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Gracilaria sp Seaweed Cultivation with Net Floating Method in Traditional Shrimp Pond in the Dungun River of Marga Sungsang Village of Banyuasin District, South Sumatera

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Abstract South Sumatera has a very large shrimp pond, most of them were abandoned and untreated. The caused is the diseases such as white spot resulted in crop failure. It requires the effort in order to optimize and utilize the pond area. One of them by cultivating the *Gracilaria* sp seaweed which has a high economic value, easy to cultivate and tolerant to environmental changes. This study aims to analyze the parameters of water, analyze the growth rate of *Gracillaria* sp seaweed with Floating Net method. The results showed that the weekly growth of *Gracilaria* sp in the first week was highest in the fifth MFN with a weight of 5,540 grams and the lowest on the second MFN with 5,425 grams. At the second week the highest growth of third MFN (6,021 grams) and the lowest on fourth MFN (5,797 grams). On the third week, the highest growth of third MFN (6,625 grams) and the lowest fourth MFN (6,380 grams). On the fourth week, the highest growth of third MFN (6,950 grams) and the lowest on second MFN (6,864 grams). On the fifth week, the highest growth of first MFN (7,450 grams) and the lowest third MFN (7,010 grams) and on the sixth week, the highest growth of sixth MFN (8,215 grams) and the lowest third MFN (7,120 grams). The highest growth rate was at sixth week gain weight of 895 grams (sixth MFN). While the lowest was at fifth week with the addition of weight amounted to 60 grams (third MFN). The highest average growth rate actually occurred at the third week with the addition of average weight of 3,653 grams and the lowest was at the fifth week (2,193 grams). The highest absolute growth was found in the sixth MFN with a final weight of 8,215 grams and an absolute growth rate of 3,215 grams. While the lowest weight on the third MFN with weight 7,120 grams and growth rate of 2,120 grams. There was an increase of 1.424 – 1.643 times the weight of the initial weight of planting. The daily growth rate ranges from 0.84515 - 1.189% /day. The DGR value is highest in the 6th of MFN with the value of 1.18922 and the lowest was in the 3rd of MFN of 0.84515% days. All of the methods (MFN) show DGR results <2% /day. Parameters of pond water are still in the range for the cultivation of *Gracilaria* sp.

Keywords Floating net; Pond; Seaweed; *Gracilaria* sp; South Sumatra

Introduction

The province of South Sumatra has a very large pond, both are owned by companies and community pond. At the moment, most of the shrimp ponds are already abandoned and untreated. The cause is a white spot disease attack. An effort is required to optimize the land. One of them by cultivating seaweed. There are various types of seaweed that have high economic value one of them is *Gracilaria*. *Gracilaria* sp belongs to a group of red algae. This type of algae is one of the most widely cultivated seaweed species, producing over 3.8 million tons/year with a value of USD 1 billion/year (FAO, 2017a). China and Indonesia are the two largest *Gracilaria* sp producing countries in the world (FAO, 2017a) *Gracilaria* sp used its biomass for various industrial sectors such as industrial agar (Pereira et al., 2008) and as animal feed (Qi et al., 2010; Johnson et al., 2014). *Gracilaria* sp accounted for more than 66% of the total production order in the world (Pereira and Yarish, 2008).

Until now, 185 *Gracilaria* sp species have been identified (Guiry and Guiry, 2014). *Gracilaria* has a very rapid growth (Abreu et al., 2011; Kim and Yarish, 2014; Kim et al., 2015; Wu et al., 2015; Kim et al., 2016; Gorman et al., 2017). This type of seaweed has a high tolerance to temperature (eurythermal). The temperature that can be tolerated by this seaweed ranges from 0 - 35 ℃ with the optimum temperature for growth ranging from 20 - 28 ℃ (Yokoya et al., 1999; Abreu et al., 2011; Kim et al., 2016). In addition, *Gracilaria* sp has a wide tolerance to salinity (euryhaline) within the range of 10-40 psu, with the optimum growth of 25 - 33 psu (Yokoya et al., 1999; Weinberger et al., 2008; Kim et al., 2016; Gorman et al., 2017).

