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GROWTH RESPONSE OF *Gracilaria* sp. AT VARIOUS PLANTING POINTS AROUND FLOATING NET CAGES IN THE WATERS OF UJUNG BETOK

Respons Pertumbuhan *Gracilaria* sp. pada Berbagai Titik Tanam di Sekitar Keramba Jaring Apung Perairan Ujung Betok

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ABSTRACT

The waters of Ujung Betok constitute a coastal area utilized for various human activities, such as aquaculture. These activities generate waste, resulting in nutrient input into the area. This study aimed to analyze the growth response of *Gracilaria* sp. at various planting points surrounding floating net cages in the waters of Ujung Betok, East Lombok. A Completely Randomized Design (CRD) was employed, consisting of three treatments based on planting distance—P1 (25 m), P2 (50 m), and P3 (75 m) from the floating net cages with four replicates each. Observed parameters included absolute weight, specific growth rate, thallus length, survival rate, and water quality. Overall, the results indicated that treatment P2 yielded the highest growth response, with an absolute weight of 67.5 g, a specific growth rate of 1.68% day^{-1}, and a thallus length of 14.4 cm. Treatment P1 resulted in an absolute weight of 50.75 g, a specific growth rate of 1.35% day^{-1}, and a thallus length of 13.7 cm, whereas treatment P3 yielded an absolute weight of 44.5 g, a specific growth rate of 1.19% day^{-1}, and a thallus length of 13.8 cm. Survival rates reached 100% across all treatments. However, statistical analysis revealed that the planting point did not have a significant effect on the growth of Gracilaria sp. ($P>0.05$). In conclusion, varying the planting distance around the floating net cages did not significantly influence the growth of *Gracilaria* sp., nevertheless, the planting point at a distance of 50 m showed a tendency toward a better growth response compared to the other planting points.
Keywords: *Gracilaria* sp., *floating net cages, growth, planting point, Ujung Betok waters*

ABSTRAK

Perairan Ujuang Betok merupakan kawasan pesisir yang dimanfaatkan untuk berbagai aktivitas manusia, seperti budidaya perikanan. Aktivitas tersebut menghasilkan limbah budidaya yang menjadikan lokasi ini menerima masukan nutrient.Penelitian ini bertujuan untuk menganalisis respons pertumbuhan *Gracilaria* sp. pada berbagai titik tanam di sekitar keramba jaring apung di Perairan Ujung Betok, Lombok Timur. Metode penelitian ini menggunakan rancangan acak lengkap (RAL) yang terdiri atas tiga perlakuan berdasarkan titik penanaman, yaitu P1 (25 m), P2 (50 m), dan P3 (75 m) dari keramba jaring apung, dengan empat ulangan. Parameter yang diamati meliputi berat mutlak, laju pertumbuhan spesifik, panjang talus, tingkat kelangsungan hidup, dan kualitas air. Hasil penelitian menunjukkan bahwa secara keseluruahan perlakuan P2 menunjukkan respons pertumbuhan tertinggi dengan berat mutlak sebesar 67,5 g, laju pertumbuhan spesifik 1,68% hari^{-1}, dan panjang talus 14,4 cm. Perlakuan P1 menghasilkan berat mutlak 50,75 g, laju pertumbuhan spesifik 1,35% hari^{-1}, dan panjang talus 13,7 cm, sedangkan perlakuan P3 menghasilkan berat mutlak 44,5 g, laju pertumbuhan spesifik 1,19% hari^{-1}, dan panjang talus 13,8 cm. Tingkat kelangsungan hidup mencapai 100% pada seluruh perlakuan.Namun berdasarkan hasil analisis statistic bahwa titik penanaman tidak memberikan pengaruh yang nyata terhadap pertumbuhan *Gracilaria* sp. (P>0,05). Berdasarkan hasil penelitian dapat disimpulkan bahwa perbedaan titik tanam di sekitar keramba jaring apung (KJA) tidak memberikan pengaruh yang signifikan terhadap pertumbuhan *Gracilaria* sp. Namun demikian, titik tanam pada jarak 50 m menunjukkan kecenderungan memberikan respons pertumbuhan yang lebih baik dibandingkan titik penanaman lainnya.

Kata Kunci: *Gracilaria* sp., keramba jaring apung, pertumbuhan, titik tanam, Perairan Ujung Betok.

