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EFFECT OF LIQUID ORGANIC FERTILIZER (POC) SOAKING ON GROWTH AND CARRAGEENAN CONTENT IN SEAWEED (*Kappaphycus alvarezii*) CULTIVATION

Perendaman Pupuk Organik Cair (POC) pada pertumbuhan dan kandungan karagenan pada budidaya rumput laut (*Kappaphycus alvarezii*)

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ABSTRACT

Kappaphycus alvarezii is a seaweed widely cultivated in Indonesia due to its ability to produce economically valuable carrageenan. This study was conducted to analyze the effect of soaking with liquid organic fertilizer (POC) on the growth and carrageenan content of K. alvarezii. The study lasted for 45 days using a Randomized Block Design (RBD) consisting of three treatments: no POC soaking (P1), soaking with 200 mL of POC (P2), and soaking with 250 mL of POC (P3). Observations were made on absolute growth, specific growth rate (SGR), and carrageenan content. Based on the analysis results, the administration of POC through the soaking method had a significant effect on the growth of K. alvarezii (P<0.05). The highest absolute growth value was found in P2, which was 392±13.23 g, while the highest carrageenan content was found in P1 which was 27, 46%.

Keywords: *Kappaphycus alvarezii*; carrageenan; growth; liquid organic fertilizer.

ABSTARK

Kappaphycus alvarezii merupakan rumput laut yang banyak dikembangkan di Indonesia karena mampu menghasilkan karagenan yang bernilai ekonomis. Penelitian ini dilakukan untuk menganalisis pengaruh perendaman menggunakan pupuk organik cair (POC) terhadap pertumbuhan serta kandungan karagenan pada *K. alvarezii*. Penelitian berlangsung selama 45 hari dengan menggunakan Rancangan Acak Kelompok (RAK) yang terdiri atas tiga perlakuan, yaitu tanpa perendaman POC (P1), perendaman POC sebanyak 200 mL (P2), dan perendaman POC sebanyak 250 mL (P3). Pengamatan dilakukan terhadap pertumbuhan mutlak, laju pertumbuhan spesifik (SGR), dan kandungan karagenan. Berdasarkan hasil analisis, pemberian POC melalui metode perendaman memberikan pengaruh nyata terhadap pertumbuhan *K. alvarezii* (P<0,05). Nilai pertumbuhan mutlak paling tinggi ditemukan pada P2, yaitu sebesar 392±13,23 g, sedangkan kandungan karagenan tertinggi terdapat pada P1 dengan nilai 27,46%.

Kata kunci: *Kappaphycus alvarezii* ; karagenan; pertumbuhan; Pupuk organic cair.

INTRODUCTION

Kappaphycus alvarezii is defined as a macroalga that produces a strong, rigid gel (Riyaz et al., 2021). According to Rudke et al. (2020), *K. alvarezii* ranks fifth among the most cultivated macroalgae globally, serving as a primary source of carrageenan for the food industry. Simatupang et al. (2021) also identified *K. alvarezii* as the most significant carrageenophyte seaweed in Indonesia. Carrageenan is extracted from dried seaweed, and its yield is expressed as a percentage of the seaweed's weight (Failu et al., 2016). Rising demand for carrageenan has driven the adoption of strategies to boost productivity, such as nutrient enrichment (NE) (Muyong & Tahiluddin, 2024).

K. alvarezii cultivation productivity faces constraints due to limited nutrient availability in the water, resulting in suboptimal growth (Sarri et al., 2022). Seaweed requires nutrients obtained through its thalli and relies on light (Xiao et al., 2019). Nutrient limitation poses a major challenge for seaweed farmers (Tahiluddin & Roleda, 2025); for instance, relatively low seaweed growth has been reported in the southern Philippines (Tahiluddin et al., 2022a). Nutrient enrichment can enhance *K. alvarezii* growth during the initial cultivation phase (Narvarte et al., 2026).

Inorganic fertilizers developed for terrestrial crops have been shown to increase the growth rate of *Kappaphycus*, resulting in high biomass production within approximately 20 days (Tahiluddin et al., 2022b). The application of fertilizers also aims to increase nutrient levels in the water, specifically the concentrations of ammonium, nitrate, and phosphate (Alam et al., 2025). Nutrients in the cultivation environment can be supplied through fertilization (Aufat et al., 2025b). Adriani et al. (2024) argue that sustainable seaweed production requires consideration of environmental factors—such as water nutrients, temperature, salinity, water clarity, and water flow—which influence metabolism, photosynthesis, and physiological balance. Low metabolic requirements are thought to depend on nutrients stored within the thallus as well as low nutrient levels in the surrounding water (Martinez et al., 2012).