Gracilaria sp can be cultivated under various methods such as, by the longline method at high sea, off base, in the pond and in cultivation tanks (Aslan, 1998; Oliveira et al., 2000; Indriani and Sumiarsih, 2005; Sahoo and Yarish, 2005; Pereira and Yarish, 2008). The success of cultivation depends on several factors, among others; season, land suitability, planting method, seed and post harvesting. Several methods are used by seaweed farmers in Indonesia such as off base, long line and pond (Aslan, 1998; Indriani and Sumiarsih, 2005).

The cultivation of *Gracilaria* sp is not yet known and has never been done in South Sumatra. The cultivation of *Gracilaria* sp has several advantages for fish farmers, among others; has a high economic value, market opportunities are still very large, does not require special cost and treatment, can be cultivated along with shrimp and milkfish and can further optimize the use of pond. Generally, *Gracilaria* sp is cultivated by the basic stocking method on the pond area with a water base that has a type of sandy clay substrate. The basic stocking method is selected by seaweed farmers because easy, inexpensive and practical. The basic types of pond waters with sandy clay substrate can prevent the thallus from attached sediments.

Pond land at Dungun River research site of Marga Sungsang Village of Banyuasin Regency generally has pond bottom with a muddy substrate. Generally, pond land in South Sumatra Province has pond bottom with muddy substrate type. This type of substrate greatly affects the growth of *Gracilaria* sp. Thallus buried in mud substrate will die if not routinely cleaned. It requires a design of the *Gracilaria* sp cultivation method on pond land with a muddy substrate. One of them with floating net method. This method, other than preventing from the muddy substrate will also facilitate control, treatment, and harvesting. In addition, this method can avoid the cultivation of pest and disease of *Gracilaria* sp like predators and others.

In this research, *Gracilaria* sp cultivation in pond land will be implemented by using floating net method (MFN). The method is designed in such a way that the influence of mud and sediment can be minimized on the growth of the thallus. Floating net will be in the design when the tide up is not drowning and when the tide does not run aground at the bottom of the pond. Cultivated cultivation will be treated to continue to get sunlight.

The objective of the study is to analyze the daily growth rate, weekly growth rate, absolute growth rate and environmental parameters.

1 Research Method

Samples were collected from Khor Al-Zubair channel, southern Iraq (Figure 1) from five stations. Water samples (500 ml) were collected at two depths in sterile glass bottle, all samples transferred to an ice box and transported to the laboratory.

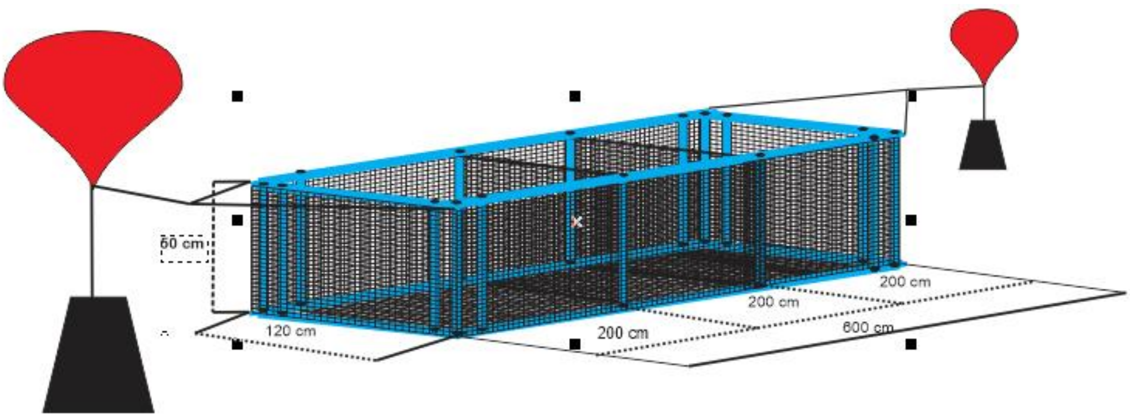

Figure 1 Design of floating net method of *Gracilaria* sp

2 Research Design

The treatment conducted in this research is by planting seaweed using floating net method, which is made of six (6) units with the size of 200 cm x 120 cm x 50 cm per unit.

