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Effect of Harvest Time on Growth Performance, Biomass and Productivity of *Kappaphycus alavarezii* in Waworada Bay

Pengaruh Kedalaman Terhadap Pertumbuhan Rumput Laut Eucheuma Cottonii Yang Dibudidayakan Dengan Metode Longline Di Teluk Waworada Kabupaten Bima

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ABSTRACT

West Nusa Tenggara has a lot of marine and fishery potential, one of which is Waworada Bay where there is an increasing number of seaweed developments, which is the latest breakthrough and helps the economy of coastal communities in West Nusa Tenggara. The purpose of this study was to determine the effect of planting depth on the growth of Eucheuma cottonii seaweed. The depths used in this study were 20 cm, 30 cm, 40 cm, 50 cm and 60 cm using the long line method and were further tested for carrageenan content at the Base Laboratory of the Aquaculture Study Program, University of Mataram. This study used a completely randomized design (CRD) consisting of 5 treatments and 3 replications to obtain 15 experimental units. P1: 20 cm depth, P2: 30 cm depth, P3: 40 cm depth, P4: 50 cm depth, P5: 60 cm depth. The results showed that different spacing between 20 cm, 30 cm, 40 cm did not significantly affect the growth of Eucheuma cottonii seaweed, while at depths of 50 cm and 60 cm it had an effect so that the growth of seaweed was inhibited and at depths of 20 cm, 30 cm and 40 cm has the potential for faster growth in contrast to the depth of 50 cm and 60 cm Eucheuma cottonii seaweed has slower growth so that it shows a real effect at each depth.

ABSTRAK

Nusa Tenggara Barat memiliki banyak potensi kelautan dan perikanan, salah satunya adalah Teluk Waworada perkembangan rumput laut semakin banyak, dan menjadi trobosan terbaru serta membantu perekonomian masyarakat pesisir di Nusa Tenggara Barat. Tujuan penelitian ini untuk mengetahui pengaruh kedalaman penanaman terhadap pertumbuhan rumput laut Eucheuma cottonii. Adapun kedalaman yang digunakan pada penelitian adalah kedalaman 20 cm, 30 cm, 40 cm, 50, cm dan 60 cm dengan metode long line dan diuji lanjut kandungan karaginan di Laboratorium Basa Program Studi Budidaya Perairan Universitas Mataram. Penelitian ini menggunakan rancangan acak lengkap (RAL) terdiri dari 5 perlakuan dan 3 ulangan sehingga diperoleh 15 unit percobaan. P1: Kedalaman 20 cm, P2: Kedalaman 30 cm, P3: Kedalaman 40 cm, P4: Kedalaman 50 cm, P5: Kedalaman 60 cm. Hasil penelitian menunjukan bahawa jarak tanam yang berbeda antara 20 cm, 30 cm, 40 cm tidak berpengaruh nyata terhadap

pertumbuhan rumput laut Eucheuma cottonii sedangkan pada kedalaman 50 cm dan 60 cm berpengaruh sehingga pertumbuhan rumput laut terhambat dan pada kedalaman 20 cm, 30 cm dan 40 cm memiliki potensi pertumbuhan lebih cepat berbeda dengan kedalaman 50 cm dan 60 cm jenis rumput laut Eucheuma cottonii memiliki pertumbuhan lebih lambat sehingga menunjukkan pengaruh nyata di setiap kedalaman.

Kata Kunci	*Kedalaman, Pengaruh Kedalaman yang Berbeda, Potensi Pertumbuhan, Rumput Laut.*
Keywords	*Depth, Effect of Different Depths, Growth Potential, Seaweed.*
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INTRODUCTION

