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EFFECT OF CULTURING DEPTH ON THE GROWTH OF *Euchema cottonii* USING MODIFIED FLOATING NET CAGE METHOD IN JEPARA BAY

Perbandingan Kedalaman Berbeda Terhadap Pertumbuhan Rumput Laut (*Euchema cottonii*) Pada Metode Modifikasi Keramba Jaring Apung di Teluk Jepara

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ABSTRACT

Seaweed farming is one of the most important aquaculture sectors in Indonesia, contributing significantly to the national economy. Among various species, Eucheuma cottonii is widely cultivated due to its high carrageenan content and industrial value. Optimizing environmental conditions, such as culturing depth, is crucial to improving growth performance and productivity. This study evaluated the effect of different culturing depths on the growth of E. cottonii using a modified floating net cage system in Jepara Bay. The experiment applied three depth treatments—25 cm (A), 45 cm (B), and 65 cm (C)—each with two replications. Seaweed growth was monitored over 49 days and assessed based on absolute weight and specific growth rate (SGR). Results showed that seaweed cultivated at 25 cm had the highest growth performance, with an absolute weight of 102.2 g and the highest SGR, whereas the lowest values were recorded at 65 cm. ANOVA analysis confirmed a significant effect of depth on growth ($p < 0.05$), supported by Duncan's test indicating clear differences among treatments. Water quality parameters (temperature, salinity, pH, and dissolved oxygen) remained within optimal ranges, suggesting depth was the primary factor influencing growth. The findings highlight that shallower depths promote greater light penetration and photosynthetic efficiency, thus enhancing E. cottonii growth. A culturing depth of 25 cm is recommended for optimal productivity in similar cultivation systems.

Keywords: Culturing Depth, Eucheuma cottonii, Floating Net Cage, Jepara Bay, Specific Growth Rate

ABSTRAK

Budidaya rumput laut merupakan salah satu sektor akuakultur yang penting di Indonesia dan berkontribusi besar terhadap perekonomian nasional. Di antara berbagai jenis, *Eucheuma cottonii* banyak dibudidayakan karena kandungan karagenannya yang tinggi serta nilai ekonominya dalam industri. Optimalisasi faktor lingkungan, seperti kedalaman budidaya, menjadi kunci untuk meningkatkan pertumbuhan dan produktivitas. Penelitian ini bertujuan untuk mengevaluasi pengaruh kedalaman budidaya yang berbeda terhadap pertumbuhan *E. cottonii* menggunakan sistem keramba jaring apung modifikasi di Teluk Jepara. Percobaan terdiri dari tiga perlakuan kedalaman, yaitu 25 cm (A), 45 cm (B), dan 65 cm (C), masing-masing dengan dua ulangan. Pertumbuhan rumput laut diamati selama 49 hari dan dievaluasi berdasarkan bobot absolut dan laju pertumbuhan spesifik (LPS). Hasil menunjukkan bahwa perlakuan kedalaman 25 cm menghasilkan pertumbuhan tertinggi, dengan bobot absolut sebesar 102,2 g dan LPS tertinggi, sedangkan nilai terendah diperoleh pada kedalaman 65 cm. Analisis ANOVA menunjukkan pengaruh yang signifikan dari kedalaman terhadap pertumbuhan ($p < 0,05$), didukung oleh uji Duncan yang menunjukkan perbedaan nyata antar perlakuan. Parameter kualitas air (suhu, salinitas, pH, dan oksigen terlarut) berada dalam kisaran optimal selama penelitian, sehingga kedalaman merupakan faktor utama yang memengaruhi pertumbuhan. Hasil penelitian menunjukkan bahwa kedalaman yang dangkal meningkatkan penetrasi cahaya dan efisiensi fotosintesis, sehingga mendukung pertumbuhan *E. cottonii*. Disarankan penggunaan kedalaman 25 cm untuk hasil budidaya yang optimal dalam sistem serupa.

