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Enrichment of *Kappaphycus striatus* var. Sacol (Solieriaceae: Rhodophyta) using Liquid Organic Fertilizer Cultivated with Floating Net Cage and Longline Methods

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ABSTRACT

Kappaphycus striatus, a member of the Rhodophyta class, is extensively farmed by the coastal residents of Kupang, East Nusa Tenggara. The objective of this study was to examine the development and productivity of seaweed by the application of liquid organic fertilizer (LOF) using both floating net cages and the longline method. The data analysis was conducted via a factorial full random analysis approach. The findings indicated that the mean values of absolute growth, relative growth, daily growth rate, and production associated with the floating net cage method were 11.91± 0.80g/ day, 0.032± 0.002g/ g/ day, 3.14± 0.17%/ day, and 16.19± 1.08gdw/ m, respectively. Regarding the longline approach, the values obtained were 9.48± 2.09g/ day, 0.027± 0.004g/ g/ day, 2.65± 0.43%/ day, and 12.89± 2.84gdw/ m, respectively. The growth and output of seaweed can be influenced indirectly by the quality of water. The statistical analysis revealed a significant difference (P< 0.01) in the effect of seaweed cultivation when comparing the cultivation method with the LOF treatment.

INTRODUCTION

The East Nusa Tenggara Province is recognised as one of the five provinces in Indonesia that plays a significant role in seaweed production. In the year 2017, it contributed over 50% of the total wet seaweed production in Indonesia **(Waters *et al.*, 2019; van der Heijden *et al.*, 2022)**. The seaweed sector in Kupang, located in the East Nusa Tenggara region, has emerged as a significant contributor to aquaculture production over the past decade. Nevertheless, the present state of seaweed production is deemed suboptimal as a result of encountering ice- ice disease, experiencing shifts in seasonal patterns from the west wind season to the monsoon season, or vice versa, and contending with the repercussions of oil industry waste **(Ryan, 2018; Bagaskara *et al.*, 2021; Parry**

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& Ryan, 2021), employing rudimentary cultivation techniques **(Kusuma, 2020; Kusuma *et al.*, 2021; Kusuma *et al.*, 2021; Serihollo *et al.*, 2021)**, and utilising seeds of inferior quality **(Kusuma *et al.*, 2022)**.

Seaweed growth refers to the daily percentage increase in size or biomass. The development and production of seaweed are subject to various circumstances, including environmental elements such as water quality, climate conditions, current speed, and wave patterns. Additionally, biological factors like pests and diseases, as well as technical factors such as cultivation methods, varieties of seaweed, and site selection, also play a significant role in influencing seaweed growth and production. Nutrients are necessary for the stimulation of thallus growth in seaweed. According to **Umasugi and Polanunu (2019)**, the application of a growth stimulant to a plant induces the stimulation of meristem tissue cell division, resulting in cellular proliferation and development.

Enhanced productivity can be attained by leveraging readily available and adaptable technologies. There is a current endeavor to enhance the production of seaweed, which involves employing growing techniques that are tailored to suit the aquatic environmental conditions. Additionally, the supplementation of seaweed with nutrients, such as liquid organic fertilizer (LOF), is being explored as a means to further augment its growth. The longline method is frequently employed by seaweed producers in coastal regions. However, it is important to note that this approach presents a notable vulnerability to herbivorous fish, leading to potential attacks that can result in a significant decline in seaweed production, with reductions of up to 60% being seen. The implementation of the floating cage approach was initiated by Indonesian farmers in 2014 as a strategy to mitigate herbivorous fish predation **(Kasim *et al.*, 2016)**.

Alternative techniques for cultivating seaweed have been developed, such as the floating cages **(Kasim & Mustafa, 2017; Rauf *et al.*, 2021)** and the net bag method **(Kusuma *et al.*, 2021)**. The utilisation of LOF has been found to yield notable outcomes in terms of the development and productivity of seaweed, as demonstrated in studies conducted by **Sarira *et al.* (2018)** and **Kusuma *et al.* (2022**). Floating net cages represent a novel approach of cultivating seaweed, in contrast to the longline method which is plagued by several issues including the presence of predatory pests, thallus breakage, and the risk of epiphytic attacks. This study seeked to investigate the effects of employing floating net cage cultivation techniques and incorporating LOF on the growth and production of seaweed. The study examined two distinct methods of seaweed cultivation and evaluated the impact of *K. striatus*-fed LOF on seaweed growth and production.