Seaweed seeds (BRL) *Gracilaria* sp grown comes from the cultivators of seaweed in Banjarsari Village of Garut regency Banten Province. The planted thallus is in good condition, young and has many thallus branching. Seeds are inserted in floating net and each MFN weighs of 5,000 grams (early seedling/ Wo). Length of Maintenance six (6) weeks (42 days). BRL weighing is done every week.

3 Observed Variables

The data observed in this study are:

Water quality parameter includes aquatic physics parameter namely: temperature, depth, current velocity, brightness and chemical parameters such as salinity, nitrate and phosphate.

Weekly Growth (WG) is the weight of seaweed measured every seven (7) days. Weekly Growth Rate (WGR) is the weight of the a-week, (Wa) is the average weight of the i- week (Ti) minus the weight of the previous week (Wb), with the formula:

WGR=Wa - Wb

Absolute Growth Rate (AGR) is the final weight (Wt) reduced by initial weight (Wo), with the following formula:

AGR=Wt - Wo

Daily Growth Rate (DGR) is the final weight (Wt) divided by the initial weight (Wo) ranked by per time of planting (t) minus one and multiplied by 100%, referring to (Mtolera et al., 1995; Gerung and Ohno, 1997; Aguirre-von-Wobeser et al., 2001; Bulboa et al., 2007; Hayashi et al., 2007; Hori et al., 2009), with the following formula:

$$DGR=\left[\left(\frac{Wt}{Wo}\right)^{\frac{1}{T}}-1\right] \times 100\ \%$$

4 Results and Discussion

4.1 Environmental parameter

The result of measurement of physics and chemical factors in the study area is still good for seaweed growth. Data are presented in Table 1.

Table 1 Physical-chemical water parameter

Substrate	Temperature	Salinity	pH	Brightness	Flow	Nitrate	Phosphate
Muddy	33-35	5-13 ppm	6.5-7.0	30-50 cm	0.012	0.41	0.016

Water temperature range from 33-35 ℃, with an average temperature of 34 ℃. There were no striking differences in the measurement of water temperature during the treatment period. The optimum temperature of seaweed growth is 20 ℃ - 28 ℃ (Aslan, 1998; Indriani and Sumiarsih, 2005). *Gracilaria* has a high tolerance to temperature (0 - 35 ℃), (Yokoyama, 1999; Raikar et al., 2001; Abreu et al., 2011; Kim et al., 2016). Optimum temperature can improve the absorption of nutrients, so it can accelerate the growth rate. Seaweed has a range of different temperatures. High-temperature fluctuation can disrupt the metabolism and growth of *Gracilaria* sp. Excessive temperature fluctuation can be avoided by movement of water mass (stream) or circulation. According to Aslan (1998), the temperature has a very important role in the life and growth of the seaweed. Water temperature can affect some physiological functions of seaweed such as photosynthesis, respiration, metabolism, growth, and reproduction.

Water salinity ranges from 5 to 13 ppm, with an average salinity of 9 ppm. The measured salinity at the study sites is very low and falls into the category of brackish water. The concentration of the salinity value is still within the limiting factor of *Gracilaria* sp. The salinity range of *Gracilarai* sp is very wide, unlike the narrower type of *E.cottonii*. The optimum salinity of seaweed growth is 32 ppm (Aslan, 1998; Indriani and Sumiarsih, 2005). *Gracilaria* has a salinity tolerance of 10 - 40 psu (Gorman and Zucker, 1997; Yokoyama, 1999; Klionsky et al., 2016). Seaweed has a range of variety salinity. *Gracilaria* sp is a type of seaweed that has a wide range (euryhaline). Salinity greatly affects metabolic and growth process.