Seaweed is a low-level plant that has thallus and is included in the macroalgae group (Kurniawan et al., 2018). This plant belongs to the Thallophyta division with three large classes, namely Clorophyceae, Phaeophyceae, and Rhodophyceae (Nurjanah et al., 2021). Seaweed class Rhodophyceae (red algae) is widely cultivated by people, especially the Eucheuma cottonii type (Wijayanto et al., 2011). This type has relatively cheap product costs and post-harvest handling is relatively easy and simple (Damayanti et al., 2019; Meiyana, et al., 2001). According to Widowati et al. (2015) Eucheuma cottonii is a seaweed that has high economic value as an export commodity. Apart from that, Eucheuma cottonii is very profitable as a basic material for production in the industrial world (Surni, 2014). Eucheuma cottonii is also widely cultivated because it contains carrageenan, especially the kappa carrageenan type (Distantina, et al 2011). Types of carrageenan can be grouped into 3 (three), namely kappa, iota and lambda (Webber et al., 2012). Kadi and Atmadja (1988) in Sirajuddin, (2009), stated that a good current speed for seaweed growth is between 0.08-0.17 m/sec. The average water depth of Waworada Bay ranges from 3.33-13.33 m.

The depth of the water greatly influences the growth of seaweed. Seaweed planting, the deeper the seaweed is planted, the less sunlight intensity will be so that the growth of the seaweed will be increasingly hampered, if it is too shallow it will cause the seaweed to be exposed to direct sunlight. The depth of the water is closely related to the amount of sunlight penetration which plays a very important role in the photosynthesis process. Susilowati (2012) stated that maximum production success in seaweed cultivation can be achieved if it is supported by a suitable environment for seaweed growth, such as substrate, sunlight, nutrient elements and water movement when cultivating seaweed. Meanwhile, depth is a very important factor to know because it greatly influences the absorption of sunlight by seaweed. Because sunlight is closely related to the photosynthesis process which produces food for the growth of seaweed.

This research aims to determine the effect of planting depth on the growth of Eucheuma cottonii seaweed. The depths used during the research were 20 cm, 30 cm, 40 cm, 50 cm and 60 cm. Susilowati, T et al., (2012), said seaweed can grow well if the water depth is suitable for maintenance. Garpenassy et al., (2016), stated that previous research said that a good depth for seaweed growth is 30 cm. This similar research was

carried out by Runtuboy & Abadi (2018), stating that based on calculation results, carrying out production activities can be planted at a depth of 10 to 30 cm. Tamala et al., (2022), stated that the factors that trigger the growth rate of seaweed (*Eucheuma cottonii*) are nutrients, nutrients regulate the growth of seaweed. Rucerita et al., (2020), stated the water quality requirements for the suitability of locations to be used in developing seaweed cultivation. Therefore, ongoing research is really needed to determine the effect of depth on the cultivation of seaweed (*Eucheuma cottonii*) using the longline method so that later it can become information and knowledge for seaweed cultivators (*Eucheuma cottonii*).

METHODS

This research will be carried out for 45 days, taking place in Doro O'o Village, Langgudu District, Bima Regency. and in July further carrageenan content in the Base Laboratory of the Aquaculture Study Program, Mataram University. The tools and materials used in this research are Do meter, pH meter, refractometer, scales, thermometer, ruler, eucheuma cottonii, tissue, stones, distilled water, float, wood, boat, stationery, camera, basic stakes, milon rope, rope milon 1 in. This research used a completely randomized design (CRD) consisting of 5 treatments and 3 replications to obtain 15 experimental units. P1: Depth 20 cm, P2: Depth 30 cm, P3: Depth 40 cm, P4: Depth 50 cm, P5: Depth 60 cm.

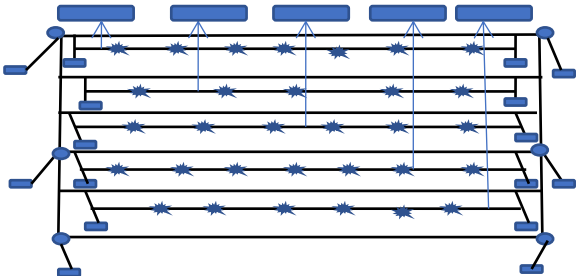

Figure 1. Longline Construction

The research parameters measured to test the research results are:
The parameters that will be measured include absolute weight growth, specific weight growth, carrageenan content test, and water quality as follows.