Increasing the availability of nitrogen and phosphorus is crucial for seaweed growth (Kai et al., 2026). An appropriate cultivation system influences the effectiveness of nutrient uptake (Glauco et al., 2024). Previous studies have shown that soaking *K. alvarezii* in liquid organic fertilizer can enhance its growth (Akmal et al., 2015; Ismail et al., 2014). Methods capable of improving both harvest yields and product quality are needed (Aufat et al., 2025a). Therefore, this study aims to investigate and evaluate the effects of liquid organic fertilizer on seaweed growth and carrageenan content. The findings are expected to serve as a scientific resource to help boost seaweed harvest productivity.

RESEARCH METHODS

Place and Time

This research was conducted in the waters of Pasir Panjang, Kelapa Lima Urban Village, Kupang City, East Nusa Tenggara Province, over a 45-day period from December 2025 to January 2026. Analysis of carrageenan content was performed at the Bioscience Laboratory of Nusa Cendana University. This location was selected for the study because it is one of the most active seaweed farming areas in Kupang City.

Water temperatures at the site remained within the optimal range. Throughout the 45-day study period, observations were made regarding various water quality parameters, including temperature, pH, and salinity. The results showed water temperatures ranging from 29 to 32°C, pH levels between 7.5 and 7.9, and an average salinity of 29 ppt. Overall, these conditions were conducive to the growth of *Kappaphycus alvarezii*. According to the

National Board of Standards (BSN, 2022), the water temperatures recorded during the study—ranging from 26 to 32°C—fall within the ideal range for seaweed cultivation.

Tools and Materials

The tools used in this research are long line, anchor rope, buoy, weight, bamboo support, ruler, thermometer, refractometer, pH meter, digital scale, camera, writing instruments, and a soaking container measuring 120 × 40 × 32.5 cm. The materials used consist of Kappaphycus alvarezii seaweed seeds, sea water, and NASA liquid organic fertilizer (POC NASA).

Research Design

The study employed a Randomized Block Design (RBD) consisting of three treatments and three replicates. Blocking was based on the position of the cultivation units along the longline—specifically the front, middle, and rear sections—to account for environmental variation. For each treatment, 20 L of seawater was added as the soaking medium; this volume was selected because it allowed for the complete and uniform submersion of the samples without excessively diluting the fertilizer solution. The seaweed seedlings were obtained from local farmers and selected based on specific criteria: they were healthy, brightly colored, free of thallus damage, and showed no symptoms of disease. Each seedling bundle had an initial weight of 50 g. While previous research by Suheri et al. (2015) utilized fertilizer dosages in the range of 25–150 ml/L, the present study tested higher dosages to observe the seaweed's response to increased fertilizer concentrations. The fertilizer dosages used in this research are listed below:

P1 : Without soaking in POC NASA fertilizer
P2 : Soaking in 200 ml of POC NASA fertilizer
P3 : Soaking in 250 ml of POC NASA fertilizer

Research Procedure

Prior to treatment, clean seawater was used to cleanse *K. alvarezii* seedlings of debris and attached organisms. The seedlings were then soaked according to the treatment protocol for 6 hours in containers holding 20 L of seawater. No aeration was used during the soaking process. The containers were left uncovered and exposed to direct sunlight so that the soaking conditions approximated the environmental conditions of field cultivation. Following the 6-hour soaking period, the seedlings were tied to cultivation lines at 20 cm intervals and cultured using the long-line method for 45 days. According to Aslin et al. (2019), a planting distance of 20 cm yields the highest biomass growth, daily growth rate, and chlorophyll content across all *K. alvarezii* seedling sources. The study population consisted of all *Kappaphycus alvarezii* seedlings cultivated at the research site, while the study samples comprised seedlings that met health criteria and were used in each experimental unit. Each experimental unit utilized seedlings with an initial weight of 50 ± 2 g. Observations were conducted on growth parameters, carrageenan content, and water quality. Growth measurements were taken every eleven days—specifically on days 0, 11, 22, and 33. Water quality measurements, covering temperature, salinity, and pH, were also performed throughout the study period. At the end of the cultivation period, carrageenan content was analyzed.

