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Effect of Phosphorus Concentration on Sea Grape Growth Rate (*Caulerpa racemosa*)

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Abstract

Sea grapes are one type of seaweed in Indonesia. One of them is *Caulerpa racemosa*. This study was conducted to determine the effect of phosphorus concentration on the growth rate of *C. racemosa* with different doses of fertilizer. This study was designed using a completely randomized design (CRD) consisting of four treatments and three replicates. The dose used is 0 ppm (control), 1.5 ppm, 3 ppm, and 4.5 ppm. *C. racemosa* were reared for 15 days in 35 cm plastic containers with a volume of water used during the rearing period of 10 liters, equipped with aerators and small aeration bubbles set with a stocking density of 25 grams. The results showed that the daily growth rate (DGR) of sea grapes ranged from 5.6-17.55%, final weight ranged from 10-31.3 g, antioxidant activity ranged from 30.49-38.66%, and chlorophyll content ranged from 26.21-31.35 mg/L. The DGR of *C. racemosa* was not substantially affected ($p>0.05$) by the fertilizer formulation dose concentrations. Further research needs to be done by adding phosphorus fertilizer doses for standard daily growth rate results.

INTRODUCTION

Indonesia is a maritime country with vibrant diversity and abundant natural resources, which can be utilized to improve the welfare of local communities, especially those living in coastal areas. One of the abundant biological resources in Indonesian waters is algae called seaweed. Seaweed contains components that are very beneficial for human health, including phenolic compounds, natural pigments, sulfate polysaccharides, and fiber. Seaweed is not only good for health, but also used in industry. Seaweed found in Indonesian waters is the most diverse compared to other countries. One type of seaweed in Indonesia is *Caulerpa racemosa* sea grapes (Adam *et al.*, 2023).

The seagrass species *C. racemosa* belongs to the Chlorophyceae class. Throughout the tropical Pacific region, particularly in the Philippines and Indonesia, *C. racemosa* is frequently eaten as a vegetable or as a fresh vegetable. The nutritional information of *C. racemosa* includes protein (10.7%) and carbs (27.2%), while the fat content varies between 0.3% and 0.3%, the water content is between 16 and 20%, and the crude fiber level ranges from 4.4 to 15.5%. In addition to having bioactive components that are beneficial as an antioxidant source, *C. racemosa* also

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includes carotene pigments (0.294%), chlorophyll derivatives (18.731%), chlorophyll a (26.817%), chlorophyll b (12.906%), and xanthophyll (29.758%). Along with minerals including phosphorus, potassium, salt, and iron, sea grapes also include vitamins A, B1, B2, B6, B12, and C. (Murti *et al.*, 2021).

Phosphorus is an important part of plant growth because cell membrane components and DNA have an important role in photosynthesis. Phosphorus plays a role in the formation of ATP (adenosine triphosphate), which is needed in the process of chlorophyll biosynthesis. Adequate phosphorus availability can increase the growth of sea grapes.

Seaweed growth is generally supported by phosphorus. Phosphorus interacts with other nutrients to influence how components required for the synthesis of sea grape growth are absorbed and utilized. In addition, the benefits of phosphorus for seaweed include aiding cell division, producing energy, helping the formation of cell structures, and helping seaweed in the process of photosynthesis. Growth can be inhibited by phosphorus deficiency. But too much phosphorus can also be harmful, causing toxicity or nutritional imbalances. Seaweed growth rate factors are influenced by several factors, such as water quality, temperature, salinity, pH, and the amount of light the seaweed receives. Two environmental elements have a significant impact on its growth. Different growth results are produced when sea grapes are grown in different locations with varying environmental conditions. Therefore, it is important to conduct this study to determine the effect of phosphorus concentration on the growth rate of sea grapes (*C. racemosa*).

METHODOLOGY

Ethical Approval

Not applicable as none of the authors of this paper have worked with animals in this study.

Place and Time

This research activity will be carried out from September to November 2024. Located at the Aquaculture Laboratory, Aquaculture Study Program, Department of Fisheries and Marine Science, Faculty of Agriculture, University of Mataram.

Research Materials

The tools used in this study include aerator stone type 30 mm (round), blower type LP 100, centrifuge tube type 50 ml, container type 35 cm x 46 cm x 32 cm (length x height x width), microscope type digital 12 MP with monitor & metal stand, digital scales type 50 grams, transparent aeration hose, Dissolved Oxygen meter type portable analyzer (China), refractometer type marumura brix size 17 x 4 cm (China), pH meter type digital marumura water quality (China), and lux meter type LX-1010B (USA).