MATERIALS AND METHODS

Research sites

A study was undertaken to investigate the production of seaweed utilising the floating net cage (FNC) technique in Bolok Waters, located in the Kupang Regency of East Nusa Tenggara Province, situated at coordinates 10°12′ 58"S and 123°31′21"E. The observations were conducted throughout the months of October and November in the year 2022. The initial investigation was conducted in three successive phases, specifically spanning from July to October 2022.

Cultivation materials, tools and construction

The acquisition of seaweed seeds is sourced from nearby agricultural producers. The seaweed that underwent testing was the young thallus of *Kappaphycus striatus*, which had an initial weight of 210.39± 6.58g. The seedlings were transported to the Teaching Factory for Aquaculture at the Kupang Maritime and Fishery Polytechnic, where they underwent a three-day acclimatisation period in the nets before being subjected to the experimental treatment. The LOF employed in this study is a commercially available fertilizer known as "D.I. Grow." The tools utilised for the application of this fertilizer include a 5 liter container, a ½ inches PVC pipe, T elbow, L elbow, elbows, PE nets with an eye size of ½ inches and a length of approximately 15m, an anchor rope measuring 8 inches in length and approximately 20m in total length, stone weights, buoys for 12 empty container with a capacity of 5 liter, and digital scales.

The fabrication of buoyant net enclosures utilising polyvinyl chloride (PVC) material, incorporating pipes and connectors as integral components. The netting envelops the cover and walls of the construction, secured in place through the utilisation of nylon rope. The seaweed floating net cages are specifically constructed to possess dimensions of 9 meters in length, 1.5 meters in width, and 1 meter in height. These cages are further separated into nine partitions, each partition measuring 1 meter in length, 1.5 meters in width, and 1 meter in height. To facilitate water entry and air escape, the PVC structure is perforated with small apertures. This design feature mentioned effectively mitigates buoyancy by ensuring that the surface of the floating cage remains submerged below sea level during low tide. The longline method involves the building of a lengthy rope of 10m, with clumps spaced at intervals of 20cm. This construction is equipped with anchor ropes and weights to provide stability and support to the extended structure.

Research design

The research employed a factorial fully randomised design (CRD) consisting of six treatments and three replications. The experimental variables included in this study encompassed the application of liquid organic fertilizer (LOF), the implementation of a floating net cage (FNC), and the utilisation of longline farming techniques. The treatment administered is outlined as follows:

- ✓ FNC_0 : FNC method + LOF 0 ml/l seawater (control)
- ✓ FNC_5 : FNC method + LOF 5 ml/l seawater
- ✓ FNC_7 : FNC method + LOF 7 ml/l seawater
- ✓ LL_0 : Longline method + LOF 0 ml/l seawater (control)
- ✓ LL_5 : Longline method + LOF 5 ml/l seawater
- ✓ LL_7 : Longline method + LOF 7 ml/l seawater

The process of irrigating the seaweed seedlings with LOF was conducted in the morning, utilising a concentration of 5 and 7ml/ l of seawater. Simultaneously, the experimental group alone employed seawater as a control, without the addition of any fertilizers. The immersion procedure was conducted for a duration of 15 minutes. Following the process of soaking, the seaweed seeds undergo coding, labelling, and subsequent placement into floating net cages, which are then fastened to longline ris ropes.

Data collection

At the Environmental Laboratory Technical Implementation Unit, Department of Environment and Forestry, East Nusa Tenggara Province, water samples were collected at the commencement and conclusion of the study to assess the amounts of nitrate, orthophosphate, and turbidity. These measurements were conducted ex-situ. The measurement of water quality in each variable is conducted with distinct devices. Dissolved oxygen and temperature were assessed using a dissolved oxygen M (Lutron DO-5510, with an accuracy of ±0.4mg/ l for dissolved oxygen and ±0.1℃ for temperature). pH was measured using a pH m (YEGREN TDS-PH01, with an accuracy of ±0.1). Salinity was determined using a refractometer (Atago S/Mill-E, with an accuracy of ±2g/ l). These measurements were conducted in-situ at the cultivation site. The collection of growth data was conducted on a weekly basis. Seaweed was extracted from floating cages and rope lines, thereafter subjected to a rinsing process utilising clean seawater in order to eliminate silt and epiphyte contaminants. The seaweed was then weighed to determine its mass.