1. Absolute Growth Rate

Tiwa et al., (2013), stated that absolute growth is the weight growth of Eucheuma cottonii during maintenance following the existing formula.

$$\Delta W = Wt - W0$$

Where,
ΔW= Absolute growth (g)
Wt= Average weight of test seaweed at the end of the experiment (g)
W0= Average weight of test seaweed at the start of the experiment (g)

2. Specific Growth Rate (%hari)

Specific growth rate is a percentage of the difference between final weight and initial weight, compared to the length of maintenance time. The specific growth rate can be calculated using the formula Anggadireja et al., (2006) in Ruceritaet al., (2020) as follows:

$$\text{SGR} = \frac{LnWt - LnWo}{t} \times 100\%$$

3. Relative Growth (%) of Seaweed (*Eucheuma cottonni*)

Relative growth can be calculated using the formula according to Effendi (1979) in Ruceritaet al., (2020) as follows:

$$G = \frac{Wt - Wo}{woxt} \times 100\%$$

Note:

G = Weight growth rate (%)
Wt = Weight at time t (gr)
Wo = Initial planting weight (gr)

4. Agility Test

First, the seaweed is dried for 3 days until it is completely dry, then washed clean, the seaweed is soaked in fresh water for 24 hours, then the seaweed is weighed, 12.5 grams, put into a blender, put water in a ratio of 3x the weight of the seaweed, blended until smooth, then cooked. Use medium heat for 15 minutes and turn off the stove, add alcohol in a ratio of 1x the weight of seaweed and stir until evenly mixed, filter using a cloth and place on the tray provided and dry in the sun until completely dry. According to Bualemo, (2017), 5 grams of algae flour (A gram), extracted with 300 ML of hot water (1:60), at a temperature of 85-95 C in an alkaline atmosphere pH 8-9 for 4 hours. The extraction results obtained are filtered with a fine cloth, then the filtrate is concentrated to approximately 150 ml by heating. The filtrate was added with ethanol solution (95% alcohol) using a 200 ML measuring cup to precipitate the carrageenan. Leave it overnight and the precipitate formed is filtered again with a soft cloth and the precipitate is dried in the oven or sunlight at a temperature of 60 C for 8 hours. Dried carrageenan was weighed (B grams) to determine its weight.

$$\text{keraginan } (\%) = \frac{berat\ keraginan\ (B\ gram)}{berat\ sampel\ (A\ gram)} \times 100$$

5. Water Quality

Water quality data is supporting data which includes temperature, salinity, brightness current speed, and dissolved oxygen (DO). Water quality dilution is carried out for 10 days every morning.

RESULT AND DISCUSSION

Result

1. Absolute Growth Rate (grams)

Based on the results of the absolute growth of Eucheuma cottonii seaweed which was observed from the initial weight of planting to the time of harvesting Eucheuma cottonii seaweed, it can be seen in Figure 4 below.

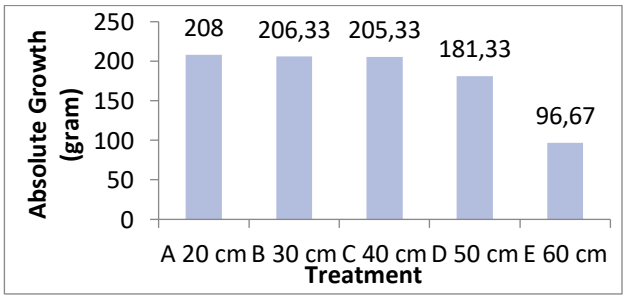

Figure 2. Absolute Growth Chart (gram)

Based on Figure 4, it shows that absolute growth has a very significant effect on the growth of seaweed. The best growth was obtained from treatment P1 208% with a depth of 20 cm, treatment P2 206.33% with a depth of 30 cm, treatment P3 205.33%

with a depth of 40 cm, treatment P4 181.33 % with a depth of 40 cm, and with treatment P5 95.67% with a depth of 60 cm, the deeper the seaweed is planted, the growth of the seaweed will be hampered because the intensity of sunlight cannot penetrate to the bottom of the water. Tiwa et al., (2013), stated that the photosynthesis process of the seaweed Eucheuma cottonii occurs when the light intensity is high and the temperature is 20-28 then the growth of the seaweed will be faster and if the intensity of sunlight is less, the growth of the seaweed will be slower.