INTRODUCTION

The waters of Ujung Betok constitute a coastal area utilized for various human activities, such as aquaculture. As of 2025, the area hosts over 150 floating net cage units operated by the local community for cultivation purposes (Asri et al., 2025). These activities generate aquaculture waste (uneaten feed and feces); studies indicate that 60–80% of this waste enters the marine environment as dissolved substances or organic particles (Dutta et al., 2023), while it is estimated that only about 20–30% of the nitrogen in the feed is successfully converted into fish biomass (Howarth et al., 2019). Furthermore, the proximity of the Ujung Betok waters to residential areas results in nutrient inputs from household and settlement waste. Consequently, without proper management, waste accumulation can degrade water quality and trigger eutrophication a condition characterized by an excess of nutrients (nitrogen and phosphorus) in the water, which impacts the aquatic ecosystem.

Gracilaria sp. seaweed is known for its ability to absorb dissolved nutrients, which are utilized in its physiological processes. This nutrient-absorbing capability stems from the fact that the seaweed acts as a filter feeder—an organism capable of directly filtering or accumulating elements from its environment and assimilating them into its tissues (Dwiyanti, 2023), including nitrogen. The presence of nutrients in the water influences metabolic processes, specifically the growth of *Gracilaria* sp. Asia et al. (2016) state that environmental conditions also play a crucial role, as the seaweed requires aquatic conditions that support photosynthesis, nutrient uptake, thallus elongation, branching, and biomass accumulation.

Feed cultivation, as every location is influenced by nutrient inputs from the surrounding waters and adjacent coastal areas. Floating net cages are considered a significant source of nutrient input into the water; this aligns with Howarth et al. (2019), who noted that fish farming activities can introduce nutrients into the aquatic environment, thereby affecting local organisms. While seaweed can utilize adequate nutrient levels to support growth, excessive amounts can lead to reduced water quality, increased turbidity, lowered dissolved oxygen levels, and interference with photosynthesis.

Various previous studies indicate that differences in cultivation sites can influence both the growth and quality of *Gracilaria* sp. Research by Khudin et al. (2019) reported that variations in cultivation sites affect the growth and agar content of *Gracilaria* sp. These differences are linked to site-specific environmental characteristicssuch as water quality, oceanographic conditions, and nutrient availability that support the seaweed's physiological processes. Additionally, a study by Trianti & Adharini (2020) demonstrated that *Gracilaria verrucosais* capable of utilizing nitrogen and phosphorus derived from aquatic waste as nutrient sources to support its growth.

However, information regarding the growth response of *Gracilaria* sp. in relation to optimal planting sites around floating net cages specifically in waters affected by aquaculture and domestic waste in the Ujung Betok area remains limited. Therefore, this study is crucial for examining the growth response of *Gracilaria* sp. at various planting sites around the KJA in Ujung Betok waters; the findings will serve as a basis for determining optimal planting locations and supporting the development of more productive and sustainable seaweed farming.

METHOD

Time and Location

This study was conducted over a 30-day rearing period in the waters of Ujung Betok, East Lombok Regency**.**

Tools and Materials

The equipment prepared for the floating raft setup includes 8 mm lines used as anchor lines to secure and stabilize the raft at the planting site; 4 mm lines used for each replicate to hold the seaweed seedlings; and 2 mm lines used to tie the *Gracilaria* sp. seedlings securely during the cultivation period. Additionally, the tools used include writing instruments, a mobile phone or camera, a ruler, and a scale, while the material used is *Gracilaria* sp. seaweed.

Experimental Design

This study employed an experimental method using a Completely Randomized Design (CRD). The treatments involved varying the planting locations for *Gracilaria* sp. using the floating raft method, based on the distance from the cultivation activity source (floating net cages). The study consisted of three treatments and four replicates, resulting in a total of 12 experimental units. The treatments were as follows:

P1 : Planting location very close to the floating net cages (25 m).
P2 : Planting location close to the floating net cages (50 m).
P3 : Planting location at a moderate distance from the floating net cages (75 m).

