

## COMPARISON OF SPECIFIC GROWTH OF VARIOUS TYPES OF CAULERPA CULTIVATED IN TRAY ON BARRANG CADDI ISLAND, MAKASSAR CITY

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### Abstract

This study compared the growth performance of three *Caulerpa* species cultivated in tray systems on sandy substrates at Barrang Caddi Island, Makassar City, Indonesia. The experiment was conducted for 14 days using *Caulerpa lentillifera*, *Caulerpa racemosa*, and *Caulerpa cylindracea* under similar environmental conditions. Growth performance was evaluated based on absolute biomass growth, specific growth rate (SGR), and frond length, while water quality parameters, including temperature, salinity, and pH, were monitored to assess environmental suitability. Data were analyzed descriptively and statistically using Tukey's multiple comparison test. The results showed that all three species exhibited growth throughout the cultivation period. *Caulerpa racemosa* produced the highest biomass gain and specific growth rate, indicating greater adaptability to sandy substrates and more efficient nutrient utilization than the other species. In contrast, *Caulerpa lentillifera* achieved the greatest frond elongation, suggesting its suitability for fresh edible sea grape production. Water quality remained within the optimal range for tropical *Caulerpa* cultivation, with average values of 27.7°C for temperature, 29.7 PSU for salinity, and pH 8.33. These favorable environmental conditions supported continuous growth and physiological performance throughout the experiment. Overall, tray cultivation on sandy substrates proved to be a feasible cultivation method for *Caulerpa*, with *C. racemosa* recommended for maximizing biomass production and *C. lentillifera* preferred for commercial production targeting high-quality edible fronds. These findings provide valuable information for improving sustainable sea grape aquaculture in tropical coastal ecosystems.

**Keywords:** Aquaculture; *Caulerpa*; Growth; Sandy Substrate; Tray Cultivation

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### INTRODUCTION

Indonesia is the world's largest archipelagic country, with approximately 70% of its territory consisting of marine waters, providing exceptional opportunities for the development of marine aquaculture and the sustainable utilization of coastal resources (FAO, 2024; Kementerian Kelautan dan Perikanan [KKP], 2023). Among Indonesia's economically valuable marine commodities, seaweeds have become increasingly important because of their contributions to food security, coastal livelihoods, pharmaceutical industries, and ecosystem services. Besides serving as a source of dietary fiber, seaweeds contain diverse bioactive compounds, antioxidants, vitamins, minerals, and pigments that have attracted considerable attention for functional food and nutraceutical applications (Pereira, 2022; Holdt & Kraan, 2019). Consequently, the diversification of commercially cultivated seaweed species has become an important strategy to increase aquaculture productivity while supporting sustainable blue economy initiatives.

One promising green seaweed is *Caulerpa*, commonly known as sea grapes or green caviar. Species belonging to the genus *Caulerpa* naturally inhabit shallow tropical and subtropical coastal waters, where they colonize sandy, rocky, or coral substrates under relatively clear water conditions with moderate hydrodynamic energy (Espinosa-Antón et al., 2023). Several commercially important species, including *Caulerpa lentillifera*, *Caulerpa*

*racemosa*, *Caulerpa serrulata*, *Caulerpa taxifolia*, and *Caulerpa cylindracea*, are widely distributed throughout the Indo-Pacific region, including Indonesian waters (Tapotubun et al., 2020; Belton et al., 2020). Their creeping stolons and extensive rhizoidal systems enable efficient attachment to substrates while facilitating rapid vegetative propagation, making these macroalgae attractive candidates for commercial cultivation.

The commercial value of *Caulerpa* has increased considerably over the last decade because of its multifunctional uses. In Indonesia, particularly in South Sulawesi, *Caulerpa* is locally known as "lawi-lawi" or "bu'ne," while communities in Java commonly refer to it as "latoh." Traditionally, it is consumed fresh as a vegetable or salad ingredient, but recent studies have demonstrated its considerable nutritional and pharmaceutical potential. *Caulerpa* contains abundant polyunsaturated fatty acids (PUFAs), essential amino acids, chlorophylls, carotenoids, minerals, vitamins, and secondary metabolites such as caulerpin, caulerpicin, and phenolic compounds. These bioactive constituents exhibit antioxidant, anti-inflammatory, antimicrobial, antidiabetic, anticancer, antifungal, antiparasitic, and immunomodulatory activities, making *Caulerpa* an increasingly valuable commodity for the food, pharmaceutical, cosmetic, and biotechnology industries (Rushdi et al., 2020; Pereira, 2022; Tapotubun et al., 2020).