2. Relative growth (%)

From the results of measurements of the relative growth of Euchuma cottoni seaweed at different depths for 45 days, the average relative growth in each treatment P1 (20 cm) was 942.67%, P2 (30 cm) was 832.67%, P3 (40 cm) was 799.33 %, P4 (50 cm) is 573.33%, P5 (60 cm) is 480%. The relative growth of Eucheuma cottoni seaweed can be seen in the graph below.

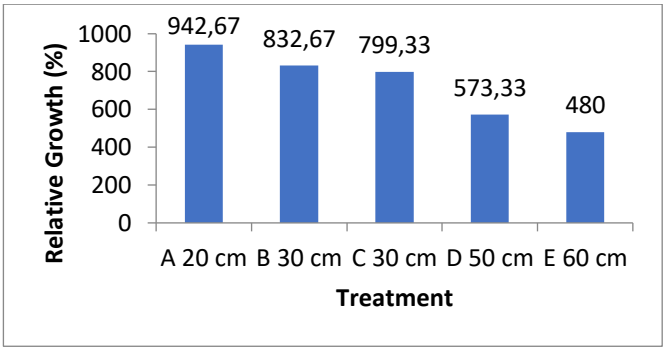

Figure 3. Relative Growth Chart (%)

Based on Figure 5, the results of the ANOVA test show the daily growth rate of seaweed in Waworada Bay planted using the longline system, showing significant differences in treatments P1 942.67%, P2 832.67%, P3 799.33%, P4 573.33%, P5 480%. Differences in daily growth rates can be distinguished because the growth cycle of the seaweed Eucheuma cottonii has a relatively fast growth rate. (Rucerita, Ihsan B, 2020) said that seaweed growth shows that seaweed development at a depth of 10 cm tends to be better compared to depths of 20 cm and 30 cm.

3. Specific Growth Rate (% hari)

The specific growth rate of *Eucheuma cotonii* seaweed shows that there was an increase in growth from the beginning of planting until the second week, but there was a decrease in the third week due to the lack of sunlight penetration so that the seaweed growth decreased, in the fourth and fifth weeks it increased again because it was supported by Several factors include sufficient sunlight intensity. The average value (SGR) for 5 weeks, namely at P1 (20 cm) was 5.86% of the day, P2 (30 cm) was 5.75% of the day, P3 (40 cm) was 5.66% of the day, P4 (50 cm) was by 5.41% of days, P5 (60 cm) by 5.41% of days. It can be seen in the graph below.

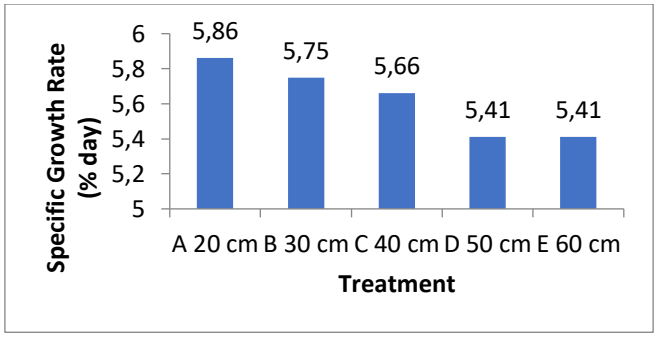

Figure 4. Specific Growth Rate Graph (% days)

Based on Figure 6, it shows that the results of specific growth (% of days) have a very significant effect on the treatment, the specific growth rate obtained during the research is in the range of P1 depth 20 cm 5.86%, P2 depth 30 cm 5.75%, P3 depth 40 cm 5.66%, P4 depth 50 cm 5.41%, P5 depth 60 cm 5.41%. Zainuddin & Rusdani., (2018), stated that the daily growth rate is in the range of 4%, as stated by Akmal et al., (2008), that cultivation activities are considered good if the daily growth rate obtained is greater than 3%. And furthermore, Bachtiar (2004), stated that the daily growth rate of seaweed is equal to 3-5%.

