



A study of water depth on the growth and productivity of seaweed *Kappaphycus alvarezii*



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ABSTRACT. This study aims to investigate the depth of impact of varying the water on the growth and productivity of seaweed *Kappaphycus alvarezii*. The study was carried out in the seas of Pallette. The research methodology used in this study incorporates three different planting depth treatments, specifically 1.5 meters, 3 meters, and 4 meters. Each treatment used 50 grams of *Kappaphycus alvarezii* seeds per bunch. The findings of this study indicate that seaweed cultivation at a depth of 1.5 m yields significantly favourable outcomes compared to the treatments conducted at depths of 3 m and 4 m, where growth is comparatively less optimal. This occurrence can be attributed to the diminished level of light penetration at such a depth. There is an inverse relationship between the depth of seaweed planting and the rate of weight gain. The optimal depth for seaweed cultivation for 42 days is 1.5 meters, with an average specific growth rate of 3% daily. On the contrary, the treatment carried out at a depth of 1.5 m showed the most substantial increase in biomass, averaging 122 g. Additionally, the maximum yield of seaweed was observed in the same treatment, precisely measuring 1,208 g/m².

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1. Introduction

According to Rozaki *et al.* (2013), seaweed holds significant economic significance as a food and industrial ingredient, making it a prominent export commodity for Indonesia. This contributes to the country's income and foreign exchange. One of Indonesia's most-grown seaweed species is *Kappaphycus alvarezii*, also known as *Euचेuma cottonii* in commercial terms. *Kappaphycus alvarezii*, a species of red seaweed, has numerous advantages in various industries. It is utilized as a food source, in the production of pharmaceuticals and cosmetics, and as an ingredient in gels and thickeners (Rima *et al.*, 2016). Seaweed is a botanical classification encompassing plants that exhibit a lack of discernible differentiation between their root structures, stems, and leaves, resulting in the entirety of the seaweed being referred to as the thallus (Gultom *et al.*, 2019).

The quantity of seaweed production is contingent upon the suitability of the area and the level of expertise in growing technologies. The choice of the maintenance location is a crucial determinant in the overall efficacy of seaweed farming. The optimal site for seaweed growth should be situated considerably from terrestrial influences while avoiding direct exposure to the open ocean. Ideally, a barrier reef should serve as a protective measure against any harm caused by the impact of solid waves on plants (Rozaki *et al.*, 2013). Intense wave action can lead to the formation of turbid waters, potentially impeding the photosynthesis process. The cultivation, upkeep, and reaping processes will also be hindered (Indriani & Sudarman, 2000).

The depth influences the level of light intensity entering the waterways. In conjunction with the solar irradiance component, the

photosynthetic mechanism of seaweed is contingent upon the presence of carbon dioxide gas and dissolved nutrients within the aquatic environment. According to Darmawati (2013), it was proposed that an augmentation in light intensity would result in a corresponding elevation in the rate of photosynthesis. Hence, the water depth influences the magnitude of light intensity penetrating its surface, resulting in variations in sunlight intensity throughout different water zones. Polysaccharide molecules that constitute carrageenan are produced as a result of photosynthesis. Disruption of photosynthetic activity can lead to suboptimal growth of seaweed. The present study investigates the impact of varying water depth distances on the growth and productivity of *Kappaphycus alvarezii* seaweed.

2. Materials and Methods

2.1. Determine the location of the cultivation.

Identifying the growing site is a crucial component that necessitates careful consideration before engaging in cultivation endeavours. An optimal site for seaweed production is characterized by the absence of hurricanes, minimal industrial pollution, and convenient accessibility. The chosen site exhibits favourable nutritional conditions for cultivating seaweed and avoids selecting a place susceptible to significant variations or substantial alterations in salinity levels.