Research parameters

1. **Absolute growth**

Absolute growth refers to the increase in seaweed weight, calculated as the difference between the weight at the end of the cultivation period (day 33) and the weight at the beginning. Growth observations were conducted from the start to the end of the study period. According to Aslin et al. (2019), the absolute growth value can be calculated using the following formula:

$$G = Wt - W0$$

Description:
G = Average absolute growth (g)

Wt = Seedling weight at the end of the study (g)
W0= Weight of the seedlings at the start of the study (g)

2. Specific growth rate

Specific growth rate was measured at 11, 22, and 33 days, resulting in three measurements by the end of the study. According to Aslin et al. (2019), the specific growth rate can be calculated using the following formula:

$$LPS = \frac{lnWt - lnWo}{t} X\ 100\%$$

Description:
SGR : specific growth rate (%/day)
Wt : Seaweed weight at the end of the cultivation period (gr)
Wo : Seaweed weight at the start of the cultivation period (gr)
T : Maintenance time (days)

3. Carrageenan

Carrageenan is a compound obtained through the extraction of dried seaweed; the yield is expressed as a percentage of the seaweed's weight (Failu et al., 2016), with samples for parameter measurement collected on day 45. Carrageenan content analysis was conducted following the Standard Operating Procedures (SOP) of the Bioscience Laboratory at Nusa Cendana University, incorporating modifications from previous studies. The analysis began by thoroughly washing the seaweed to remove adhering impurities (Erjanan et al., 2017; Dhewang et al., 2023), followed by soaking the samples in water for approximately 24 hours. Subsequently, the samples were drained and cut into smaller pieces to facilitate the extraction process. Extraction was performed using a 0.3 N NaOH solution at a ratio of 1 g of sample to 30 mL of solution, maintaining the pH between 8 and 9. The mixture was then heated in a water bath at 90°C for 2 hours (Dhewang et al., 2023) until the carrageenan components dissolved.

The extract was filtered while hot using a filter cloth or a 50-mesh sieve to separate the filtrate from the residue. Ethanol (95%) was added to the filtrate—in a volume twice that of the filtrate—to precipitate the carrageenan. The solution was allowed to stand until a precipitate formed; the precipitate was then separated and dried in an oven at 50–60°C until a constant weight was achieved. Carrageenan content was calculated based on the ratio of the obtained carrageenan weight to the sample's dry weight, using the following formula:

$$\text{Carrageenan percentage} = \frac{Carrageenan\ weight}{Dry\ weight}\ x\ 100\%$$

Data collection technique

Data on the absolute growth of the seaweed were analyzed using ANOVA to determine the effect of applying POC NASA fertilizer on the growth of *K. alvarezii*. If significant differences were found, the analysis proceeded with an LSD test at the 5% level to examine differences between treatments. Data on specific growth rate (SGR) and carrageenan content were processed using Microsoft Excel to calculate mean values and were presented in graphical form to facilitate comparison across treatments.

RESULT

Absolute Growth

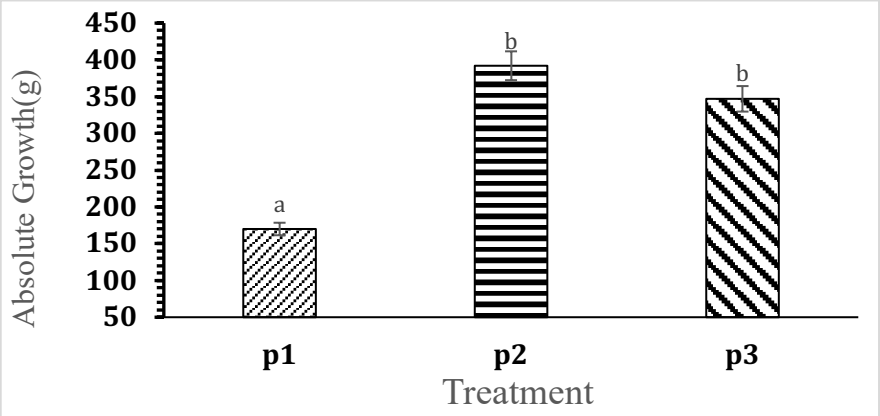

Figure 1. Absolute growth graph of *K. alvarezii* seaweed

Figure 1 illustrates the absolute weight for each treatment; the highest absolute growth value was observed in treatment P2 (200 ml POC NASA) at 392 ± 13.23 g, followed by treatment P3 (250 ml POC NASA) at 347 ± 58.16 g, while treatment P1 (no soaking) showed the lowest value at 170 ± 19.43 g.