The measurement of the degree of acidity (pH) during the study ranged from 6.5 to 7.0. This range is under the terms of seaweed cultivation. According to Sujatmiko and Angkasa (2003), the appropriate pH range for seaweed cultivation is likely to be alkaline, the pH suitable for seaweed cultivation is in the range of 7.3 - 8.2. The optimum pH value of seaweed growth is 7.5 – 8.0 (Aslan, 1998; Indriani and Sumiarsih, 2005). According to Papalia and Arfah (2013), condition of water that is very acidic or very alkaline will endanger the survival of the organism because it will cause metabolic and respiratory disorders. Current velocity at the study site was 0.010 m/s.

The measured average current velocity is very low, the current occurs during high and low tide. When the tide has reached, the current tends to be constant. Tide has a great influence on the exchange of water mass, aeration, nutrient transportation and water mixing in the pond, thus affecting the growth. Flows are also very important and play a major role in avoiding the accumulation of sediment (silt) and epiphytic plants attached to the thallus that can block the process of photosynthesis and its growth. Very weak currents will potentially cover the thallus from the mud substrate. If this condition is left without treatment there will be problems with seaweed growth. Conversely, overcurrent currents can cause thallus damage such as fracture and detachment. The good flow of seaweed cultivation ranges from 0.2 - 0.4 m/sec (Indriani and Suminarsih, 2005). In calm water, plants get fewer nutrients, thus interfering with the process of photosynthesis (Atmadja et al., 1996). Hartanto and Gunarso (2001) added that adequate water movement causes the increase of oxygen and nutrients in the water and can clean the dirt on the thallus of seaweed. The surface of the clean thallus allows seaweed to absorb nutrients and sunlight so that the photosynthesis process runs well.

In the location of the research, the bottom of the waters of the substrate is muddy, when the high and low tide of the bottom of the waters will be mixed (mixing) consequently the water column will be muddier. In addition, water input from the Musi River and Banyuasin River will further create a muddy column of pond water. Water Brightness ranges from 30-50 cm. The brightness value is very low, this condition occurs because the bottom of the water has a muddy substrate and close to the mouth of the River Banyuasin and Musi River which are very muddy. The source of the water supply and the water base is very influential on the brightness level. The waters brightness at the study site will be lower during the rainy season and high tide. The brightness of the ocean water is closely related to the penetration of sunlight into the waters required for photosynthesis. This very high sedimentation process is very influential in the process of photosynthesis and growth of seaweed. Thallus will be covered in sediment/substrate that will block the absorption of nutrients and photosynthesis. The concentrations of nitrate and phosphate are in the range of 0.41 mg/l and 0.016 mg/l. Seaweeds can grow optimally with nitrate content ranging from 0.9 to 3.5 mg/l (Atmadja et al., 1996), while the optimal phosphate range is 0.051 mg/l - 1.00 mg/l (Indriani and Suminarsih, 2005). The content of nitrates and phosphates at the study site is in the low range to support seaweed growth.

5 Seaweed Growth

5.1 *Gracilaria* sp seaweed weekly growth

The growth rate of *Gracilaria* sp is measured seven (7) days. The weight gain per week of seaweed is presented in Table 2.

The growth of seaweed floating net method (MFN) in the first week, the highest growth is in the fifth MFN with the weight of 5,540 grams and the lowest is in the second MFN with the weight of 5,425 grams. At the second week, the highest growth is in third MFN weight of 6,021 grams and the lowest is in the fourth MFN with the weight of 5,797 grams. While at the third week, the highest growth is in the third MFN (6,625 grams) and lowest is in fourth MFN (6,380 grams). While at the fourth week, the highest growth is in the third MFN (6,950 grams) and the lowest is in second MFN (6,864 grams). At the fifth week, the highest growth is on first MFN (7,450 grams) and the lowest is in third MFN weight of 7,010 grams. At the sixth week, the highest growth is in the sixth MFN (8,215 grams and lowest is in third MFN (7,120 grams).