Kata Kunci: *Eucheuma cottonii*, Kedalaman Budidaya, Keramba Jaring Apung, Laju Pertumbuhan Spesifik, Teluk Jepara

INTRODUCTION

Seaweed is one of Indonesia's marine resources and has become the leading commodity for fisheries farming; the highest production in 2018 was 16.17 out of 33.53 million tons (Directorate General of Aquaculture, 2018). Seaweed in Indonesia has very promising potential and can be used as a commodity that has a role in the movement of national economic advance (Saputra et al., 2021). The potential for seaweed cultivation has a very wide area, with a current farming area of 1.1 Ha or 9% of the total potential marine cultivation area, which is 12,123,383 Ha (Saleky et al., 2020). The potential of seaweed in Indonesia is expected to be continuously explored, considering the high diversity of seaweed in Indonesia waters (Nasrullah et al., 2021). According to (Widowati et al.,2015), *Eucheuma cottonii* is one of the seaweeds with high economic value as an export commodity. Moreover, *Eucheuma cottonii* is really profitable as a basic production material in the industrial sector and contributes to labor absorption (Surni, 2014).

The types of seaweed that are widely found in Indonesia waters are Gracilaria, Gelidium, Eucheuma, Hypnea, Sargasum, and Tubrinaria (Nashrullah et al., 2021). Eucheuma is grouped into several species: Eucheuma edule, *Eucheuma spinosum*, *Eucheuma cottonii*, *Eucheuma cupressoideum*, and many others. The E. cottonii species is a seaweed that is widely traded, both for the needs of domestic industrial raw materials and for export (Sanger et al., 2018).

Eucheuma cottonii seaweed is also widely farmed by coastal communities because this species has a content that is really required for industrial production needs, and it also contains a lot of carrageenans (Distantina et al., 2011). Carrageenan has advantages for the industry, so many seaweeds are used as basic ingredients in making a product. Carrageenan has several types: kappa, iota, and lambda (Webber et al., 2012). Carrageenan can be used as a thickening and stabilizing agent, especially in food and sauce products. Furthermore, carrageenan is used in pharmaceutical and cosmetic formulations as a stabilizer in the emulsion system, viscosity regulator, and gelling agent (Abdassah et al., 2019).

Based on the study by Hamdu et al. (2022), the depths used in the study on *Eucheuma cottonii* seaweed were 20, 30, 40, 50, and 60 cm. This activity aims to determine the effect of different depths on seaweed growth. Susilowati et al. (2021) stated that seaweed can grow well if the water depth is suitable for maintenance. According to Garpenassy et al. (2016), the previous study stated that the best depth for seaweed growth is 30 cm. This is similar to the study conducted by Runtuboy and Abadi (2018), in which, according to the results of the calculation, planting can be carried out at a depth from 10 cm to 30 cm. According to Tamala et al. (2022), nutrients can affect the growth rate of *Eucheuma cottonii* seaweed. Besides nutrients, other factors that can have effects are the suitability of farming location, contents in the water, water quality, farming method, depth, and intensity of sunlight received by the seaweed. Therefore, this study aimed to evaluate the optimal culturing depth for *Eucheuma cottonii* growth using a modified floating net cage method in Jepara Bay.

METHODS

Time and Place

This study was conducted from March to June 2023 at Jepara Brackish Water Aquaculture Center (BBPBAP), Central Java.

Tools and Material

The tools and materials used in this study were bamboo, PVC pipe, Styrofoam, Styrofoam box, needle, steam machine, steam, large net, small neat, large rope, small rope, lifebuoy, knife, saw, bottle, bucket, scissor, digital scale, pH meter, refractometer, thermometer, DO meter, sedcchi disk, and current measuring instrument. The main material used in this study was seaweed (*Eucheuma cottonii*).

Research Procedure

This study began with land preparation, choosing superior seeds, planting, maintenance, and harvesting. Observation in this study was conducted using different depths of 25 cm, 45 cm, and 65 cm (Hamdu et al., 2022; Garpenassy et al., 2016; Runtuboy & Abadi, 2018) and using two replications in each treatment with the same weight of seaweed seeds in three treatments, which was 25 g. In point A, the depth used was 25 cm, treatment B with a depth of 45 cm, and treatment C with a depth of 65 cm. The distance between each construction was 2 meters and had a width of 3 meters from each supporting construction. The tie distance of each seaweed seed was approximately 25 cm, where in 1 rope line, there were four individuals/clusters, and in 1 construction, there were three rope lines, so the number of individuals used in one construction was twelve.

