of *C. racemosa* seaweed. The lowest results occurred in treatment C. This is probably because there is a limit to the value of nitrate and phosphate that can be absorbed by *C. racemosa*. Each seaweed organism has a limit of nutrients that can be absorbed and has a sufficient ratio, especially between nitrate and phosphate, so that excess nutrients can cause plants to damage and wilt (Zainuddin and Nofianti, 2022). Differences in the specific growth rate of seaweed in *C. racemosa* in addition to influenced by the availability of sufficient nutrients is also influenced by water parameters (Budiyani *et al*., 2012).

Media that are given the addition of liquid organic fertilizer as an additional nutrient can increase the growth rate in certain treatments. When the media is given liquid organic fertilizer, the SGR value can increase, but it is necessary to control the media given additional fertilizer. Water turnover is one of the control efforts on media treated with fertilizer. The research conducted did not apply water changes to the media, causing a decrease in nutrient absorption due to nutrient accumulation or the growth of nuisance microorganisms such as algae.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results obtained in the study, it can be concluded that the effect of giving various doses of liquid organic fertilizer between treatments is significantly different. The effect of dosing liquid organic fertilizer in treatment A and treatment C is significantly different. This is evident from the results of the analysis of Post Hoch test show significance value of 0,033 <0,05. Treatment A has the highest average value of seaweed wet weight of 65,0 ± 4,72 g with an SGR value of 1,33% per day.

FURTHER STUDY

Further research is needed on the effect of giving a range of doses of liquid organic fertilizer on the specific growth rate of *C. racemosa* seaweed so that a more diverse specific growth rate of *C. racemosa* seaweed can be obtained. Need to do chlorophyll test on seaweed as supporting data on the growth of *C. racemose.*

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