Specific Growth Rate (SGR)

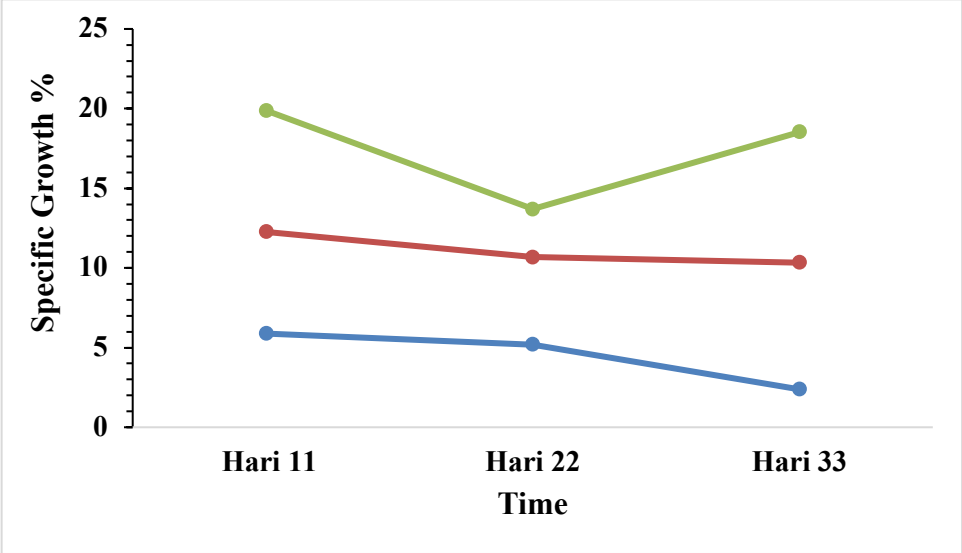

Figure 2. Graph of the specific growth rate (SGR) of *K. alvarezii* seaweed during the study

The specific growth rate (SGR) results are shown in Figure 2; the SGR values fluctuated across the observation periods. On day 11, treatment P3 (250 ml POC NASA) yielded the highest SGR at 7.62%, followed by P2 (200 ml POC NASA) at 6.38% and P1 (no soaking) at 5.88%. On day 22, all treatments showed a decline in SGR, particularly P3 (250 ml POC NASA), which dropped to 3.02%. Subsequently, on day 33, SGR values increased again for P2 (200 ml POC NASA) and P3 (250 ml POC NASA) to 7.95% and 8.21%, respectively, whereas P1 (no soaking) exhibited the lowest value at 2.38%.

Carrageenan Content

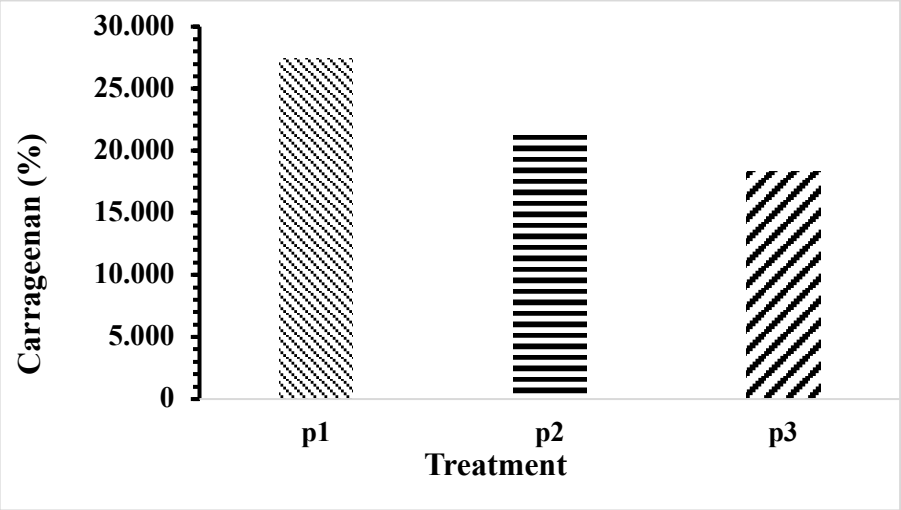

Figure 3. Carrageenan content of *K. alvarezii* seaweed for each treatment

The results of the carrageenan analysis are shown in Figure 3. The analysis indicates that the highest carrageenan content was obtained in treatment P1 (without fertilizer soaking) at 27.460%, followed by P2 (200 ml POC NASA) at 21.586% and P3 (250 ml POC NASA) at 18.340%.