Table 2 Weekly growth data of the floating net method (MFN)

MFN	Weight of BRL MFN (Gram)						
	Early weight	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
1	5,000	5,430	5,896	6,550	6,929	7,450	7,890
2	5,000	5,425	5,847	6,460	6,864	7,297	7,782
3	5,000	5,523	6,021	6,625	6,950	7,010	7,120
4	5,000	5,429	5,797	6,380	6,750	7,140	7,656
5	5,000	5,540	5,938	6,480	6,891	7,250	7,830
6	5,000	5,469	5,837	6,494	6,890	7,320	8,215

The high *Gracilaria* sp growth in the study site indicates that this species can grow and be cultivated in these locations, although the environmental parameter values are less favorable and are within the limit of tolerance of *Gracilaria* sp. There are several causes of this, not optimum growth, namely the high sedimentation from the mouth of the river, low current, high daily temperature fluctuations, and the managed pond is tradition pond that is never given fertilizer and cultivated biota (shrimp and milkfish) rely on natural feed. While artificial feed is not given at all.

The sedimentation that occurs at the study site is very strong, it can be seen with the number of thallus covered in mud. Such sediments will block the process of photosynthesis. The maintenance process by cleaning the thallus is done every week, this will help to get rid of the attached sediments. High daily temperature fluctuations are caused by low pond water column depth which is only 40-60 cm at low tide and 100-120 cm at high tide. During the day, the low tide recedes with strong sun exposure (dry season) and the absence of fresh water entering the pond will increase the temperature. During the low tide, the water enters the pond and will immediately lower the temperature. Such temperature fluctuations will affect the growth of cultivated *Gracilaria* sp. The pond used is a traditional pond with a total area of four (4) hectares of land, fish farmers do not provide fertilizer and do not feed the cultivated biota. The need for feed is very dependent on the availability of nature from the circulation of water that comes and goes to the pond.

Flow has a function of distributing nutrient, nutrient requirements sufficient for growth will greatly affect the growth rate of seaweed. Current (movement of water) is very influential on the growth of seaweed because of positive correlation to the size of the transportation (distribution) of nutrients. The current plays a role in the water agitation in the water column. This is in accordance with the opinion of Prud'homme van Reine and Trono (2001), the current benefit is supplying nutrients, dissolving oxygen, spreading plankton, and removing sludge, detritus and marine biota excretion products.

According to Susanto (2005), the relatively weak currents and waves can cause the attachment of substrate to seaweed. The substrate attached to the thallus will block out sunlight and nutrient absorption. This condition will affect the process of photosynthesis and metabolism. The process of photosynthesis and impaired metabolism will inhibit the optimal growth.

The highest growth rate of the floating net method occurred at sixth week with a weight gain of 895 grams (sixth MFN). While the lowest was at fifth week with the addition of weight 60 grams (third MFN) (Table 3). On average, the highest average growth rate occurred on the third week with an average weight increase of 3,653 grams and the lowest was at fifth week (2,193 gram). In general, the highest growth rate of *Gracilaria* sp occurred during the first week until the third week and decreased at fourth and fifth week. At the sixth week, there was an increase in weight gain rate (3,026 gram), allegedly the increase of growth because during the sixth has entered the rainy season that will bring more nutrients.