Reseach Parameters

The research parameters consisted of length and weight growth of *Gracilaria* sp., as well as survival rate. Growth and survival data were sampled on days 0, 15, and 30. The research parameters consisted of length and weight growth of *Gracilaria* sp., as well as survival rate

a. Absolute Growth

Absolute growth was measured using the equation by Ikhsan et al. (2025), as follows:

$$W= Wt-Wo$$

Note:
W : Average absolute growth (g)
Wt : Final weight of seaweed seedlings (g)
Wo : Initial weight of seaweed seedlings (g)

b. The Spesific Growth Rate (SGR)

The specific growth rate (SGR) is calculated using the following formula (Cokrowati et al., 2019):

$$SGR = \frac{In\ Wt\text{-}In\ Wo}{t} x100\%$$

Note:
SGR : Average specific growth rate (%/day)
Wt : Final seed/juvenile weight (g)
W0 : Initial seed/juvenile weight (g)
T Observation period

c. Thallus lenght

Thallus length was measured using a ruler, and the number of thalli was determined by manually counting each individual thallus

$$\Delta L = Lt - L0$$

Note:
ΔL : Absolute length growth (cm)
Lt :Thallus length at the end of the observation period (cm)
L0 : Thallus length at the start of planting (cm)

d. Survival Rate

The survival rate was calculated using the formula by Ikhsan et al. (2025), as follows:

$$SR = Nt/No \times 100$$

Note
SR :Survival rate (%)
Nt :Number of surviving seaweed at the end of the cultivation period
No :Number of seaweed at the start of the cultivation period

Data Analysis

The obtained data were analyzed using Analysis of Variance (ANOVA) via SPSS software to determine the effect of each treatment, followed by Duncan's post-hoc test. Water quality results were analyzed descriptively. Finally, the data were presented as histograms using Microsoft Excel.

RESULTS

Absolute Weight Growth

Research results indicate that the average absolute weight of *Gracilaria* sp. cultivated using the floating raft method at various planting locations ranged from 44.5 g to 67.5 g. The highest absolute weight was recorded for treatment P2 a planting location 50 m from the source of cultivation activity or floating net cages with an average of 67.5 g. Conversely, the lowest absolute weight was found in treatment P3, located 75 m from the source of cultivation activity or KJA, at 44.5 g. Meanwhile, treatment P1, located 25 m from the source of cultivation activity or KJA, yielded an average absolute weight of 50.75 g (Figure 1).

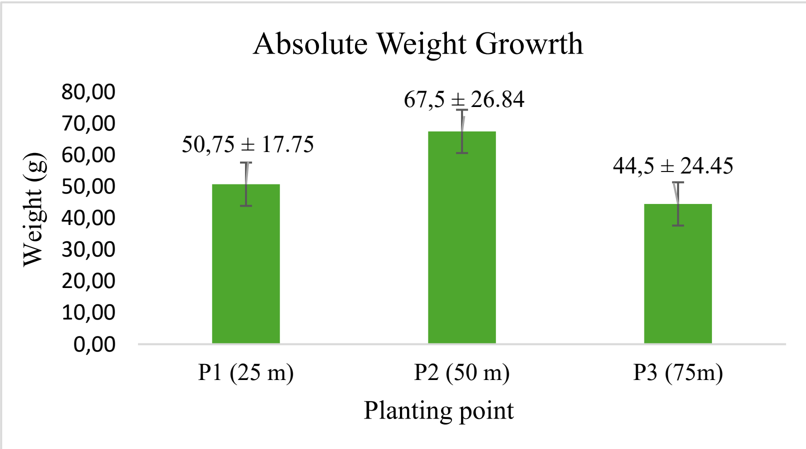

Figure 1. Absolute Weight Growrth

Based on the Analysis of Variance (ANOVA) results, it was found that the planting location using the floating raft method for *Gracilaria* sp. cultivation—did not significantly affect absolute weight gain (P > 0.05). This indicates that the planting location treatments at distances of 25 m, 50 m, and 75 m did not result in significant differences in the absolute weight of *Gracilaria* sp.

Specific Growth Rate

The specific growth rates observed in this study ranged from 1.19%/day to 1.68%/day. The mean specific growth rate of * sp. varied across the different planting sites. Treatment P2, located 50 m from the source of cultivation activity (floating net cages), yielded the highest specific growth rate at 1.68% per day, whereas treatment P3, located 75 m from the source of cultivation activity, showed the lowest value at 1.19% per day (Figure 2).