4. Carrageenan Content (gram)

The analysis results showed that the highest carrageenan content was in the P1 treatment, 4 grams, in the P2 3 and P3 3 treatments it was very specific and in the P4 2 and P5 2 treatments it was very specific, which can be seen in the graph. 5.

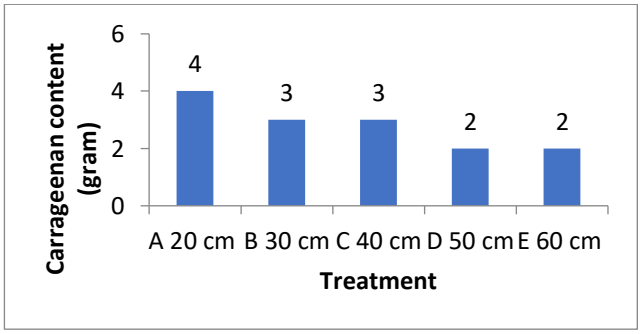

Figure 5. Chart of Carrageenan Content (gram)

Based on Figure 7, it shows that the excellent carrageenan content in treatment P1 was 4 grams, which was very significantly different from all other treatments, whereas in treatment P2 it was 3 grams, P3 3 grams, in treatment P4 2 grams, P5 2 grams. Failu et al., (2016), stated that Eucheuma cottonii seaweed has optimal carrageenan content after reaching 45 days of age. It is very important to know the carrageenan content of seaweed because the carrageenan content is the main parameter in developing seaweed cultivation, the carrageenan content was tested in the wet laboratory of the Mataram University Aquaculture Study Program after taking samples at the research location. The analysis results showed that the interaction between depth and eucheuma cottonii content did not have a significant effect. According to (Sirajuddin, 2009), therefore parameters such as DO (0.53%), phosphate (0.50%), and pH (0.36%) have an influence on biomass production and seaweed dryness even though they are below ($\alpha = 0.05$), then it is still included in the land suitability matrix for seaweed cultivation as a complementary parameter. Akmal, (2017), stated that the results of photosynthesis are polycaride compounds which are

part of carrageenan. If photosynthetic activity is disrupted it will result in seaweed growth and carrageenan content that is not optimal.

(Anton, 2017), stated that the high and low growth of seaweed carrageenan content is influenced by the season and type of plant as well as the location where the seaweed is kept. (Bhernama, n.d. 2019), stated that the success of eucheuma cottonii seaweed cultivation depends on the right rearing location, and affects the viability of the seaweed and the carrageenan content.

5. Water Quality

Water quality has a very important role in supporting the life and growth of the seaweed Eucheuma cottonii biota. The water quality parameters observed during the research can be seen in the table 4.

Table 4 Water Quality Data During Research

Parameter	Unit	Observation result	Quality standards	References
Temperature	°C	27-30	27-30	28-32 (Burhanuddin, 2012)
DO	mg/	7,2-7,4	3-8	4-10 (Effendy,2003)
Salinity	Ppt	32	31,6- 32,9	31,6-32,9 (Pauwah *et al*, 2020)
Ph	-	7,3	6-9	7,5-8,0 (Santoso,2001)
Current speed	m/Det	0,5-1,4	0,2-0,4	0,2-0,4(Susilowati, T. Rejeki, S. Dewi, E, 2012)
Brightness	M	2,5	2-5	2-5 (Suparman,2014)
Nitrate	(mg/I)	0,05-0,06	0,02-0,04	(Effendi,2003)
Nitrite	(mg/I)	0,05-0,06	0,01	0,051-0,100 (Zainuddin & Rusdani, 2018)
Phosphate	(mg/I)	0,01-0,04	0,02-1,0	Majid *et al.*, (2016)