Some of the materials used include seawater, sea grapes, foam, NK fertilizer brand meroke kalinitra, 46% urea fertilizer, and TSP fertilizer brand meroke.

Research Design

An experimental approach was used in this research project. A completely randomized design (CRD) with four treatments and three replications was used in this study. The growth rate of sea grapes as a function of dosage treatment was applied to the concentration of phosphorus fertilizer, namely 1: 0% (control), where nitogen+potassium, 2: 30 ppm Nitrogen + 1.5 ppm Potassium + 3 ppm Phosphorus, 3: 30 ppm Nitrogen + 3 ppm Potassium + 3 ppm Phosphorus, and 4: 30 ppm Nitrogen + 4 ppm Potassium + 3 ppm Phosphorus.

Work Procedure

Preparation of media and test materials

The medium used for the research activities was a rectangular 10-liter water container measuring 35 cm x 46 cm x 32 cm (length x width x height) with a container volume of 40 L, equipped with aeration using aerators and small aeration bubbles

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arranged with a stocking density of 25 grams of sea grapes per container. Sea grape cultivation was conducted outdoors under tarpaulin and netting. Sea grapes were cultivated using racks that were set up with rearing containers. The sea grapes used were Caulerpa racemosa species that had been sampled to see which sea grapes were not dead. The sea grapes that will be used are acclimatized first so that the sea grapes can adjust to the test container for 15 minutes a day, then the sea grapes are planted on the substrate in the form of baskets.

According to Nurjanah *et al.* (2019), the initial seedlings of *C. racemosa* were found in the maintenance tub and one planting medium. Favorable environmental factors such as light, nutrients, currents, temperature, salinity, pH, and substrate are optimal to influence the growth of *C. racemosa*. It is also influenced by the quality of the seeds planted and the type of technology used. Light plays a role in the photosynthesis process of algae, but the intensity of light that can be received by algae is strongly influenced by water depth. In addition to depth, the substrate as a place of attachment also has a very important role in cultivating *C. racemosa*. The ideal medium for the growth of this seaweed is sand mixed with pieces of coral (Genara *et al.*, 2022).

Fertilizer manufacturing

The fertilizers used were NK fertilizer, urea fertilizer, and TSP. NK fertilizer was weighed using a digital scale as much as 1.304 grams, and urea as much as 12.674 grams, then combined and put into 200 ml of sterile seawater. TSP fertilizer needs are weighed using a digital scale as much as 1.304 grams, which is dissolved using 200 ml of sterile seawater.

Fertilizer application

Based on the computation, fertilizers such as NK, urea, and TSP were dissolved. Additionally, each treatment was marked after the fertilizer was uniformly dispersed into the seawater media. The fertilizer given is NPK organic fertilizer trademark guano fertilizer which contains 8-13% Nitrogen, 5-12% Phosphor, 5-10% Calium (Valentine *et al.*, 2021) Fertilizers that have been dissolved with seawater are given to sea grapes that have been planted in the media during the cultivation period with a frequency of administration of 1 time.

Daily growth rate (DGR)

Sea grapes were taken, and the daily growth and development of the sea grapes were observed. Then, the weight of sea grapes was measured to determine the growth of seaweed. Then observed and calculated using the Daily Growth Rate calculation formula during the cultivation period. To calculate the Daily Growth Rate using the formula:

$$[(Wt / W0)\ 1/t - 1] \times 100\%$$

Description:

DGR	=	Daily growth rate of seaweed
Wt	=	Seedling weight at the end of the study
Wo	=	Seedling weight at the beginning of the study
t	=	Maintenance time (Days)

Antioxidant test

Antioxidant test is carried out using the DPPH method by first making a DPPH solution using ethanol solvent and forming the desired concentration, then making a test sample with a sample that has been dried and made seaweed extract, and then dissolved in a solvent. Then the DPPH solution is added to the sample solution (seaweed extract) and incubated for 24 hours. After incubation for 24 hours, measurements are taken using a spectrophotometer at the wavelength. After that, the determination of the IC50 value (sample concentration required to inhibit 50% of DPPH radicals) and calculated based on absorbance data that has been obtained.