Beyond its economic importance, *Caulerpa* also contributes significantly to coastal ecosystem functioning. Dense *Caulerpa* meadows provide habitat and nursery grounds for numerous marine organisms, enhance sediment stabilization, improve nutrient cycling, and contribute to carbon sequestration in shallow coastal ecosystems (Duarte et al., 2022). These ecological functions further emphasize the importance of developing environmentally sustainable cultivation techniques capable of increasing biomass production while minimizing impacts on surrounding ecosystems.

Barrang Caddi Island, located within the Spermonde Archipelago of Makassar City, South Sulawesi, possesses favorable environmental characteristics for cultivating *Caulerpa*. The island is characterized by extensive shallow lagoons, relatively clear seawater, coral reef ecosystems, sandy substrates, and suitable salinity conditions throughout most of the year. Natural populations of several *Caulerpa* species are abundant in the surrounding coastal waters, indicating that environmental conditions are generally suitable for their growth (Hardiana et al., 2018). Nevertheless, despite this natural potential, commercial cultivation remains relatively underdeveloped because local farmers continue to face constraints related to cultivation technology, seasonal environmental variability, and market accessibility.

Previous cultivation efforts by coastal communities on Barrang Caddi Island have frequently produced inconsistent yields, particularly during the western monsoon season when strong waves, increased turbidity, and fluctuating environmental conditions substantially reduce crop survival. Similar production constraints have been reported in other tropical regions where seasonal weather variability influences macroalgal productivity through changes in temperature, salinity, nutrient availability, water movement, and light penetration (Mustafa et al., 2022; FAO, 2024). These challenges highlight the necessity of identifying cultivation methods and species that are more resilient under local environmental conditions.

Several studies have demonstrated that cultivation performance of *Caulerpa* depends on multiple interacting environmental and technical factors. Water temperature regulates metabolic activity and photosynthetic efficiency, while salinity affects osmotic balance and nutrient absorption. Light intensity directly controls photosynthesis and biomass accumulation, whereas water movement facilitates nutrient exchange but may also cause mechanical damage when excessive (Sitorus et al., 2020; Espinosa-Antón et al., 2023). Furthermore, substrate characteristics strongly influence rhizoid attachment, nutrient availability, and overall plant stability, making substrate selection one of the key determinants of successful cultivation (Espinosa-Antón et al., 2023).



In addition to environmental conditions, cultivation techniques significantly influence seaweed productivity. Previous research has evaluated several methods, including bottom spreading, suspended culture, substrate modification, and combined cultivation systems, each producing different growth responses depending on species characteristics and environmental conditions (Mustafa et al., 2022). Among these approaches, tray cultivation has recently attracted attention because it provides better control of planting density, minimizes thallus entanglement, facilitates maintenance and harvesting, and allows more uniform exposure to sunlight and water circulation. However, comparative information regarding the growth performance of different *Caulerpa* species cultured using tray systems remains limited, particularly under the environmental conditions of Barrang Caddi Island.

Although numerous studies have investigated the nutritional properties and commercial applications of *Caulerpa*, relatively few have compared the growth performance of multiple naturally occurring species cultured simultaneously under identical environmental conditions using standardized tray cultivation systems. Understanding species-specific growth characteristics is essential for identifying superior candidates for commercial farming, improving production efficiency, and reducing cultivation risks associated with seasonal environmental variability.

Therefore, this study aims to compare the growth performance of several *Caulerpa* species cultivated using tray culture systems on Barrang Caddi Island, Makassar City. The findings are expected to identify the species exhibiting the highest growth potential under local environmental conditions while providing scientific evidence to support sustainable seaweed aquaculture development in coastal Indonesia. Moreover, the results may contribute to improving cultivation practices, increasing coastal community income, and promoting environmentally responsible utilization of marine resources in accordance with sustainable blue economy principles.

## METHOD

This study was conducted from April to May 2025 in the coastal waters of Barrang Caddi Island, Makassar City, South Sulawesi, Indonesia. Healthy seedlings of several *Caulerpa* species were collected from natural populations using snorkeling equipment and selected through purposive sampling based on thallus health, uniform morphology, and the absence of epiphytes or physical damage. The seedlings were cleaned with seawater and cultivated using the tray culture method under identical environmental conditions. Equal initial biomass was used for each species to ensure comparable growth throughout the cultivation period (Effendie, 1979; Hurtado et al., 2020; FAO, 2024).