Data analysis

Parametric testing was verified through the utilisation of normality tests, including the Shapiro-Wilk and Kolmogorov-Smirnov tests, as well as the assessment of homogeneity of variance using Levene's test. The growth rates and yields are shown in the form of mean ± standard deviation. The formulas for calculating the absolute growth rate and relative growth rate were derived from the work of **Hunt (1990)**. The calculation of the daily growth rate was based on the formula proposed by **Yong *et al.* (2013)**. The the productivity of seaweed cultivated using the longline method was determined using the formula proposed by **Serdiati and Widiastuti (2010)**, while the productivity of seaweed cultivated in cages was determined using the formula developed by **Ali *et al.* (2014)**. The study employed a one-way analysis of variance (ANOVA) with a significance level of P= 0.05 to assess the impact of growing method and doses of LOF on the growth and production of seaweed. The post hoc comparison approach employed in this study was Duncan's test, with a significance level set at P= 0.05. The statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software, specifically version 18.0.

RESULTS AND DISCUSSION

1. Seaweed growth

Kappaphycus striatus exhibited a growth pattern characterised by a relative growth curve and daily growth in the exponential phase during the initial three weeks. This was evidenced by a continuous increase in growth rate. Subsequently, in the fourth week, the growth entered a stationary biomass phase, followed by a decline in the fifth week (Fig. 2c- f). During the initial week to the subsequent week, the growth process remains in the phase of adapting to the surrounding environment, hence resulting in a relatively moderate growth rate. The growth value of seaweed cultivated in floating net cages surpasses that of the longline method. According to the findings of **Kasim *et al.* (2020)**, the cultivation of seaweed in floating net cages yields a luxuriant thallus with tapered ends, suggesting that this method of cultivation is superior to the longline approach in terms of seaweed output. The observed decline in the growth rate and weight gain of seaweed in both culture methods during the fifth week is hypothesised to be attributed to sedimentation resulting from tidal activity.

Table 1. The average growth of *Kappaphycus striatus* in all treatments (mean ± SD)

Treatment	AGR (g/day)	RGR (g/g/day)	DGR (%/day)
FNC_0	11,40±0,08 c A	0,0301±0,00 b A	2,97±0,03 b A
FNC_5	11,49±0,06 c A	0,0317±0,00 c B	3,13±0,03 c B
FNC_7	12,82±0,06 d B	0,0335±0,00 d C	3,31±0,02 d C
LL_0	7,07±0,12 a A	0,0219±0,00 a A	2,15±0,06 a A
LL_5	10,77±0,07 b B	0,0293±0,00 b B	2,89±0,03 b B
LL_7	10,60±0,20 b B	0,0296±0,00 b B	2,92±0,09 b B

Note: According to Duncan's follow-up, the mean value followed by the same letter was similar. Test at the 0.05 significance level. Lowercase letters are read vertically, comparing two methods on the same fertilized dose. Capital letters are read horizontally, comparing two fertilized doses to the same method.

1.1 Absolute growth rate (AGR)

The study involved the observation of the absolute growth of *K. striatus* over a period of five weeks, taking into account different fertilizer doses and cultivation methods (Fig. 2a- b). The statistical analysis of variance revealed substantial variations in the absolute growth of seaweed due to differences in cultivation methods and fertilizer doses (*P*< 0.01). The coefficient of variance was calculated to be 1.02%. The treatment with the highest absolute growth rate that is 12.82± 0.06%/ day was observed in the FNC_7 treatment, whereas the treatment with the lowest absolute growth rate that is 7.07± 0.12%/ day was found in the LL_0 treatment. The floating net cage method exhibited the highest absolute growth rate, resulting in the production of 266g of wet seaweed from an initial weight of 50kg. Table (1) displays the mean absolute growth weights of *K. striatus*.

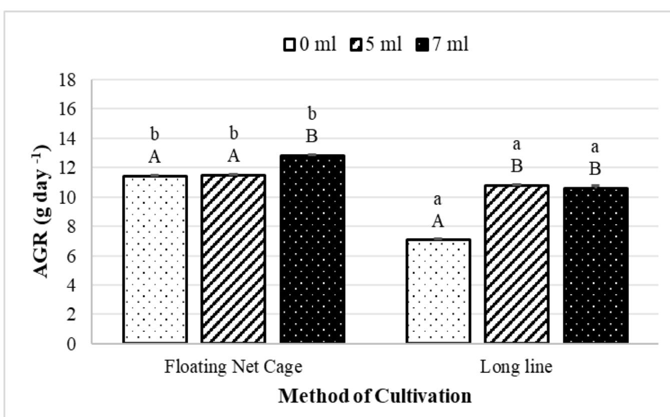

Figure 1. The absolute growth rate of seaweed cultivation in treatment. According to Duncan's follow-up, the mean value followed by the same letter was not significantly different. Test at the 0.05 significance level. Lowercase letters are read vertically, comparing two methods on the same fertilized dose. Capital letters are read horizontally, comparing two fertilized doses to the same method

The weight gain of seaweed on a weekly basis is depicted in Fig. (2a- b). The highest absolute growth was observed during the fifth week, with the floating net cage method exhibiting an absolute growth value of 11.91g/ day and the longline method showing a value of 9.48g/ day. Seaweeds get an adequate supply of nutrients through water currents and receive sufficient sunshine for the process of photosynthesis, resulting in optimal growth. Seaweed growth is facilitated by favorable environmental parameters, whereas unfavorable environmental conditions impede optimal seaweed growth.