Test Parameters

The data that has been takem during the research period includes data on the weight of seawed and specific growth rate at the beginning and end of the study, which will then be analyzed using formula for the absolute weight and the specific growth rate of seaweed. Observation of seaweed were carried out once a week. The condition of the waters was checked and data were taken 2 times during the research. Observation of water conditions including parameters of temperature, salinity, and pH were carried out in situ and nitrate, phosphate and dissolved oxygen (DO) ex situ at the analytical laboratory.

The growth of absolute weight for *Eucheuma cottonii* was measured according to the initial weight of maintenance until the final weight of maintenance. The absolute growth of *Eucheuma cottonii* can be calculated using the formula by Cokrowati et al. (2018) as follows:

$$W = Wt - Wo$$

Where:
W = Weight gain of seaweed (gr)
Wt = Final weight of seaweed (gr)
Wo = Initial weight of seaweed (gr)

The specific growth rate was obtained by weighing the wet seeds of seaweed once a week for 49 days. In order to calculate the specific growth rate, the formula by Cokrowati et al. (2018) was used as follows:

$$LPS = \frac{\ln Wt - \ln Wo}{t} \text{ x } 100\%$$

Where:
LPS = Average of specific growth rate (%)
Wt = Weight of seed in tI (gr) (I= week I, week II…t)
Wo = Initial weight of seed (gr)
t = Observation period (week)

Data Analysis

The growth data (g) and specific growth rate (%) of *Eucheuma cottonii* seaweed were first tested for normality, homogeneity and additivity, then to find out the effect of treatment on growth, analysis of variance (ANOVA) was carried out. Then if a significant effect was obtained, a Duncan test was carried out to find out the treatment that gave the best effect (Srigandono, 1981).

RESULTS

Absolute Weight

Based on the results of the ANOVA test, seaweed growth at the three depths showed that there were significant differences at the three depths (<0.05). Planting seaweed at different depths showed different growth.

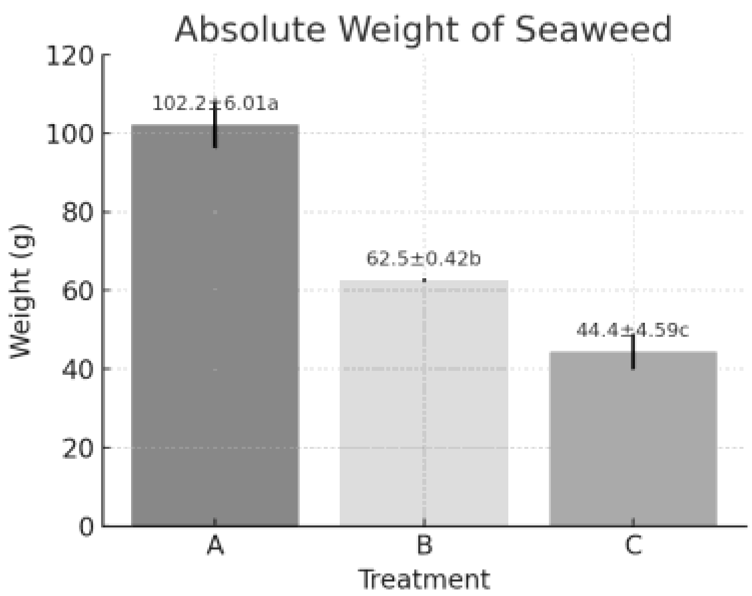

Figure 1. Absoulte Weight of Seawed

Based on the results shown in Figure 1, Treatment A (25 cm) produced the highest absolute weight of *Eucheuma cottonii* (102.2 ± 6.01 g), followed by Treatment B (45 cm) at 62.5 ± 0.42 g, and Treatment C (65 cm) at 44.4 ± 4.59 g. The different superscript letters indicate significant differences between treatments ($p < 0.05$), as confirmed by Duncan's post-hoc test.