Growth performance was evaluated using Specific Growth Rate (SGR), Absolute Weight Growth (AWG), and Absolute Frond Length Growth (AFLG). SGR was calculated according to Effendie (1979):

$$SGR = \ln \frac{(W_t)}{(W_0)} \div t$$

where **SGR** = specific growth rate (% day<sup>-1</sup>), **W<sub>t</sub>** = final fresh weight (g), **W<sub>0</sub>** = initial fresh weight (g), and **t** = culture period (days). Absolute weight growth was calculated as:

$$W = W_t - W_0$$

Where **W** = absolute weight growth (g), **W<sub>t</sub>** = final fresh weight (g), and **W<sub>0</sub>** = initial fresh weight (g). Absolute frond length growth was determined using:

$$L = L_t - L_0$$

Where **L** = absolute frond length growth (cm), **L<sub>t</sub>** = final frond length (cm), and **L<sub>0</sub>** = initial frond length (cm). All data were analyzed descriptively and presented as mean values in tables



to compare biomass accumulation and frond development among *Caulerpa* species (Magurran, 2013; Largo et al., 2021; Espinosa-Antón et al., 2023).

## RESULT AND DISCUSSION

Table 1 shows that all three *Caulerpa* species exhibited positive biomass growth after 14 days of tray cultivation on sandy substrates. *Caulerpa racemosa* produced the highest final biomass (121.5 g) with an absolute growth of  $6.09 \pm 3.34$  g, followed by *Caulerpa cylindracea* (120.3 g;  $5.44 \pm 2.65$  g) and *Caulerpa lentillifera* (103.5 g;  $4.74 \pm 2.52$  g). Although biomass increased in all treatments, Tukey's post-hoc test indicated no statistically significant difference among species ( $p > 0.05$ ).

**Table 1.**

Absolute biomass growth of three *Caulerpa* species cultivated for 14 days

Species	T0 (g)	T1 (g)	Difference
<i>Caulerpa lentillifera</i>	50	103,5	$4,74 \pm 2,52^a$
<i>Caulerpa racemosa</i>	50	121,5	$6,09 \pm 3,34^a$
<i>Caulerpa cylindracea</i>	50	120,3	$5,44 \pm 2,65^a$

Source: research results

The superior biomass production of *C. racemosa* suggests greater physiological adaptation to sandy substrates than the other species. This species possesses a creeping stolon system and efficient rhizoidal attachment that facilitate nutrient absorption from sediment while maintaining stability under moderate water movement. Similar observations have been reported for tropical *Caulerpa*, where species-specific morphology strongly influences nutrient acquisition and biomass accumulation under natural cultivation conditions (Rushdi et al., 2020; Espinosa-Antón et al., 2023; Hurtado et al., 2020).

Specific Growth Rate (SGR) analysis further demonstrated differences in growth efficiency among species. Mean SGR values reached  $6.09 \pm 1.39\% \text{ day}^{-1}$  for *C. racemosa*,  $5.44 \pm 0.30\% \text{ day}^{-1}$  for *C. cylindracea*, and  $4.74 \pm 0.01\% \text{ day}^{-1}$  for *C. lentillifera*. Pairwise comparisons showed that *C. racemosa* differed significantly from *C. cylindracea* ( $p < 0.05$ ), whereas differences between *C. racemosa* and *C. lentillifera*, and between *C. lentillifera* and *C. cylindracea*, were not significant ( $p > 0.05$ ).

**Table 2.**

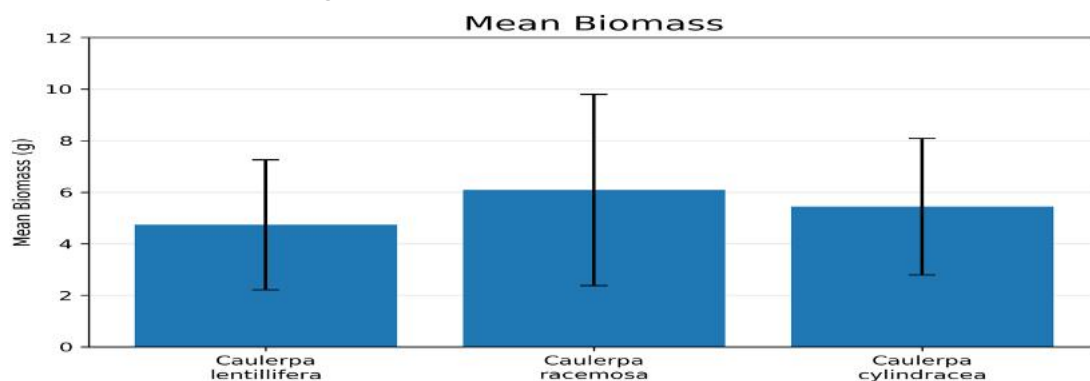
Specific Growth Rate (SGR) of three *Caulerpa* species