According to SNI (2010), the long-line method cultivates *K. alvarezii* in locations that meet specific criteria. These criteria include the protection of the cultivation site from waves, a water movement range of 20 cm/second to 40 cm/second, a considerable distance from the estuary, absence of water pollution, absence of

proximity to transportation channels or fishing areas, presence of a rocky sand bottom in the waters, natural growth of seaweed or seagrass species in the location, adherence to regional spatial layout plans for location-allocation, and the observation of annual fluctuations in water quality as outlined in Table 1.

Table 1. Water quality requirements

Parameters	Unit	Range
Temperature	°C	26-32
Salinity	mg/l	28-34
pH	-	7-8,5

2.2. Long-line Method

This study involved the cultivation of seaweed at three distinct locations and varying depths, at depths of 1.5 m, 3 m, and 4 m. The cultivation process utilized a 5 m long rope, securely fastened to anchor ropes at both ends. Additionally, at every 1 m interval along the rope, a float in the form of a plastic bottle was provided.

2.3. Seed Selection

The selection criteria for the seeds utilized in this study were established following the standards outlined in the Indonesian National Standard (SNI) 2010. Age between 25 and 30 days, weight 50 to 100 grams each tie point, numerous branches, lush leaves, no peeling or stains, and a particular colour (bright).

2.4. Planting

The *Kappaphycus alvarezii* seaweed seeds utilized in this study were obtained from the outcomes of prior cultivation efforts. The portion of the seaweed that serves as a reproductive structure is the thallus's juvenile section (Serdiati *et al.*, 2010). Before preparation, seaweed seeds are cleaned to remove any dirt and organisms that may be attached. Subsequently, the seeds are weighed, with each tie point having an initial weight of 30 g. Properly attaching each seedling clump to the thallus branches ensures they remain securely connected and resistant to separation throughout maintenance procedures.

2.5. Seaweed Culture

The seaweed seedlings are cultivated for at least 45 days. During the cultural phase, monitoring activities are conducted three times per week to assess the progress of seed growth in the garden, identify and address any issues related to pests and diseases, determine the need for seedling transplantation during the initial week in case of spreading of seeds, and remove any debris adhered to the seaweed.

2.6. Determination of seaweed growth parameters and its production

2.6.1. Absolute Growth

The researchers documented the total increase in seaweed biomass throughout the study. The absolute growth quantification was conducted using the formula suggested by Effendi (1979): $\Delta W = W_t - W_0$; ΔW = absolute growth (g), W_t = weight of t-day (g), and W_0 = initial weight (g).

2.6.2. Specific Growth Rate (SGR)

The specific growth rates were determined by measuring the weight of the seaweed seedlings in their wet state. The calculation of the particular growth rate is performed by using the formula: $SGR = (\ln W_t - \ln W_0) / t \times 100\%$; SGR = specific growth rate (%/day), W_t = weight at the end of the study (g), W_0 = weight at the start of the study (g), and t = time (days).

2.6.3. Seaweed Production

Seaweed production was calculated using the formula as follows (Serdati & Irawati, 2010): $Pr = ((W_t - W_0) B) / A$; Pr =

production (g/m), W_t = Final weight of seaweed planting (g), W_0 = initial weight of seaweed seedlings (g), B = Number of planting points, A = Length of rope (m).

2.7. Water Quality

Water quality parameters were measured simultaneously with growth sampling once a week for 42 days of cultivation. The water quality measured during the study was temperature, salinity, current velocity, nitrate and phosphate.

2.8. Data analysis

The data collected during this study was in the form of absolute growth data and specific growth rate (SGR), which will be analyzed using ANOVA (Analysis of Variance) with the help of SPSS. If it shows a significant effect, it will be followed by the Tukey test with a 95% confidence level.

3. Results and Discussion

3.1. Absolute Growth

Absolute growth is the weight gain of seaweed during the cultivation period. The highest absolute growth was obtained in treatment A (1.5 m) with an average of 122.03 ± 2.08 g, then in treatment B (3 m) with an average of 94.01 ± 1.20 g, and the lowest seaweed growth was in treatment (4 m), with an average of 87.13 ± 1.02 g. There was a significant difference between treatments A, B, and C ($P < 0.05$) (Figure 1).