Chlorophyll assay

Chlorophyll testing is done in two stages, namely sample preparation and the process of extraction and estimation of total chlorophyll. Sample preparation using fresh sea grapes. Fresh seaweed samples were prepared by cleaning the grape samples of dirt and washing them with running water.

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Fresh samples using clean seaweed were cut crosswise with a size of about 2 cm. There were four treatment groups in this study, namely fresh Caulerpa seeds extracted with acetone. Each group was replicated 3 times. 1 g of each wet sample was crushed, then added with 10 ml of acetone with a concentration of 100% while continuing to be crushed and changing color. After that, the extract was filtered, and the phosphate was centrifuged at 2500 rpm for 10 min. The supernatant was centrifuged again at 5000 rpm for 10 min. The absorbance of the supernatant for the acetone sample was measured at wavelengths 647 and 664. The absorbance values obtained were used for the calculation of chlorophyll estimation, and the original was expressed as µg/mL.

Tissue test

Tissue test is carried out using a wet sample that is sliced in the center of Caulerpa using a razor blade carefully so that the tissue part of the ramuli is not damaged. After that, observations were made using a microscope by looking for parts of the tissue that focused like a round (tissue) and the cortical part (the outer edge), and medullary (the center), then documented.

Water quality

Water quality observations were made three times a week, including temperature, salinity, pH, light intensity, and Dissolved oxygen (DO). In addition, water quality observations were made every day to prevent the occurrence of high water quality values during maintenance. Observations were made directly on each treatment.

Data Analysis

In this study, the data obtained were analyzed using analysis of variance at a confidence level of up to 95%. To be able to see the results of treatment comparison, it is necessary to conduct further tests using Duncan's test using SPSS.

RESULTS AND DISCUSSIONS

Daily Growth Rate (DGR)

Based on the results of the daily growth rate with the treatment of different concentrations of phosphate fertilizer on the daily growth rate of sea grapes *C. racemosa* species maintained for 15 days, showed that the daily growth rate of seaweed ranged from 5.6%-17.55% can shown in Figure 1. The results of the daily growth rate aim to determine the daily growth rate of seaweed during the maintenance period.

The test we did showed that adding different amounts of fertilizer (NPK) to sea grape plants didn't change how fast they grew or how many of them stayed alive. For example, when we used 1.5 grams of fertilizer (which we called P2), it was just as good as using no fertilizer at all (which we called P0). The same was true when we used 4.5 grams of fertilizer (P4) and 3 grams (P3); both were just like using no fertilizer. Since all the results were pretty much the same, we don't need to do any more complicated tests to see if there's a difference.

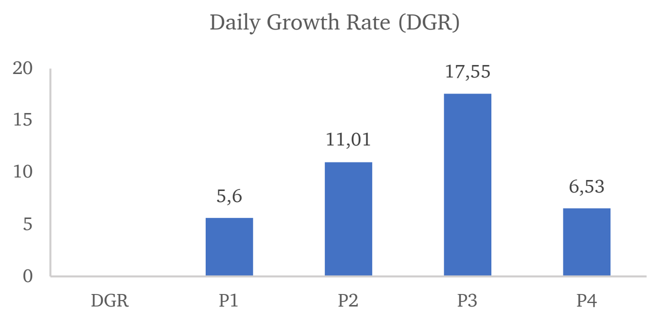

Figure 1. Daily Growth Rate Graph (DGR).

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Final Weight

Based on the results of this study showed that the average final weight of *C. racemosa* sea grapes maintained for 15 days using different concentrations of phosphorus fertilizer ranged from 10 g to 31.3 g, as shown in Figure 4.3. The highest average final weight was found in the P3 treatment with a fertilizer dose of 3 g/l, and the lightest weight at the end was seen in the P1 group, which was 0 g/l.

Based on the results of the calculation of the One-Way Anova test, it shows that the concentration of phosphorus fertilizer with different doses of fertilizer on the maintenance of sea grape species *C. racemosa* shows an effect that is not significantly different ($p > 0.05\%$) among all treatments.

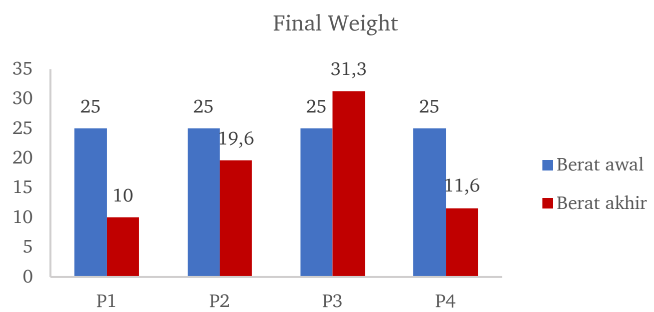

Figure 2. Final weight.