DISCUSSION

Absolute Growth

Absolute growth is defined as the average change in body weight during the cultivation period, or as the total growth achieved by the seaweed throughout the rearing phase (Mapparimeng et al., 2019). The application of POC NASA fertilizer had a significant effect on the absolute growth of *K. alvarezii* seaweed ($P<0.05$). Treatment P3 (soaking in 250 ml POC NASA) did not differ significantly from treatment P2 (soaking in 200 ml POC NASA) ($p>0.05$); however, both treatments differed from treatment P1 (no fertilizer soaking) ($p<0.05$). These results indicate that soaking seedlings in POC NASA enhances the growth of *K. alvarezii* compared to the absence of fertilizer treatment. The high absolute growth observed in the 200 ml POC NASA (P2) and 250 ml POC NASA (P3) treatments is likely attributed to the availability of macro-nutrients—specifically nitrogen (N), phosphorus (P), and potassium (K)—in quantities that meet the seaweed's requirements (Ismail et al., 2014). Nitrogen plays a role in supporting plant growth and contributes to chlorophyll formation, resulting in a greener and fresher appearance (Syamsuddin & Rahman, 2014). A deficiency in specific nutrients, such as nitrogen, leads to lighter pigmentation and a softer, weaker thallus (Tahiluddin & Roleda, 2025). Low nitrogen availability is expected to limit seaweed growth and negatively impact physiological processes, such as chlorophyll formation and protein synthesis (Kai et al., 2026). Phosphorus supports the formation of meristematic tissue, stimulates cell division, and aids in repairing damaged tissue (Syamsuddin & Rahman, 2014). Phosphorus deficiency leads to thallus fragmentation (Tahiluddin & Roleda, 2025). Meanwhile, potassium contributes to the activity of enzymes involved in protein synthesis (Manik, 2020). These findings align with the study by Ismail et al. (2014), which reported that the application of nutrients containing N, P, and K enhances seaweed growth rates by boosting photosynthetic activity and cellular metabolism. However, the growth values obtained in this study differ from those of some previous studies. These discrepancies are likely attributable to various factors, such as aquatic environmental conditions, seedling quality, cultivation duration, fertilizer application methods, and fertilizer concentrations. Such factors can influence the seaweed's ability to absorb nutrients and convert them into biomass.

Although treatment P3 (250 ml POC NASA) received a higher fertilizer dosage than P2 (200 ml POC NASA), the resulting growth did not differ significantly. This indicates that increasing the fertilizer dosage is not always accompanied by increased growth. According to Balina et al. (2016), excessive nutrient levels can induce toxic effects, significantly inhibit growth, and ultimately lead to algal mortality. At the 200 ml dosage (P2), nutrient requirements to support physiological processes and thallus growth were presumably met optimally. Increasing the dosage to 250 ml (P3) did not yield significant growth improvements because seaweed has a finite capacity for nutrient absorption. Once nutrient requirements are satisfied, excess nutrients are no longer effectively utilized for biomass formation. These findings align with Aufat et al. (2025b), who stated that fertilizer effectiveness depends on dosage and frequency.

During the study, the water quality parameters monitored included temperature, pH, and salinity. Measurement results showed water temperatures ranging from 29–32°C, pH levels between 7.5 and 7.9, and an average salinity of 29 ppt. According to the National Standardization Agency (BSN, 2022), the suitable temperature range for seaweed cultivation is 26–32°C. Thus, the temperatures recorded during the study remained within tolerable limits. The pH values, ranging from 7.5 to 7.9, were also suitable for seaweed growth, as they fell within the optimal range of 7.5–8.3 (Pauwah et al., 2020) and met the water quality standards for seaweed cultivation (7.0–8.5; BSN, 2022). Meanwhile, the average salinity of 29 ppt fell within the ideal range of 28–34 ppt (BSN, 2022); this level is tolerable for the seaweed and thus continues to support its growth.

Specific Growth Rate (SGR)

Specific growth rate (SGR) is used to describe the percentage increase in seaweed weight per day during the cultivation period. Measurements were taken every 11 days throughout the study. Observations revealed fluctuations in SGR values across the different observation periods. On day 11, treatment P3 (250 ml POC NASA) yielded the highest SGR at 7.62%, followed by P2 (200 ml POC NASA) at 6.38% and P1 (no soaking) at 5.88%; this indicates that during the initial cultivation phase, the seaweed possessed a high capacity to absorb and utilize nutrients from the fertilizer (Aufat et al., 2025b). However, P2 and P3 showed higher SGR values compared to P1, with the rapid seaweed growth linked to metabolic processes (Narvarte et al., 2026). Fertilizers can enhance metabolic activity (Aufat et al., 2025b). The superior growth observed in P2 and P3 compared to other treatments is also attributed to the seaweed's adaptability and resilience to environmental changes (Cokrowati et al., 2024).