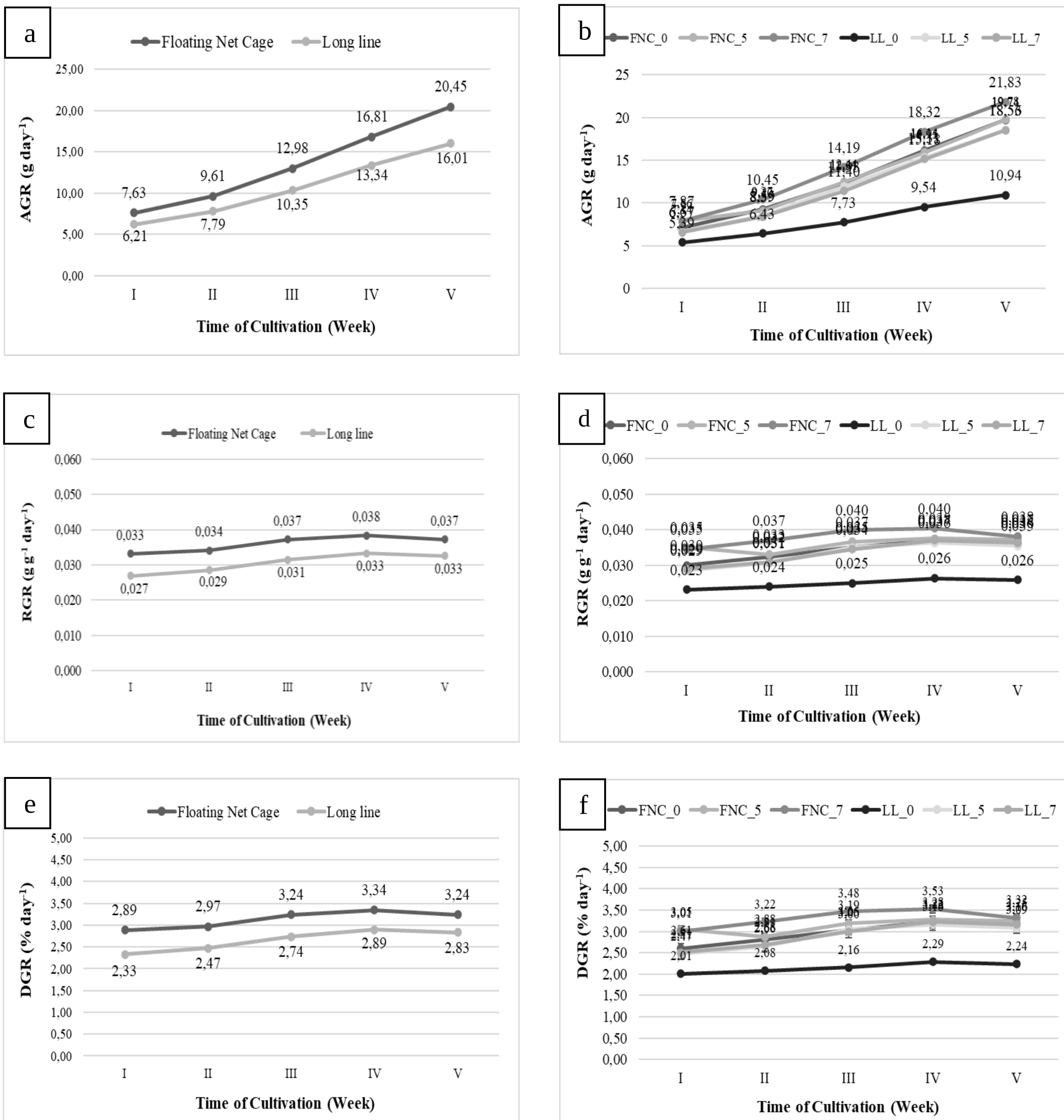

Fig. 2. Seaweed growth is based on different cultivation methods and fertilizer doses. **(a, b)** Absolute growth rate, **(c, d)** relative growth rate, and **(e, f)** daily growth rate

The comparative vulnerability to predatory fish attacks between the floating net cage method and the longline method of seaweed cultivation is less pronounced in the former. This finding aligns with the perspective pointed out by **Kasim *et al.* (2016)**, who argue that the floating net approach yields superior growth outcomes compared to the longline method. The rationale behind this assertion is that the floating net method is suitable for deployment in deep water areas, hence safeguarding seaweed from potential threats posed by predatory fish and turbulent waves. The data demonstrates that the average growth weight of seaweed in the longline method across all treatments was comparatively lower than that observed in the floating net cage approach. The occurrence of ice-ice illness is also responsible for a decrease in overall growth. When seaweed thallus is subjected to ice- ice attack, it experiences a loss of pigmentation and encounters challenges in nutrient absorption. Consequently, the seaweed becomes unable of conducting photosynthesis, which is essential for the growth and development of the thallus.