Antioxidant test

Based on the results of this study, the antioxidant activity of *C. racemosa* sea grapes reared for 15 days using phosphorus fertilizer concentrations with different doses ranged from 30.49-38.66%, as shown in Figure 4.4. The highest average was found in the P2 treatment, and the lowest antioxidant levels were in the P1 treatment.

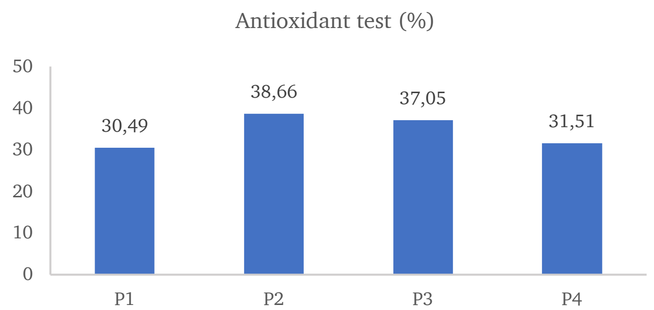

Figure 3. Antioxidant content.

Chlorophyll content

Based on the results of this study showed that the chlorophyll of sea grape species *C. racemosa*, which was maintained for 15 days with concentrations using phosphorus fertilizer with different doses, with an open maintenance site with direct solar utilization, ranged from 26.21 mg/L-31.35 mg/L. As shown in Figure 4.5. The highest average was found in the P4 treatment with a fertilizer dose of 4.5 ppm.

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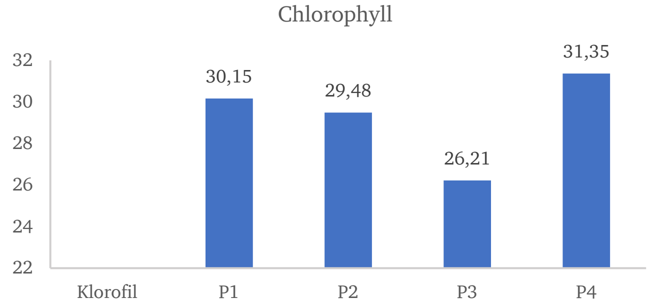
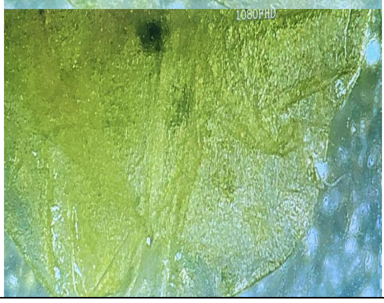


Figure 4. Chlorophyll content graph.

Tissue test

Based on the results of this study, the tissue slices of *C. racemosa* sea grape during the 15-day rearing period can be seen in Table 1.

Table 1. Tissue test.

Treatment	Picture	Description
A		K (Cortical): Small cells located at the periphery near the cell wall. M (Medular): Large cells located in the center
B		K (Cortical): Small cells located at the periphery near the cell wall. M (Medular): Large cells located in the center
C		K (Cortical): Small cells located at the periphery near the cell wall. M (Medular): Large cells located in the center
D		K (Cortical): Small cells located at the periphery near the cell wall. M (Medular): Large cells located in the center

Daily Growth Rate (DGR)

According to the findings regarding the Daily Growth Rate or the relative daily growth rate of sea grapes, specifically *C. racemosa*, the daily growth rate represents

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the assessment of how much relative daily growth occurs by the conclusion of the maintenance period. Calculation of daily growth rate by calculating the seaweed that lives at the end of maintenance (Wt) and the seaweed that is present at the start of upkeep (Wo). The results of the daily growth rate of sea grapes *C. racemosa,* with different doses of phosphorus fertilizer concentration treatment maintained for 15 days, showed that the daily growth rate obtained ranged from 5.6% to 17.5%. The highest average daily growth in the P3 treatment with a fertilizer dose of 3 mg/L was 17.5% and the lowest daily growth in the control treatment with a fertilizer dose of 0 mg/L was 5.6%.