Specific Growth Rate

The specific growth rate is the percentage of seaweed growth per day calculated during the maintenance period, which was 49 days in Jepara Bay. Sampling in the observation carried out aims to determine the specific growth rate. Sampling was carried out every 7 days, which is certainly to determine the percentage of growth per day obtained by seaweed.

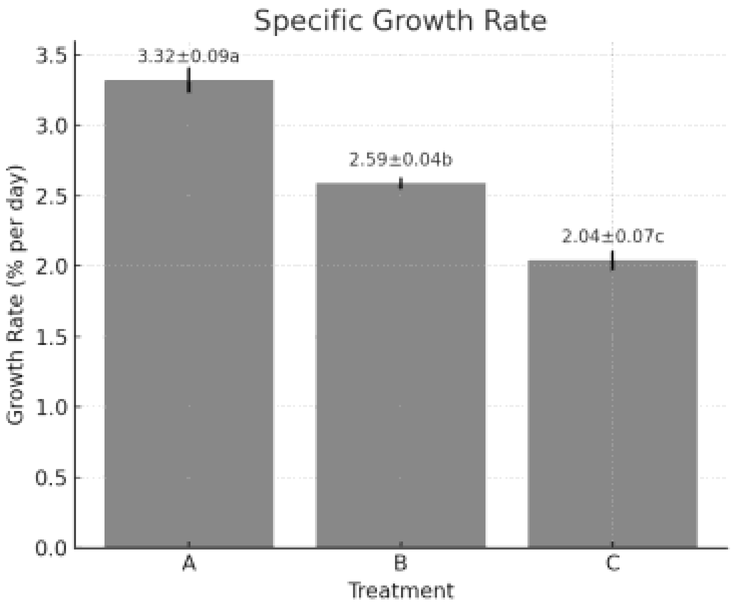

Figure 2. Specific Growth Rate of Seawed

Based on the graph showing the specific growth rate, the highest percentage of specific growth rate was obtained by treatment A, while the lowest was in treatment C. These percentages are the specific growth rate from the initial maintenance to the final maintenance for 49 days.

Water Quality

Based on the observations that have been made, the water quality test results are presented in following Table 1. In the table 1, the temperature measurement results for each treatment during the study ranged from 29.7-30.5 °C. The water quality values obtained during the study tend be normal with a pH range of 7.55-7.81, salinity ranging form 29.6-32, dissolved oxygen ranging from 4.23-6.97 mg/l.

Tabel 1. Parameter of Water Quality

Parameter	Unit	Observation Result
Temperature	°C	29.7 – 30.5
Salinity	ppt	29.6 – 32.0
pH	-	7.55 – 7.81
Dissolved Oxygen (DO)	mg/L	4.23 – 6.97
Nitrate	mg/L	0.033 – 0.184
Phosphate	mg/L	0 – 0.035
Depth	m	2.0 – 2.2
Brightness	cm	113 – 127
Water Current	m/s	0.1 – 0.4

pH has an effect on the growth of seaweed. The nitrate value obtained during the observation was approximately 0.033-0.182 mg/l. The phosphate value obtained in Jepara Bay was approximately 0-0.035 mg/l. The depth was measurement during the study was 2-2.2 m, brightness was 113-127 cm and stream was measurement 0.1-0.4 m/s.

DISCUSSION

The present study confirmed that culturing depth significantly influences the growth of *Eucheuma cottonii* when cultivated using a modified floating net cage system in Jepara Bay. Both absolute weight and specific growth rate differed significantly ($p < 0.05$) among the treatments, with the highest values observed at 25 cm (Treatment A) and the lowest at 65 cm (Treatment C). These results align with previous findings by Garpenassy et al. (2016) and Runtuboy and Abadi (2018), who emphasized that shallow cultivation depths promote optimal photosynthesis and growth due to higher light availability.