Based on the results of water quality measurements, it shows that the waters of Waworada Bay are very suitable for cultivating Eucheuma cottonii seaweed. The salinity range measured during research is still within the normal range. Majid et al., (2016), stated that the range of salinity measured during research was still within a tolerable range so as to support the growth of seaweed. During observations, the pH value of the waters was also relatively stable and within the normal range to support the maintenance of seaweed cultivation. The results of measurements of dissolved oxygen at the research location are in conditions that are still very safe for seaweed maintenance. The DO value range is around 3.5 mg/I. Meanwhile, the ideal current speed ranges from 0.5-1.4 m/s. Supiandi et al., (2020), stated that current speed has an important role in carrying the nutrients needed by seaweed growth, while the optimal current speed for seaweed cultivation is 0.5-1.4 m/s. The average brightness value obtained during the research was 2.5 m/s. Meanwhile, for phosphate and nitrate content, the nitrate content for waters ranges from 0.1 ppm and phosphate ranges from 0.2-1.0. Majid et al., (2016), stated that for phosphate and nitrate content, the nitrate content for waters is around 0.1 ppm while the phosphate content is around 0.2 ppm, it is still very suitable as a location for rearing seaweed, the fertility of seaweed is greatly influenced by nitrate and phosphate content. The phosphate content plays a role in increasing plant activity for metabolic processes, namely for growth and development. The nitrite content for waters of 0.1 ppm is still very suitable for seaweed growth. Sinta Rahmawati, et al., (2021), stated that the nitrate content in the waters is 0.09-3.5 mg/L for the growth of seaweed to absorb nutrients.

Discussion

1. Absolute Growth Rate

Based on the research results, it shows that the absolute growth of seaweed in treatment P1 was 208%, P2 206.33%, P3 205.33%, P4 181.33%, P5 96.67%. Tiwa et al., (2013), stated that seaweed growth requires sunlight for the photosynthesis process, seaweed can only grow at a certain depth. Pauwah 2020 Pauwah et al., (2020), stated that the absolute weight growth of Eucheuma cottonii seaweed was carried out by weighing the Eucheuma cottonii seaweed when planted at 25 grams on each ris rope. Next, the weight of the seaweed seeds was weighed every 10th day until the maintenance period was 45 days.

2. Relative Growth (%)

Based on the ANOVA test, it shows that the daily growth rate of seaweed in Waworada Bay which is planted using the longline system shows a significant difference in treatments P1 942.67%, P2 832.67%, P3 799.33%, P4 573.33%, P5 480% with relatively significant growth rates. Differences in daily growth rates can be distinguished because the growth cycle of the seaweed Eucheuma cottonii has a relatively fast growth rate. Rucerita, Ihsan B, (2020), stated that seaweed growth shows that at a depth of 10 cm, seaweed growth tends to be better compared to depths of 20 cm and 30 cm.

3. Specific Growth Rate (% days)

The specific growth rates obtained during the study were in the range of P1 depth 20 cm 5.86%, P2 depth 30 cm 5.75%, P3 depth 40 cm 5.66%, P4 depth 50 cm 5.41%, P5 depth 60 cm 5.41%. Zainuddin & Rusdani, (2018), stated that the daily growth rate was in the range of 4% as stated in the statement. Akmal et al., (2008), stated that cultivation activities are considered good if the daily growth rate obtained is greater than 3%. And furthermore, Bachtiar (2004) stated that the daily growth rate of seaweed is 3-5%.

The results of analysis of variance showed that the depth of seaweed cultivation had an effect on each treatment: P1 20 cm depth 5.86%, P2 30 cm depth 5.75%, P3 40 cm depth 5.66%, P4 50 cm depth 5.41%, P5 60 cm depth. Akmal et al. (2017), stated that the daily weight growth rate of Eucheuma cottonii seaweed has a significant effect on seaweed growth.