1.2 Relative growth rate (RGR)

The present study employed analysis of variance to examine the notable disparities in growth rates across various cultivation methods and fertilizer doses. The results indicated statistically significant variations in relative growth ($P < 0.01$), with a coefficient of variation of 1.69%. The study observed a significant rise in the relative growth of *K. striatus* when varying quantities of fertilizer were applied in each farming mode. Nevertheless, the control treatment in both techniques has seen a decline in seaweed growth (Fig. 3).

Fig. (2c) illustrates the comparative growth of seaweed, indicating that the initial sampling for both approaches exhibited a comparable trend. However, based on statistical analysis, it was determined that there was a notable disparity in the mean values of all treatments across the two cultivation methods, as indicated in Table (1). The growth patterns of the two techniques exhibit similarities as the seaweed is currently adapting to the phytohormone ingredients provided via LOF.

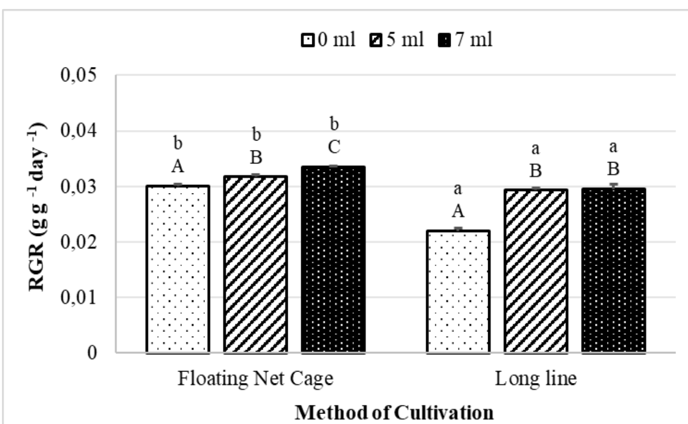

Fig. 3. The relative growth rate of seaweed cultivation in treatment. According to Duncan's follow-up, the mean value followed by the same letter was similar. Test at the 0.05 significance level. Lowercase letters are read vertically, comparing two methods on the same fertilized dose. Capital letters are read horizontally, comparing two fertilized doses to the same method.

The relative growth of the two cultivation methods was considerably influenced by the application of LOF (FNC_5 and FNC_7) in the second and third samples, as depicted in Fig. (2c- d). The application of LOF has been found to positively impact the growth of seaweed due to its inclusion of growth hormones. According to **Rochmady *et al.* (2015)**, the growth of seaweed can be attributed to the active involvement of phytohormones, which facilitate the growth process and enhance nutrient absorption. This optimal nutrient absorption subsequently accelerates the development of new shoots on the thallus. Upon entering the stationary phase, it was seen that the growth of seaweed in all treatments reached a saturation point. This phenomenon was hypothesised to be a result of the diminished impact of the LOF administered.

The results of the final sample and harvest indicate that the average relative growth rate from the initial day to the 35th day was 0.0318± 0.002g/ g/ day in the floating net cage method and 0.0270± 0.004g/ g/ day in the longlines method. The treatment with the highest relative growth rate was FNC_7, which exhibited a value of 0.0335± 0.0002g/ g/ day. Conversely, the treatment with the lowest relative growth rate was LL_0, with a value of 0.0219± 0.0006g/ g/ day (Table 1). During the maintenance period, there was a notable rise in the relative growth of seaweed in both approaches and across all treatments. Nevertheless, it is evident from Fig. (3) that the utilisation of the floating net cage technique yields superior relative growth in comparison to the longline method. According to the findings of **Kasim and Mustafa (2017)**, it has been observed that floating cages exhibit superior efficacy in sustaining seaweed growth compared to the longline approach. Floating cages offer ample room and effective shelter for the cultivation and maturation of seaweed, hence mitigating the risk of predation by herbivorous fish.