Statistical analysis using one-way ANOVA followed by Duncan's multiple range test indicated a clear separation between the treatments, confirming that depth was a significant determinant of growth performance. The results of the Duncan test showed that Treatment A was significantly superior to B and C, highlighting that 25 cm is the optimal depth under the observed environmental conditions. These findings are consistent with Hamdu et al. (2022), who suggested that the ideal range for cultivating *E. cottonii* lies between 20–30 cm, a depth range that balances light intensity and water movement to enhance nutrient uptake and reduce mechanical stress.

Light is a primary factor influencing the photosynthetic efficiency and growth of macroalgae. The attenuation of light intensity with increasing depth reduces the availability of photosynthetically active radiation (PAR), which is essential for the synthesis of organic compounds via photosynthesis (Buschmann et al., 2017). According to Hurd et al. (2014), light limitation is one of the most critical factors in subtidal macroalgae cultivation, and insufficient light availability can lead to photoacclimation stress or suppressed growth. In the current study, it is plausible that the lower growth rate observed at 65 cm resulted from reduced light penetration, particularly under conditions of moderate turbidity and water depth.

Furthermore, the physical structure of the floating net cage and its orientation can influence the microenvironment experienced by the cultured seaweed. Deeper lines may experience greater shading, both from the upper canopy and from water column particles, which can inhibit effective photosynthesis. Additionally, water movement decreases with depth, which may impact the rate of nutrient exchange at the thallus surface (Titlyanov & Titlyanova, 2010). Reduced water flow can limit the delivery of essential nutrients and removal of metabolic waste, negatively affecting physiological processes.

Although the measured water quality parameters—temperature (29.7–30.5°C), salinity (29.6–32 ppt), pH (7.55–7.81), and DO (4.23–6.97 mg/L)—remained within the optimal range for *E. cottonii* cultivation (Dawes, 1998; Hurtado et al., 2019), these uniform conditions suggest that the variations in growth were primarily due to differences in light and hydrodynamic conditions influenced by depth. This is supported by the minimal variation in nutrient concentrations (nitrate: 0.033–0.184 mg/L; phosphate: 0–0.035 mg/L), which were sufficient for growth but not limiting. Tamala et al. (2022) emphasized that while nutrient availability plays a role in growth, physical parameters such as depth and irradiance are often more influential, especially in oligotrophic or semi-enclosed coastal systems.

Another possible explanation for the higher growth at 25 cm is reduced mechanical stress. In deeper water columns, seaweed may be exposed to fluctuations in currents and vertical shear forces, which can lead to tissue damage or stress-induced reduction in growth (Reddy et al., 2008). Shallower depths may provide more stable and favorable conditions, especially in relatively calm aquaculture areas like Jepara Bay.

These findings have significant implications for improving the productivity and economic efficiency of *E. cottonii* farming in Indonesia. By optimizing depth placement to 25 cm, farmers can enhance yield per cultivation unit without increasing operational complexity or costs. Moreover, this research provides evidence-based recommendations for the design and spatial configuration of floating net cages, particularly for small-scale community farmers who depend on seaweed cultivation for livelihood.

Nevertheless, future research should consider expanding the study across different seasons, tidal patterns, and more varied depth gradients (e.g., 10 cm increments) to refine depth optimization further. It would also be beneficial to assess the interaction between depth and seedling density, which can influence self-shading and intra-species competition.

CONCLUSION

This study demonstrated that culturing depth significantly affects the growth performance of *Eucheuma cottonii* in modified floating net cages in Jepara Bay. Among the three treatments, the 25 cm depth resulted in the highest absolute weight and specific growth rate, indicating that shallower depths provide more optimal conditions for seaweed growth. The findings suggest that enhanced light availability and stable environmental conditions at shallower depths are key factors promoting growth. These results can serve as a reference for optimizing seaweed cultivation strategies, especially for small-scale coastal farmers, by recommending a culturing depth of 25 cm to maximize production efficiency. Further research involving seasonal variations and a wider range of depths is recommended to validate and refine these conclusions.

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