3.2. Specific Growth Rate and Production of Seaweed

The specific growth rate is the seaweed growth value calculated during the rearing period. The high specific growth rate indicates that the seaweed growth is getting better. Good plant growth has a growth rate of more than 2%/day (Rizqi *et al.*, 2018).

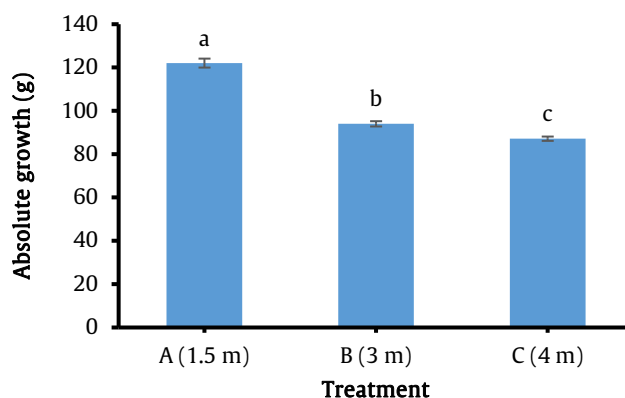


Figure 1. Absolute growth rate at various depths of cultivation.

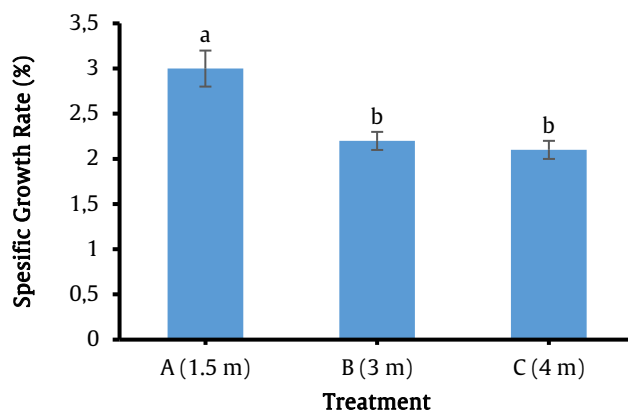


Figure 2. Graph of Average Specific Growth Rate

The specific growth rate of seaweed (Figure 2) at a depth of 1.5 m is the highest compared to other treatments. The nutrient requirements and sunlight needed for the growth process are optimal compared to other treatments. Rizqi (2018) states that seaweed's low and high growth rate at different depths is thought to be due to several ecological, physical, chemical, and other ecological conditions that affect seaweed growth at each depth. The SGR at a depth of 4 m was lower than at a depth of 3 m, although it was not significantly different between treatments ($P>0.05$). The low growth at this depth is due to reduced light penetration. Susilowati *et al.* (2012) stated that the slow growth of seaweed is thought to be due to the availability of food and the intensity of light that is not absorbed optimally, thereby reducing productivity.

Table 2. Wet-weight production of seaweed at different wr depth cultivation.

Depth of cultivation (m)	Wet-weight production of seaweed (g/m ²)
1.5	1,208
3	931
4	861

3.3. Volume of Seaweed Production

In order to produce seaweed using the long line method, 33 planting points with a rope length of 5 meters and three ropes in each treatment were used. Treatment A produced the most significant quantity of seaweed, 1,208 g/m², followed by Treatment B with 931 g/m², and Treatment C with 861 g/m².

3.4. Water Quality Parameters

Assessing water quality at the cultivation site is crucial in seaweed research. This is conducted in order to assess the state of the aquatic ecosystem. According to the research findings of Akib *et al.* (2015), the performance of seaweed production is influenced by several biological, physical, and chemical aspects associated with water. The quality of water significantly influences the growth of seaweed. This study's water quality measurement was conducted weekly during the sample period.