1.3 Daily growth rate (DGR)

The experimental manipulation of cultivation methods and fertilizer doses resulted in statistically significant changes across treatments ($P < 0.01$), as indicated by a coefficient of variation of 1.71%. Table (1) displays the mean weight of *K. striatus* across different treatment groups. The DGR values for each treatment in the floating net cage method, namely FNC_0, FNC_5, and FNC_7, were determined to be 2.97± 0.03, 3.13± 0.03, and 3.31± 0.02%/ day, respectively.

The DGR values for the LL_0, LL_5, and LL_7 treatments in the longline method were recorded as 2.15± 0.06, 2.89± 0.03, and 2.92± 0.09%/ day, respectively. The results of the investigation indicate that the DGR of *K. striatus*, when treated with fertilizer doses of 5 and 7m/ l, exhibited a statistically significant increase compared to the treatment with 0ml/ l doses, regardless of the culture mode employed (Fig. 2). The treatment labelled as FNC_7 exhibited the highest daily growth rate (DGR) value, measuring at 3.31± 0.03%/ day. Conversely, the LL_0 treatment had the lowest DGR value, measuring at 2.15± 0.06%/ day. The results of the analysis of variance indicated that all treatments exhibited significantly higher values ($P < 0.05$) compared to the control group. The DGR value of *K. striatus* in both methodologies is illustrated in Fig. (4).

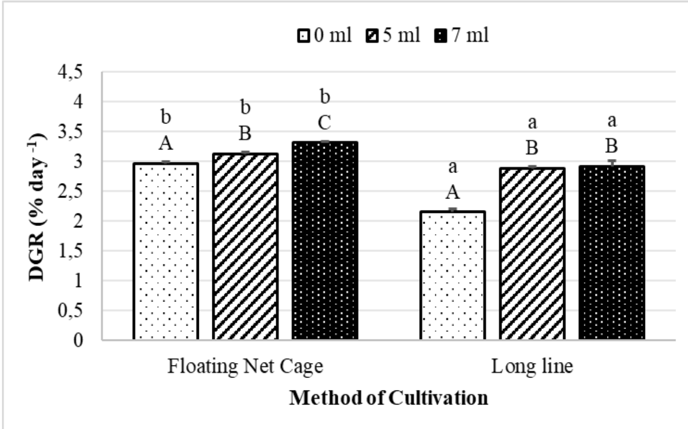

Figure 4. The daily growth rate of seaweed cultivation in treatment. According to Duncan's follow-up, the mean value followed by the same letter was similar. Test at the 0.05 significance level. Lowercase letters are read vertically, comparing two methods on the same fertilized dose. Capital letters are read horizontally, comparing two fertilized doses to the same method.

The mean daily growth rate expressed as a percentage each day. The greatest value in the fourth week was seen to be 3.34± 1.10%/ day in the floating net cage culture method, whereas in the longline cultivation method, it was recorded as 2.89± 0.52%/ day. The treatment labelled FNC_7 had the maximum daily growth value of 3.53± 1.00%/ day, whereas the treatment labelled LL_0 had the lowest daily growth value of 2.29± 0.53%/ day, as shown in Table (1). The value in question exhibits a higher level of excellence when compared to the findings found in the research of **Damayanti (2018)**. Specifically, Damayanti's research revealed that the floating raft method shown a daily growth rate of 2.15%/ day. According to a study conducted by **Kasim *et al.* (2016)**, the growth rate of seaweed using the floating net cage method was found to be 3.32%/ day, whereas the longline approach yielded a growth rate of 2.91%/ day. In accordance with the findings of **Hardan *et al.* (2020)**, it has been seen that the floating net cage method exhibits a daily growth rate of 3.23%/ day, whereas the longline approach demonstrates a daily growth rate of 3.14%/ day. According to **Cokrowati *et al.* (2018)**, it has been suggested that the ideal rate of seaweed growth exceeds 3%/ day.

The growth of seaweed can be influenced by water currents, as these currents facilitate the transportation of essential nutrients required for the growth and development of seaweed. Despite the increased water movement and currents experienced by the cultivated seaweed in the longline method, the daily growth rate remains rather modest, particularly in the control treatment where the use of LOF is absent. The reason for the inadequate fulfilment of nutritional requirements in the seaweed treated with LL_0 (control) during the initial cultivation period can be attributed to the absence of supplementary intake of growth-promoting hormones from LOF. Furthermore, the inclusion of herbivorous fish as predators poses a significant challenge in terms of the accumulation of seaweed weight in the longline approach. On the other hand, the utilisation of the floating net cage method for seaweed cultivation offers a somewhat higher level of safety against herbivorous fish predators, hence contributing to a more consistent growth rate.