Species	T0 (g)
<i>Caulerpa lentillifera</i>	50
<i>Caulerpa racemosa</i>	50
<i>Caulerpa cylindracea</i>	50

Source: research results

**Figure 1.**

Mean biomass growth of *Caulerpa* species cultivated in tray systems



Source: research results

The higher SGR recorded for *C. racemosa* indicates more efficient biomass accumulation under the prevailing environmental conditions. Growth differences among *Caulerpa* species are commonly associated with variations in photosynthetic efficiency, nutrient assimilation capacity, thallus morphology, and environmental tolerance. Previous studies have demonstrated that *C. racemosa* generally exhibits rapid vegetative growth because of its high nutrient uptake efficiency and greater adaptability to tropical coastal environments (Tapotubun et al., 2020; Ravaglioli et al., 2022; Largo et al., 2021).

FronD elongation also differed among species. *Caulerpa lentillifera* exhibited the greatest increase in frond length, with mean growth reaching 2.19 cm, followed by *C. racemosa* (1.13 cm) and *C. cylindracea* (0.98 cm). However, Tukey's multiple comparison test indicated no significant difference between *C. lentillifera* and *C. racemosa*, whereas *C. cylindracea* differed significantly from both species.

**Table 3.**  
FronD length growth of three *Caulerpa* species

Species	T0	T1	Panjang total
<i>Caulerpa lentillifera</i>	1,45	3,23	0,98 ± 0,31 <sup>a</sup>
<i>Caulerpa racemosa</i>	1,04	3,43	2,19 ± 0,77 <sup>a</sup>
<i>Caulerpa cylindracea</i>	1,95	3,25	1,13 ± 0,34 <sup>a</sup>

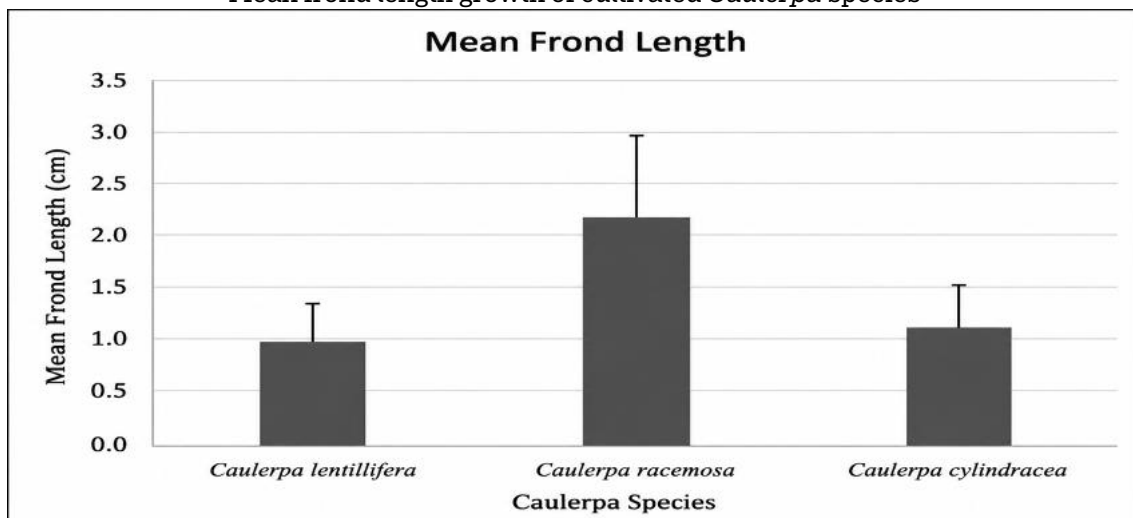
Source: research results

**Table 4.**  
Specific Growth Rate (SGR) based on frond length

Species	Average
<i>Caulerpa lentillifera</i>	0,98 ± 0,02 <sup>b</sup>
<i>Caulerpa racemosa</i>	2,19 ± 0,01 <sup>b</sup>
<i>Caulerpa cylindracea</i>	1,13 ± 0,343 <sup>a</sup>