The water temperature observed during the study decreased within the optimal range of 29-30°C. This finding aligns with Anggadiredja *et al.* (2010) and Hardan *et al.* (2020), who reported that the optimal temperature for the growth of *K. alvarezii* seaweed

is between 26-30°C. SNI7579 (2010) also states that the optimal temperature for seaweed growth generally falls within the range of 24-32°C. Extreme temperatures, whether too high or excessively low, can impact the growth rate of seaweed and potentially lead to mortality. Salinity can affect seaweed; each organism has a different tolerance, including *K. alvarezii* (Syahrir, 2020). The measurement results obtained during the study were 29-30 ppt. This is by SNI7579 (2010) optimal salinity for seaweed cultivation ranges from 28-34 ppt.

The presence of dissolved oxygen (DO) is a vital necessity for the survival of aquatic organisms. The study observed a range of dissolved oxygen (DO) levels between 5.17-6.11 mg/L, within the optimal range determined by the Dirgenkanbud (2008). The previously mentioned source suggests that DO levels between 3.0-8.0 mg/L are suitable for supporting seaweed farming.

The measurement of acidity, often known as pH, is a crucial chemical indicator for assessing water stability (Simanjuntak, 2009). The investigation yielded a measurement value of 7, which aligns with the recommended pH range of 7-8.5 (SNI, 2010) for cultivating *K. alvarezii* seaweed in the specific area.

The presence of current plays a crucial role in facilitating the dispersion of nutrients, removing debris such as epiphytes adhering to the thallus, and facilitating the transportation of oxygen (Rizqi *et al.*, 2018). The present velocity at the research site, namely at a depth of 1.5 m, ranges from 21 to 32 m/s. At a depth of 3 m, the velocity ranges from 23 to 34 m/s, and at a depth of 4 m, the velocity ranges from 23 to 36 m/s. According to the perspective of SNI 7673.2 (2011), the optimal velocity for seaweed cultivation is reported to range between 20-40 cm/s. Water currents are quantified by employing a methodology including using a bottle securely fastened to a rope, possessing a length of precisely 2 meters. This bottle is then thrown into the sea, synchronously activating a stopwatch.

According to the laboratory test conducted by Maros BRPBAP3, the nitrate concentration in Pallette waters was determined to be 1.5384 mg/l, while the examination of phosphate yielded a value of 0.0040 mg/l. According to Asni (2015), Nitral and phosphate are essential nutrient sources seaweed requires to facilitate growth. According to Labenua (2021), optimal seaweed growth occurs between 1.0-3.2 mg/l nitrate and 0.02-0.1 mg/l phosphate concentrations.

4. Conclusion

The growth of seaweed at varying depths produced significant differences compared to the growth of *Kappaphycus alvarezii*. Particularly, the treatment A (1.5 m) showed the highest specific growth rate, averaging at 3% per day. The study showed that treatment A (1.5 m) exhibited the best absolute growth, with an average of 122 g. Treatment A (1.5 m²) also had the highest production, specifically 1,208 g/m².

Table 3. Water quality parameters observed throughout the research.

Parameters	Units	Range	Feasibility	References
Salinity	ppt	30-34	28-34	SNI7579 (2010)
Temperature	°C	29-30	24-32	SNI7579 (2010)
pH	-	7	7-8,5	SNI7579 (2010)
DO	mg/l	5,17-6,11	3-8	SNI7579 (2010)
Current	cm/s	21-32	20-40	SNI7673.2(2011)
Nitrate	mg/l	1,5384	1,0-3,2	Labenua (2021)
Fosfat	mg/l	0,0040	0,02-0,1	Labenua (2021)

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Not available.

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Supplementary files

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study, and/or contains supplementary material available to authorized users.

Competing interest

All author(s) declare no competing interest.

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