2. Seaweed productivity

The results of the analysis of variance indicate that the variables of technique, fertilizer dose, and their interactions had a statistically significant impact on *K. striatus* production *(P*< 0.01). Additionally, the coefficient of variation was found to be 1.02% (*P*< 0.01). The productivity of seaweed is depicted in Fig. (4), illustrating a consistent rise in seaweed yield across all treatments on a weekly basis. The cultivation of seaweed in floating net cages resulted in increased output in the FNC_7 treatment, namely 17.44± 0.08gdw/ m, compared to the control group (FNC_0), which had a production of 15.51± 0.11gdw/ m. Similarly, in the longline approach, the LL_7 treatment exhibited a greater production yield of 14.41± 0.27gdw/ m, in contrast to the control group (FNC_0) which yielded 9.61± 0.16gdw/ m.

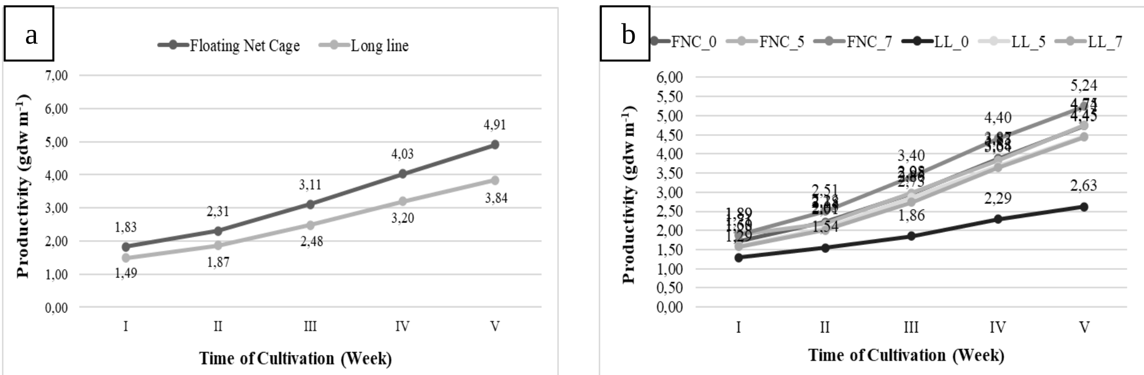

Fig. 5. Seaweed productivity based on different cultivation methods and fertilizer doses

The utilisation of the floating net cage method for seaweed cultivation yields a greater quantity of seaweed production in comparison to the longline approach. Furthermore, the application of fertilizer treatment had a significant impact on the production of seaweed. Specifically, the seaweed that received LOF exhibited a higher level of production compared to the control group, which did not get any fertilizer. The pace of growth is a determining factor in the quantity of seaweed output. If the rate of growth is augmented, there will be a corresponding rise in the quantity produced. The seaweed farmed using the floating net cages approach exhibited a greater daily growth rate compared to the longline method. According to the findings of **Failu *et al.* (2016)**, there exists a positive correlation between seaweed output and its growth rate, indicating that higher growth rates of seaweed are associated with increased production levels.

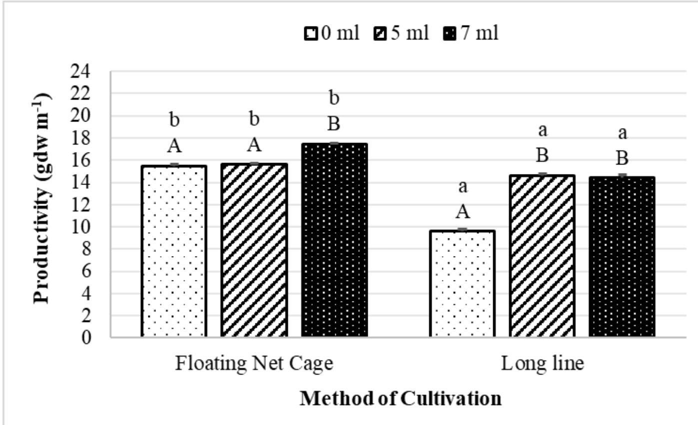

Fig. 6. Productivity of seaweed cultivation in treatment. According to Duncan's follow-up, the mean value followed by the same letter was similar. Test at the 0.05 significance level. Lowercase letters are read vertically, comparing two methods on the same fertilized dose. Capital letters are read horizontally, comparing two fertilized doses to the same method

The cultivation of seaweed by the longline method exhibits reduced productivity across all fertilizer dose treatments when compared to seaweed cultivated in floating net cage systems. According to the findings of **Awaluddin *et al.* (2016)**, it was observed that enriched seaweed seeds had a greater production value of 220% (44gdw/ m) compared to non-enriched seaweed seeds, which had a production value of 45% (9gdw/ m). Furthermore, the limited yield of seaweed in the longline growing technique can be attributed to its poor absolute and relative growth rates. The implementation of net-based enclosures has proven effective in safeguarding seaweed from predatory fish, hence resulting in increased seaweed yield. Furthermore, the incorporation of LOF into floating net cages has been observed to enhance the growth rate of seaweed. This can be attributed to the presence of growth-promoting hormones inside LOF.