According to Hendri *et al.* (2017), Growth can be deemed positive if the daily increase exceeds 2%. Additionally, it is explained that various factors can influence the growth rate, including the intensity of sunlight and sediment buildup on the talus, which can hinder growth. Sunlight is very important for photosynthesis; sunlight intensity, nutrient availability in the form of fertilizer, and depth also affect the growth of seaweed. The fertilizer used in this study was NK fertilizer with 13% N, 0% P_2O_5, and 46% K_2O. In contrast to the research of Ismail *et al.* (2014), fertilization is done using commercial NPK fertilizer brand Nitrophoska (15%, 15%, 15%), with the best growth rate at a dose of 2.5 gr/L fertilizer.

Fertilizer content in the form of nitrogen, potassium, and phosphate is a nutrient that is good for seaweed growth. The element phosphate is good for cell constituents that are important for thallus and as a nutrient for thallus growth. A high increase in phosphate concentration can result in seaweed growth that is not optimal and can cause the tip of the thallus to become clear. The phosphate content in sea grapes in this study was 9.07 mg/L. The good phosphate content for seaweed growth ranges from 2-3%. The value is relatively high for P content in sea grapes. The high value of P in seawater is thought to be due to the presence of aerators that are set large so that stirring occurs and can leave deposits of compounds below the surface of the media. Furthermore, the high P content in the seawater media of sea grape rearing is thought to be influenced by environmental habitats such as wave currents that carry nutrients. A good phosphate content in seawater ranges from 0.021- 0.201%. Surface seawater contains lower dissolved phosphate than deep-sea waters. According to Kushartono *et al.* (2009), the element P is part of the cell nucleus and is important for cell division. P deficiency can cause stunted growth and slow growth. Phosphorus deficiency can also cause the accumulation of large amounts of fat in the cells. Seaweed needs the element nitrogen is 5.44% and for the element P required seaweed requires 2-3%.

The concentration of nutrients (nitrate, phosphate, and ammonia) in seawater is the most important water quality parameter associated with the distribution and diversity of macroalgae in tropical waters. If nutrient levels are low, seaweed growth is inhibited. In treatment P1, sea grapes lack nutrients to support their growth. According to Roleda and Hurd (2019), explains that improving growth conditions in production systems requires a basic grasp of the sources of nutrients (carbon, nitrogen, and phosphorus) that seaweed may use and their nutritional requirements for maximum growth. The nutrients form a barrier to seaweed growth when the seaweed's demand for them exceeds its needs.

Final Weight

The final weight during the 15-day rearing period with different concentrations of phosphorus fertilizer doses, as in treatment P1, decreased in weight due to sea grapes bleaching in the ramuli, so that the sea grapes rotted and fell off. The final weight loss of sea grapes is thought to be due to weather, season, and environmental conditions. According to Nurjanah *et al.* (2018), stated that seasonal and environmental conditions greatly affect the growth of *C. racemosa*. Other factors that

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cause the low final weight of sea grapes are influenced by the presence of small animals that live in the ramuli of sea grapes. In addition, the low final weight value is due to the maintenance of seaweed different environment from its natural habitat, which can make seaweed re-adapt to the environment, such as substrate, salinity, temperature, light intensity, and nutrients.

According to Basyuni *et al.* (2024), states that the physiological habits of shellfish are highly dependent on the physical, biological, and chemical properties of macroalgae. The final weight loss of sea grapes is also thought to be due to a lack of adaptation to the new environment, so that sea grapes experience stress, resulting in sea grape ramuli beginning to turn white and gradually rot. According to Sia *et al.* (2024), photosynthetic organs, namely leaves, are more sensitive and susceptible to stress under unfavorable conditions, such as low salinity. In addition to salinity, high water temperatures may also have reduced the water content of sea grapes, resulting in leaf discoloration. Following this, damage occurs to the cells and reducing the fluidity of the cell membrane, and results in the leaves becoming limp. Further, the interaction and combined effects of multiple environmental conditions are crucial for outdoor farming, taking into account daily, seasonal, or long-term fluctuations and transitions (Stuthmann *et al.*, 2023).