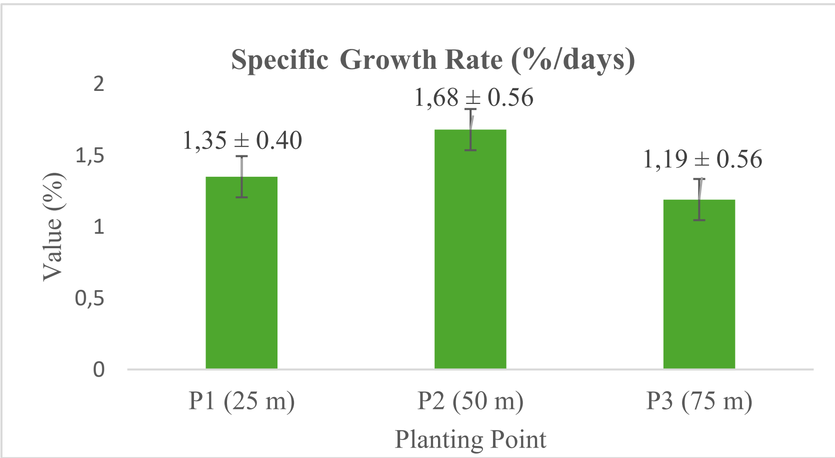

Figure 2. Spesific Growth Rate

Based on the Analysis of Variance (ANOVA) results, the planting location—using the floating raft method for *Gracilaria* sp. cultivation—did not significantly affect absolute weight gain (P > 0.05). This indicates that planting at distances of 25 m, 50 m, and 75 m did not result in significant differences in the specific growth rate of *Gracilaria* sp.

Thallus Length

In this study, the thallus length of the seaweed *Gracilaria* sp. ranged from 13.7 cm to 14.4 cm. The greatest thallus length was observed in treatment P2 (planting site 50 m from the floating net cage), measuring 14.4 cm. Meanwhile, treatment P1 (planting site 25 m from the floating net cage) showed an average thallus length of 14.2 cm, whereas the lowest average thallus length was recorded in treatment P3 (planting site 75 m), at 13.7 cm (Figure 3).

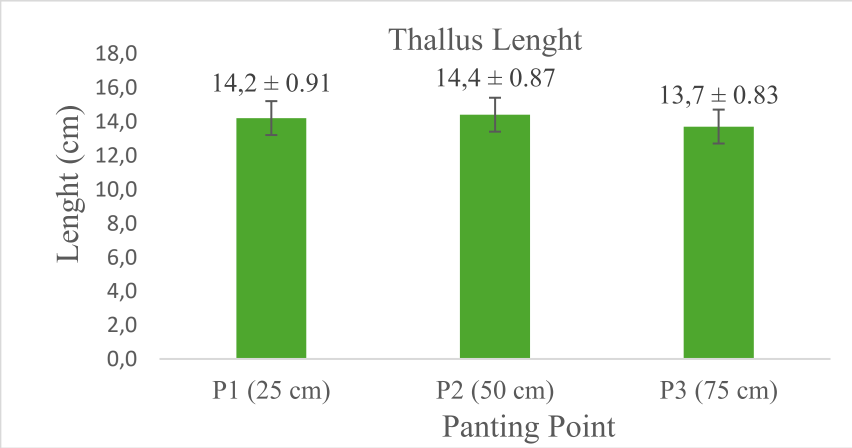

Figure 3. Thallus Lenght

Based on the Analysis of Variance (ANOVA) results, the planting location—using the floating raft method for *Gracilaria* sp. cultivation—did not significantly affect absolute weight gain (P > 0.05). This indicates that planting at distances of 25 m, 50 m, and 75 m did not result in significant differences in the specific growth rate of *Gracilaria* sp.

Survival Rate

Based on the research results, the average survival rate of *Gracilaria* sp. cultivated using the floating raft method at different planting sites—determined by their proximity to floating net cage activities—showed no significant differences among treatments. All treatments (P1, P2, and P3) yielded a survival rate of 100%, indicating that the seaweed was able to survive successfully until the end of the cultivation period.

DISCUSSION

Based on the growth results, treatment P2with a planting location 50 m from the floating net cagesdemonstrated superior growth compared to the other treatments. This is evidenced by the highest mean absolute weight of 67.5 g in treatment P2 (50 m from the cages), whereas the lowest value was 44.5 g in treatment P3 (75 m from the cages). Although descriptive analysis revealed differences in mean absolute weight growth across treatments, ANOVA results indicated that these differences were not statistically significant (P > 0.05). This suggests that the variations in planting distance (25 m, 50 m, and 75 m from the aquaculture activity source) did not create environmental conditions sufficiently distinct to significantly influence the absolute weight growth of *Gracilaria* sp. The highest absolute weight observed in treatment P2 is thought to be linked to more optimal nutrient availability at this intermediate distance from the floating net cages, as waste output from the cages likely contributes nutrients to the waters of Ujung Betok.