Table 2. The average value of seaweed productivity in each treatment (mean ± SD)

Method	**Fertilizer dose**		
	0 ml/l	**5 ml/l**	**7 ml/l**
Floating Net Cage	15,51±0.11 b A	15.63±0.08 b A	17.44±0.08 b B
Longline	9.61±0.16 a A	14.64±0.10 a B	14.41±0.27 a B

Note: According to Duncan's follow-up, the mean value followed by the same letter was similar. Test at the 0.05 significance level. Lowercase letters are read vertically, comparing two methods on the same fertilized dose. Capital letters are read horizontally, comparing two fertilized doses to the same method.

The growth hormone comprises cytokinin, gibberellin, and auxin as its principal constituents. Seaweed possesses chlorophyll pigments that facilitate the process of photosynthesis, necessitating the acquisition of nutrients as essential substrates. The process by which nutrients are transported into the thallus tissue of seaweed involves diffusion facilitated by the movement of water. The rate of metabolic processes can be enhanced by facilitating more diffusion, hence promoting a higher growth rate. The uptake of LOF may be influenced by the duration of seaweed immersion. According to

Aliyas and Hasnawati (2021), inadequate nutrient absorption occurs when seaweed is soaked for a brief duration, resulting in nutrient deficiency. Conversely, excessive soaking leads to bleaching or damage in the seaweed.

Table 3. Water quality parameters observed during the study

No.	Parameter	Measurement result	Standard	Source
1	Current speed (cm/sec)	16.75-36.50	15-30	**WWF, 2014**
2	Temperature (°C)	29.90-32.50	26-32	**SNI, 2010**
3	Salinity (g/l)	30.50-33.70	15-32	**WWF, 2014**
4	Water brightness (cm)	150-200	> 40	**SNI, 2010**
5	pH	7.90-8.30	7.00-8.50	**WWF, 2014**
6	Nitrate (mg/l)	0.0472-0.0556	1-3	**WWF, 2014**
7	Phosphate (mg/l)	0.0074-0.0092	0.01-0.02	**WWF, 2014**

The growth and production of seaweed can be influenced by various environmental conditions, including water quality and the presence of predatory fish. Table (3) displays the water quality characteristics, specifically temperature, brightness, and pH, which adhere to the established norms necessary for facilitating the growth and production of seaweed. Simultaneously, the present velocity, salinity, nitrate, and phosphate levels do not conform to the established criteria as outlined by the **WWF (2014)**. Despite the unsuitability of these characteristics, seaweed development can still be facilitated by optimising appropriate methods and doses of fertilizer. The findings of **Rustam *et al.* (2020)** provide support for the notion that the application of growth hormone to seaweed seedlings yielded the most favorable outcomes in terms of absolute weight growth and the development of new shoots in the seaweed thallus.

The monitoring of seaweed growth is conducted by the use of sampling and cleaning procedures. The growth sampling procedure involved the weekly measurement of seaweed weight. The process of cleaning involves agitating the seaweed in order to detach it from the mud that is adhered to it. The process of pest and disease monitoring involves the observation of the thallus, which exhibits depigmentation as a result of ice-ice formation. Subsequently, the thallus is collected or excised for proper disposal. In the event that epiphytes are encountered, they are promptly removed from their marine habitat and eradicated due to their potential to impede the photosynthetic activity of seaweed. Furthermore, the ris rope and the main rope underwent a thorough cleansing process to remove epiphytes and associated moss.

CONCLUSION

The application of a liquid organic fertilizer at a concentration of 5ml/ l seawater prior to seaweed cultivation in marine environments has demonstrated positive effects on the development and productivity of seaweed in various cultivation methods. The utilization of the floating net cage technique is deemed appropriate for aquatic environments characterised by robust currents due to its capacity to endure wave forces and efficiently safeguard seaweed against herbivorous fish pests. *Kappaphycus striatus* exhibits a growth pattern that is distinguished by an initial rapid period of growth, succeeded by a decline in the growth rate during the final phase. This decline is attributed to the limited exposure of the thallus interior to light, resulting in a reduction in the rate of photosynthesis.

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