Antioxidant Test

Based on the analysis of antioxidant tests on *C. racemosa* sea grapes during the 15-day maintenance period, where antioxidants are bioactive compounds contained in seaweed that can protect seaweed with strong antioxidant capacity. Antioxidant compounds in seaweed are referred to as phenolics and flavonoids. According to Sommer *et al.* (2022), seaweed contains bioactive compounds that have a significant antioxidant capability to safeguard itself. Seaweed antioxidant components are members of a significant class of phytochemicals called phenolics and flavonoids (phenolic derivatives). This is because seaweed contains hydroxyl groups, which act as hydrogen donors to stabilize free radicals and stop them from forming new ones. *C. racemosa* sea grapes possess elevated phenolic and flavonoid characteristics. Further explained by Syakilla *et al.* (2022), *C. racemosa* is found to have high phenolic and flavonoid content, good scavenging and reducing properties, and high antioxidant capacity.

Seaweed contains many antioxidants because it has photosynthetic content, contains several pigments, and phenolic compounds. Phenolic compounds function as antioxidants. Photosynthetic activity requires sunlight, which is necessary for the photosynthesis process. Lack of light absorption in sea grapes can inhibit the photosynthesis process and cause stress. Under stress conditions, sea grapes can inhibit the process of cell division. According to Sia *et al.* (2024), under stress conditions, inhibition of photosynthetic activity can be caused by a reduction in chlorophyll content, caused by the inability of chloroplasts to align themselves for maximum light absorption required for photosynthesis.

In this study, the value of P2 has a value of 38.66%; the value of this content is high because there is no competition for nutrients in the form of sunlight supply needed for the photosynthesis process. In the P1 treatment, the antioxidant content value is 30.49%, the P3 treatment has an antioxidant content of 37.05%, and the P4 treatment has an antioxidant content of 31.51%. The value of antioxidant content includes very strong antioxidant activity, where the antioxidant activity of *C. racemosa* sea grapes has an IC_{50} range value of <50 ppm – IC_{50}> 200 ppm. According to Damayanti *et al.* (2024), the value of IC_{50} 50-100 ppm is strong, IC_{50}>100-150 ppm is moderate, IC_{50}>151-200 ppm is weak, and IC_{50}>200 ppm then the antioxidant activity in sea grapes is very weak. The antioxidant process is influenced by light intensity, which can affect the quality of antioxidants.

Tissue test

The thallus tissue of *C. racemosa* is irregular because it contains liquid. The form of cortical tissue, cell walls, and epidermal tissue is not visible. Environmental conditions affect cell changes, tau tissue cell formation, and the growth of seaweed. Seaweed growth is influenced by the environment, and seaweed requires low rainfall. This is caused by water quality that supports the growth of seaweed and cell tissue.

Observations of thallus tissue in *C. racemosa* seaweed after the maintenance period for 15 days obtained results in treatment A (control), showing the shape and size of the tissue is still clearly visible where the shape of the tissue in the outer layer which is near the cell wall has a small size and elongated, then in the middle there is a network of cells that are large and not visible like cell tissue in general. Observation of tissue slices in treatment B (P1) shows that the shape and size of the cortical layer are still clearly visible, and there are cells in the middle, namely, large medullary cells that are not visible. According to Jayusri *et al.* (2023), which states that different seaweed environmental conditions can affect the speed can affects the need for nutrients needed for thallus growth, which affects cell changes to form organs with different structures.

Observations of thallus tissue in treatment C (P2), showed that the cortical or tissue at the edge of the cell wall has the same shape and size as the initial slice of the cortical is still clearly visible where the cortical is small and oval, while in the middle there is a medular not visible which has a large size and the distance between cells is very tenuous with irregular slices of tissue cells. According to Yatin *et al.* (2023) and Utami *et al.* (2024), the characteristics of a good seaweed tissue structure are characterized by the presence of cells on the outside with a small size, round/oval shape, and dense, while there is a middle part of the cell that is larger and more tenuous.

The shape of the thallus tissue in treatment D (P3) showed that the slices of cell tissue near the cell wall were small, round, dense, but irregular, and damaged. While the slices of medullary cell tissue were large in the center, and more tenuous in the periphery. According to Yatin *et al.* (2023), the growth and development of seaweed is inhibited if it does not get enough nutrients.

Chlorophyll content

Based on the results of the analysis of chlorophyll content in sea grapes of the type *C. racemosa,* which was maintained for 15 days with phosphorus fertilizer concentrations at different doses. Sea grapes have content such as chlorophyll. Chlorophyll is a substance that plays a role in the process of photosynthesis and the growth of sea grapes. Placement of sea grape rearing on the surface is very important to note so as not to hinder the penetration of incoming light. Sea grapes need sunlight for the photosynthesis process. In addition to sunlight, the photosynthesis process in seaweed also requires chlorophyll. Sea grapes of type *C. racemosa* had a chlorophyll concentration ranging from 26.21 mg/L to 31.35 mg/L. The dark thallus color after the investigation indicates a high chlorophyll concentration. The higher the chlorophyll content in sea grapes, the more optimal the photosynthesis process will be. In addition, the high value of chlorophyll content in the P4 treatment is thought to be due to the placement of planting media exposed to direct sunlight.