4. Carrageenan content (gram)

Based on the research results, it shows that the results obtained for yeast content are P1 4 grams, P2 3 grams, P3 3 grams, P4 2 grams, P5 2 grams. According to Sirajuddin, (2009), parameters such as DO (0.53%), phosphate (0.50%), and pH (0.36%) have an influence on biomass production and seaweed dryness even though they are below ($\alpha = 0.05$), then it is still included in land suitability for seaweed cultivation as a complementary parameter. Akmal et al. (2017), stated that the results of photosynthesis are polysaccharide compounds which are part of carrageenan. If photosynthetic activity is disrupted it will result in seaweed growth and carrageenan content that is not optimal.

According to (Sirajuddin, 2009) the results of the principal component analysis occurring in several biophysical parameters of Waworada Bay show that a positive correlation occurs between biomass production and DO (0.71%), nitrate (0.82%), salinity (0.92%) temperature. (0.82%), current (0.97%), brightness (0.96%) depth (0.97%), phosphate (0.10) and negatively correlated with pH (-0.04), COD (-0.76), Pb (-0.78) and pests (-0.93). Furthermore, carrageenan values were positively correlated with DO (0.03%), pH (0.32%), nitrate (0.51%), salinity

(0.50%), temperature (0.28%), current (0, 32%), brightness (0.75%), depth (0.66%), phosphate (0.20%) and negatively correlated with COD (-0.14), Pb (-0.33) and pests (-0,35).

5. Water Quality

Water quality is one of the indicators that influences the success of seaweed cultivation maintenance activities. The parameters measured during maintenance are temperature, DO, pH, salinity, current speed, depth, photofa, nitrate and nitrite. Water temperature during maintenance is 27 °C -30 °C. This indicates that the water temperature during research activities was normal. According to (Nur et al., 2016) the optimal water temperature is around 26 °C-29 °C. (Dahuri, 2001), so that temperature provides good water quality for the growth of seaweed that has been studied. The degree of acidity during maintenance is 6-7. The degree of acidity during cultivation is the optimal acidity level for cultivation activities. According to (Susilowati, T. Rejeki, S. Dewi, E, 2012) the presence of the degree of acidity (pH) in seaweed (Eucheuma cotonii) cultivation activities also influences this. A value (pH) of 7-9 is productive water and plays a role in encouraging the growth of organic material in the water and becoming minerals that can be consumed by phytoplankton. The dissolved oxygen (DO) value during the study was 7.2-7.4. According to (Herdan et al., 2020), aquatic organisms always depend on the availability of dissolved oxygen in the waters, the seaweed Kapaphycus alvarezii is very capable of living at conditions of 4-6 mg/l. Water flow is very important to know, while the water flow during the research was 0.5-1.4 m/sec. Currents are very important as carriers of nutrients for seaweed metabolism. Current speed is also very necessary for the growth of seaweed. The ideal current speed of 0.4-0.5 m/sec is considered very good because the ideal current is 0.2-0.4 m/sec. Akmal et al., (2008), stated that water brightness is an important factor for the growth of seaweed, because low brightness of the feeding water will affect the growth of seaweed and result in reduced sunlight entering the water. The brightness of the waters at the time of the study was 2.5 m, which is considered good. Zainuddin & Rusdani, (2018), stated that good water clarity for seaweed cultivation is > 1.5 m. The phosphate values obtained during the research were in the range of 0.2-1.0 ppm. Zainuddin & Rusdani., (2018), stated that the phosphate conditions for optimal growth are 0.02-1 ppm. Nitrate and nitrite are compounds that produce nitrogen needed by seaweed growth, the nitrate content obtained during the research was 0.05-0.06 and 0.05-0.06 nitrite which is considered very good for seaweed growth based on Vollenweider, (1998) in Iksan (2005) states that the ideal nitrate range for seaweed growth is 0.227-1.129 ppm and nitrite 0.051-0.100.

CONCLUSION

The conclusions from the research results are as follows:

1. The growth of Eucheuma cottonii seaweed using the longline method at different depths had no significant effect on the treatment.
2. See the potential growth rate of Eucheuma cottonii seaweed at different depths and determine the growth of seaweed in each treatment.
3. The best growth occurred in treatment P1 with absolute growth weight of 208, relative growth of 942.67%, specific growth of 5.86%, and carrageenan content. 4%.

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