Fish farming waste comprising uneaten feed and excretions contains nitrogen and phosphorus that seaweed can utilize as nutrient sources. At distances that are too close, organic matter concentrations may be elevated, potentially reducing nutrient uptake efficiency, whereas at distances that are too far, nutrient availability tends to decline. Consequently, a planting distance of 50 m yielded a superior growth response compared to the other treatments. Research by Asri et al. (2025) indicates that water quality parameters specifically temperature, salinity, dissolved oxygen (DO), pH, transparency, and current velocity—at the sand lobster and rabbitfish floating net cage (KJA) sites remained within optimal ranges; however, certain nutrient parameters (nitrite, nitrate, and phosphate) exceeded optimal levels. This suggests that waste from the floating net cages likely contributes nutrients to the water, thereby directly influencing the thallus's ability to absorb the nitrogen and phosphorus present in the surrounding water. Nasmia et al. (2021) explain that the growth of *Gracilaria verrucosa* can be enhanced when nutrient requirements are adequately met.

These nutrients are utilized in the formation of proteins, amino acids, chlorophyll, and new tissues, thereby increasing seaweed biomass. This suggests that the P2 treatment positioned 50 m from the floating net cages (KJA) likely achieved the optimal balance between nutrient availability (derived from fish farming waste) and hydrodynamic conditions, resulting in higher biomass growth compared to the other treatments. Research by Sawant & Jaiswar (2024) demonstrated that the biomass growth of *Gracilaria corticata* increased when cultivated in shrimp pond wastewater, likely due to the accumulation of nitrates and phosphates. Furthermore, the use of the floating raft cultivation method in this study influenced the physiological capacity of *Gracilaria* sp. to absorb environmental nutrients; this aligns with the findings of Hendri et al. (2018), who stated that the cultivation of *Gracilaria* sp. using the floating net method is influenced by site conditions and water quality parameters.

The absolute weight growth observed in this study was lower than that reported by Susilowati et al. (2019), who achieved an absolute growth of 83.10 g for *Gracilaria verrucosa* using a verticulture method with a planting area of 75 x 75 cm². This discrepancy may be attributed to differences in cultivation methods, study locations, culture duration, experimental treatments, and aquatic environmental conditions. These findings are further supported by Shalehah et al. (2025), who stated that *Gracilaria* sp. cultivated using the floating raft method near floating net cages is capable of absorbing nitrogen and phosphorus while exhibiting increased biomass.

The growth of *Gracilaria* sp. under treatment P1 (a distance of 25 m from the floating net cages) tended to be lower than under treatment P2 (50 m). This condition is thought to be related to the planting site's proximity to aquaculture activities, resulting in a higher influx of organic matter, such as feed residue and fish feces. Although such organic matter can serve as a nutrient source for the seaweed, excessive accumulation has the potential to degrade water quality. Increased concentrations of organic matter can raise water turbidity, thereby reducing light penetration into the water column. Consequently, the light intensity reaching the thallus decreases, which can ultimately inhibit photosynthesis and lower the growth rate. Conversely, treatment P3 (75 m from the floating net cages) exhibited the lowest absolute weight and specific growth rate values. This condition is attributed to reduced nutrient availability resulting from the dilution and dispersal of aquaculture waste as the distance from the nutrient source increases, thereby limiting the nutrients accessible to *Gracilaria* sp. These findings align with the study by Ross et al. (2024), which demonstrated that *Gracilaria* sp.growth is strongly influenced by environmental conditions, particularly nutrient availability and light intensity.

Specific growth rate represents the daily percentage increase in weight. According to Sahabati et al. (2016), the specific growth rate indicates the speed at which seaweed grows; the ideal average daily growth rate generally falls within the range of 1.5%–3.5% per day. The results of this study show that the highest specific growth rate over the 30-day cultivation period was observed in treatment P2 (1.68%/day), while the lowest was in treatment P3 (1.19%/day). Although there were variations in specific growth rates among treatments at different planting sites, analysis of variance (ANOVA) results indicated that the differences in location did not significantly affect ($P > 0.05$) the daily growth rate of *Gracilaria* sp. The specific growth rates in this study were higher than those reported by Susilowati et al. (2019), who found a specific growth rate of 1.48%/day for *Gracilaria verrucosa* with an initial weight of 25 g.According to Wahdaningsih et al. (2025), initial weight and stocking density can influence the biomass and specific growth rate of *Gracilaria verrucosa* consequently, observed differences may be attributed to variations in initial weight, cultivation methods, rearing locations, duration of culture, and environmental conditions during the study.