According to Valentine *et al.* (2021), the high content of chlorophyll a and chlorophyll b in sea grapes is caused by high pigment content. High pigment content in sea grapes can be evidenced by the color of the thallus, which is rather gel-like at the end of the study. *C. recemosa* has a chlorophyll a content (10.08 – 17.4 µg/mL) and chlorophyll b (15.2 – 31.2 µg/mL), while Sanchez *et al.* (2018) reported chlorophyll a (3.0151 ± 0.4273 µg/mL), chlorophyll b (3.4289 ± 1.1454 µg/mL). The different chlorophyll content values indicate that the seaweeds have comparable chlorophyll content values and that location and seaweed species have an effect on chlorophyll content.

Water quality

Based on sea grape research on the effect of the use of phosphorus fertilizer concentrations given with different doses on the growth of sea grape species *C. racemosa*, water quality measurements are also carried out because it is very important to do so. Temperature, pH, dissolved oxygen, salinity, and light intensity are the water quality characteristics that are assessed during the maintenance period.

The results of temperature measurements during the study period ranged from 22.1 to 26˚C, indicating that the seawater media used in rearing sea grapes still have a good range of temperature values for the cultivation of *C. racemosa*. Low salinity values are influenced by seasons, such as erratic rainfall. According to Tolentino and Sorio (2021), sea grapes decay rapidly at temperatures below 15°C and above 30°C; therefore, maintaining a steady temperature of 20°C is ideal for handling. In the meantime, as per Maradhy *et al.* (2022), the physical, chemical, and biological characteristics of the environment have an impact on seaweed production, and water quality is one of the key elements that promote seaweed development. Aquaculture performance will be impacted by a decline in water quality. The talus becomes yellowish and pale due to high water temperatures, which might potentially be harmful. Burdames and Ngangi (2014) added that choosing the right site for seaweed growth operations has an impact on the success of seaweed cultivation.

Salinity is the amount of salt dissolved in seawater. Salinity is expressed in grams per liter of seawater. During the study, the salinity obtained ranged from 33-35 PPT, which is a good range of values in the growth of *C. racemosa* sea grapes. According to Aris *et al.* (2021), the optimal salinity can increase the increase in the number of cells and explant weight in the range of 25, 30, and 35 PPT. However, during the maintenance period, there was an increase in salinity, which inhibited the growth of sea grapes and caused the sea grape thallus to turn white and rot. Yuliyana *et al.* (2015) claimed that every marine creature, including *C. racemosa*, has a unique spectrum of tolerance to salinity. At salinities of 15 ppt and 55 ppt, *C. racemosa* species decay in three days, turn white over time, and soften. If the salinity is too low (less than 20 parts per thousand) or too high for a certain time, seaweed will develop slowly. The growth and development of algae cells is linear and inversely proportional (negative) to the increase in salinity when the seawater's salinity range exceeds what is ideal for algae. During the maintenance period, the salinity value. Salinity reduces the growth rate by reducing the rate of cell enlargement in some parts of the talus. The impact of high salinity on algal growth and structural changes includes a reduction in stomatal size. As a result, nutrient and water absorption decrease and inhibit algal growth at the organ, tissue, and cell levels. High salinity is thought to be caused by an erratic environment.

CONCLUSION

The study concludes that the sea grape species *C. racemosa,* with the effect of phosphorus concentration on growth rate with different doses, does not significantly affect the daily growth rate. The highest growth rate was 17.5 g in the P3 treatment with a 3 ppm fertilizer dose. Suggestions from the research that has been done, researchers suggest conducting further research by adding fertilizer doses to determine the optimal growth of *C. racemosa* grapes.

CONFLICT OF INTEREST

No conflict of interest among all authors upon writing and publishing the manuscript.

AUTHOR CONTRIBUTION

Nunik Cokrowati (Conceptualization, project administration, and data curation), Rizky Amrina Rossada (Formal analysis), Eka Sunarwidihi Prasedya (Methodology).

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