Source: research results

**Figure 2.**  
Mean frond length growth of cultivated *Caulerpa* species



Source: research results

Unlike biomass accumulation, frond elongation appeared to depend more strongly on species-specific growth strategies than on total nutrient uptake. *C. lentillifera* is characterized



by elongated grape-like fronds with rapid vertical extension, making it particularly suitable as a fresh edible seaweed. In contrast, *C. racemosa* tends to allocate more assimilated carbon toward stolon development and lateral branching, thereby increasing biomass without proportional increases in frond length. Meanwhile, *C. cylindracea* generally invests more energy in dense vegetative proliferation rather than frond elongation. These contrasting growth strategies have been widely documented in comparative studies of tropical green macroalgae (Rushdi et al., 2020; Espinosa-Antón et al., 2023; Belton et al., 2022).

Water quality remained relatively stable throughout the cultivation period, with temperatures ranging from 27–29°C (mean 27.7°C), salinity between 29 and 30 PSU (mean 29.7 PSU), and pH values ranging from 8.07 to 8.46 (mean 8.33). All measured parameters were within the recommended range for tropical *Caulerpa* cultivation.

**Table 5.**

Water quality parameters recorded during cultivation

No	Parameter	Station 1	Station 2	Station 3	Average
1	Temperature	27	27	29	27,7
2	Salinity	30	30	29	29,7
3	pH	8,46	8,46	8,07	8,33

The favorable environmental conditions contributed substantially to the successful cultivation of all three *Caulerpa* species. Water temperature remained within the optimal physiological range for photosynthesis, respiration, and nutrient assimilation. Similarly, salinity values close to normal seawater conditions minimized osmotic stress and maintained cellular homeostasis, while slightly alkaline pH enhanced the availability of dissolved inorganic carbon required for photosynthesis. Stable environmental conditions therefore supported continuous biomass production throughout the cultivation period (Alwi et al., 2023; FAO, 2024; Sitorus et al., 2020).

Overall, the present study demonstrates that sandy substrates can support the cultivation of multiple *Caulerpa* species under tropical coastal conditions, although species respond differently in terms of biomass production and frond development. *Caulerpa racemosa* consistently exhibited the highest biomass accumulation and specific growth rate, indicating superior adaptation to sandy habitats, whereas *C. lentillifera* produced the greatest frond elongation, an important commercial characteristic for fresh sea grape markets. These findings highlight that species selection should consider the intended production objective, whether maximizing biomass yield or obtaining longer, market-preferred fronds. Similar conclusions have been reported in recent studies emphasizing the importance of matching species-specific ecological traits with cultivation environments to optimize macroalgal productivity in tropical aquaculture systems (Espinosa-Antón et al., 2023; Hurtado et al., 2020; Largo et al., 2021; Tapotubun et al., 2020).

## CONCLUSION

This study demonstrated that tray-based cultivation on sandy substrates at Barrang Caddi Island successfully supported the growth of three *Caulerpa* species, although their growth performances differed. All species exhibited positive increases in biomass and frond length during the 14-day cultivation period, confirming that the environmental conditions were suitable for tropical sea grape farming. Among the tested species, *Caulerpa racemosa* achieved the highest absolute biomass growth and specific growth rate, indicating superior adaptation to sandy substrates and greater efficiency in nutrient utilization, whereas *Caulerpa lentillifera* produced the greatest frond elongation, making it more suitable for fresh edible sea grape production. *Caulerpa cylindracea* showed intermediate growth performance, demonstrating satisfactory adaptability but lower productivity than *C.*



*racemosa*. Statistical analysis indicated that although differences in growth were observed, several pairwise comparisons were not statistically significant, suggesting that all three species responded similarly to the prevailing environmental conditions. Water quality remained within the optimal range throughout the study, with an average temperature of 27.7°C, salinity of 29.7 PSU, and pH of 8.33, providing favorable conditions for photosynthesis, nutrient uptake, and biomass accumulation. Overall, the results suggest that tray cultivation is a promising cultivation technique for *Caulerpa* in tropical coastal waters, with *Caulerpa racemosa* recommended for maximizing biomass production and *Caulerpa lentillifera* preferred for commercial production targeting fresh markets due to its superior frond development. These findings provide scientific evidence for optimizing sustainable *Caulerpa* aquaculture and contribute to the development of environmentally appropriate seaweed farming practices in Indonesia.

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