The absence of significant differences in this study is likely attributable to the fact that the physicochemical conditions of the water across all observation points (25 m, 50 m, and 75 m from the floating net cages) remained within a homogeneous range conducive to optimal growth. Current velocity and water circulation at the study site were deemed sufficiently strong to ensure the even distribution of nutrients derived from organic waste associated with the cage operations throughout the cultivation area. Tarmizi & Diniarti (2022) explain that the suitability of *Gracilaria* sp. cultivation sites in Lombok waters is influenced by physicochemical water conditions. The growth of *Gracilaria* sp. seaweed is influenced by interrelated internal and external factors throughout the cultivation period. Internal factors include the seaweed species, seedling quality, thallus condition, seedling age, and the seaweed's ability to adapt to the cultivation environment.

Thallus length growth in *Gracilaria* sp. results from cell division and elongation at the apical section of the thallus. The study results indicate that the greatest thallus length was achieved with treatment P2 (planting point 50 m from the floating net cage/KJA) at 14.4 cm, followed by treatment P1 (25 m distance) at 14.2 cm, while the lowest value was observed in treatment P3 (75 m distance) at 13.7 cm. However, ANOVA results show that the differences in planting points did not have a significant effect on thallus length ($P > 0.05$). This indicates that planting distances of 25 m, 50 m, and 75 m from the floating net cage fall within an environmental range capable of supporting relatively uniform thallus length growth in *Gracilaria* sp.Across all treatments, the thallus length did not increase by the end of the cultivation period. This phenomenon occurs because seaweed growth is not limited to elongation; it also encompasses thallus thickening, branch formation, and increased biomass. This finding aligns with the research of Risnawati et al. (2018), which states that seaweed growth is modular in nature. When the main thallus undergoes length stagnation (remaining static), apical meristem points trigger the formation of new shoots and lateral branches, thereby directly increasing total weight even though the length of the main thallus does not change significantly. Furthermore, the thallus may suffer breakage or minor damage due to currents, rope friction, or handling during maintenance. Consequently, thallus length does not always increase, even though the seaweed's weight continues to rise. Purwanti et al. (2024) noted that variations in planting spacing for *Gracilaria verrucosa* influence cell count and agar content; therefore, growth space and the physical condition of the thallus must be considered during cultivation. Thus, thallus length cannot serve as the sole indicator of successful seaweed growth; rather, it must be evaluated alongside other parameters, such as absolute weight and specific growth rate.

The survival rate results from this study indicate that all treatments yielded a survival rate of 100%. This figure demonstrates that *Gracilaria* sp. is capable of adapting exceptionally well to the cultivation environmental conditions at all planting sites. The high survival rate indicates that water quality throughout the study remained within the physiological tolerance range of *Gracilaria* sp. Factors such as temperature, salinity, pH, dissolved oxygen, and currents were sufficient to support metabolic and photosynthetic processes, thereby causing neither physiological stress nor plant mortality.This aligns with the findings of Abeng et al. (2021), who stated that the cultivation of *Gracilaria* sp. relies heavily on appropriate site selection and the ecological conditions of the water. Furthermore, the use of the floating raft method facilitates good water circulation, ensuring a continuous supply of nutrients and oxygen. Survival rate is a key indicator of seaweed cultivation success, as it reflects the plant's ability to adapt to the cultivation environment. An SR value of 100% indicates that all planted seedlings survived until the end of the study. Dwiyanti and Muahiddah (2023) noted that

Gracilaria sp. possesses a high capacity for adaptation, particularly regarding environmental conditions and the presence of heavy metals in the water.

CONCLUSION

The study concludes that differences in planting locations around the floating net cages (KJA) in the waters of Ujung Betok did not significantly affect the growth of *Gracilaria* sp. However, overall, the planting location at a distance of 50 m from the KJA tended to offer the most favorable conditions for *Gracilaria* sp. growth, yielding an absolute weight of 67.5 g, a specific growth rate of 1.68% per day, and an average thallus length of 14.4 cm.

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