A seaweed growth rate exceeding 3% per day is considered favorable for cultivation (Arjuni et al., 2018). Based on this criterion, the initial SGR values for P1, P2, and P3 indicate that the seaweed was in an optimal growth state, suitable for successful cultivation. Haryasakti (2017) explains that environmental factors, such as the availability of phosphate and nitrate, play a crucial role in determining seaweed growth rates. The nitrogen content in the fertilizer contributes to chlorophyll formation, while phosphorus plays a role in meristem tissue formation, stimulates cell division, and aids in repairing damaged tissue (Syamsuddin & Rahman, 2014). By day 22, all treatment groups exhibited a decline in Specific Growth Rate (SGR) values; notably, treatment P3 (250 ml POC NASA) dropped to 3.02%. This decline is attributed to the reduced availability of nutrients from the fertilizer treatments (Aufat et al., 2025b). Furthermore, while the fertilizer is rapidly absorbed by the seaweed, it does not persist for long in the aquatic environment (Aufat et al., 2025b). Subsequently, on day 33, SGR values rose again for treatments P2 (200 ml POC NASA) and P3 (250 ml POC NASA) to 7.95% and 8.21%, respectively, whereas P1 (no soaking) showed the lowest value at 2.38%. The increase in SGR on day 33—particularly in the treatments receiving POC NASA fertilizer—indicates a

rapid physiological response to nutrient availability (Aufat et al., 2025b). This initial increase likely reflects accelerated nitrogen assimilation, which supports photosynthetic capacity and thallus growth (Narvarte et al., 2026).

Carrageenan Content

Carrageenan is the weight percentage of carrageenan produced from extracted dried seaweed (Failu et al., 2016). Carrageenan content is expressed as the percentage of carrageenan extraction results to the dry weight of seaweed samples. The analysis results showed that the highest carrageenan content was obtained in P1 (without fertilizer soaking) at 27.460%, followed by P2 (200 ml POC NASA) at 21.586%, and P3 (250 ml POC NASA) at 18.340%.

Based on the graph in Figure 3, it shows that increasing the dose of liquid organic fertilizer was not followed by an increase in carrageenan content. On the other hand, the treatment without fertilizer produced a higher carrageenan content than the treatment with fertilizer. This condition indicates that the growth response and carrageenan formation in K. alvarezii do not always run in the same direction. The results of this study are in line with several previous studies which reported that the relationship between growth and carrageenan content in K. alvarezii was not always positive. According to research by Narverta et al. (2026), i.e. Although repeated nutrient administration maintained higher growth and physiological performance, carrageenan yields decreased significantly. Rijoly et al. (2020) stated that high nitrogen absorption can increase the water content and growth of seaweed tissue so that the percentage of carrageenan formed tends to decrease. Thus, even though biomass increases, the carrageenan content calculated based on dry weight does not always increase. Based on the results of this research, it can be concluded that soaking in liquid organic fertilizer plays a greater role in increasing biomass growth than carrageenan accumulation. This shows that the success of seaweed cultivation is not only measured by increasing growth, but also needs to consider the quality of the results indicated by the carrageenan content.

CONCLUSION

Research results indicate that soaking *Kappaphycus alvarezii* seaweed in NASA liquid organic fertilizer (POC) effectively enhances its growth. Treatments involving soaking in 200 ml (P2) and 250 ml (P3) of the fertilizer yielded similar absolute growth results, whereas the treatment without soaking (P1) produced the lowest absolute growth. Throughout the cultivation period, specific growth rate (SGR) values fluctuated across all treatments; however, treatments P2 (200 ml NASA POC) and P3 (250 ml NASA POC) exhibited higher values compared to P1 (no soaking). Conversely, the highest carrageenan content was obtained from the treatment without fertilizer soaking (P1) at 27.460%, while treatments P2 (200 ml NASA POC) and P3 (250 ml NASA POC) yielded 21.586% and 18.340%, respectively. Thus, the application of NASA POC fertilizer can increase growth compared to no soaking, although carrageenan content may decrease with the use of this fertilizer.

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