Table 3 The weekly growth rate of the floating net method (MFN)

MFN	Weight of BRL MFN (Gram) Week of -							total growth rate	average
	early	1	2	3	4	5	6		
1	5,000	430	466	654	379	521	440	2,890	1,445
2	5,000	425	422	613	404	433	485	2,782	1,391
3	5,000	523	498	604	325	60	110	2,120	1,060
4	5,000	429	368	583	370	390	516	2,656	1,328
5	5,000	540	398	542	411	359	580	2,830	1,415
6	5,000	469	368	657	396	430	895	3,215	1,607.5
		2,816	2,520	3,653	2,285	2,193	3,026	16,493	8,246.5

Different growth rates each week are influenced by various factors. In the first week of seaweed, the growth rate is usually not optimal, in the first week of seaweed is still adjusting to the new environment. Growth will continue to increase until the third week. The growth rate will then tend to slow down at the fourth week and so on. However, at the sixth week, there is an increase in the expected rate of growth due to the influx of nutrients brought in by the flow of water during rain. *Gracilaria* sp grass, as well as other types of macro-algae, has the same growth pattern. The rate of growth will begin from the adjustment phase (acclimatization) to the exponential phase in the first week to the third week. Furthermore, the rate of growth will decrease or stationer at fourth week and so on. This is in accordance with Masyahoro and Mappiratu (2010), the growth rate of seaweed will increase by 9 am of first week – third week and then stationary at fourth week and begin to decrease at fifth week until harvest period.

Seaweed has a certain time span to achieve optimal growth. Growth will tend to slow down after optimum growth. This is in accordance with Erpin et al (2013), the duration of seaweed treatment has an effect on the specific growth rate. At the optimum duration of treatment, the maximum growth rate is achieved, whereas in the shorter maintenance period or longer the growth rate is low or decreased. Furthermore, Rasyid (2003) added that the increase of cell enlargement has reached the highest or optimum limit. At 45 days of treatment span, cells in seaweed utilize the nutrients that exist in the water to the maximum, resulting in maximum growth.

Temperature, salinity, sunlight, pH, Do are the factors affecting the growth of *Gracilaria* sp. (Bold and Wynne, 1985; Pratiwi and Ismail, 2004), seaweed requires sunlight for the process of photosynthesis (Insan et al., 2013). While (Lombardi et al., 2006) state the factor of brightness affects growth. Muddy water containing sediment will affect growth. Sediment can attach to the thallus and block the absorption of nutrients and photosynthesis. The penetration of sunlight will decrease with increasing water depth. According to Kune (2007), depth is the limiting factor of growth rate.

5.2 Absolute growth of *Gracilaria* sp

Absolute Growth Rate (*Gracilaria* sp) in this study is presented in Table 4. At the end of the study, the highest end weight is found in the sixth MFN with the final weight of 8,215 grams and the absolute growth rate of 3,215 grams. While the lowest weight on the third MFN with the weight of 7,120 grams and growth rate of 2,120 grams. There was an increase of 1,424 - 1,643 times the weight of the initial weight of planting.

Table 4 Absolute growth rate (AGR)

MFN	Wo	Wt	AGR
1	5000	7890	2890
2	5000	7782	2782
3	5000	7120	2120
4	5000	7656	2656
5	5000	7830	2830
6	5000	8215	3215

The sunlight factor is considered to be one of the dominant factors affecting the growth rate of *Gracilaria* in addition to other factors. The intensity of sunlight greatly affects the growth of *Gracilaria* sp. Substrate water in the columned water will greatly affect the penetration of sunlight, the small chance of sunlight entering the water column will affect the rate of photosynthesis, the growth will tend to slow down. According to Pratiwi and Ismail (2004), seaweed requires sunlight to do photosynthesis process. Seaweed can grow in water that has a certain depth of sunlight reaching the base. The results of research (Insan et al., 2013) mention that the size of growth is influenced by the method of cultivation and absorption of sunlight as a regulator of the photosynthesis process. Seaweed growth is seen when there is an increase in thallus and weight gain in seaweed.

5.3 Daily Growth Rate (*DGR*)

The daily growth rate of seaweed cultivation (BDRL) of *Gracilaria* sp on the floating net (MFN) method used ranged from 0.84515 - 1.189 %/day (Figure 2). The DGR value is highest in the sixth MFN with the value of 1.18922 and the lowest is in the third MFN of 0.84515% days. The full daily growth rate calculations are presented in Table 5. All methods (MFN) show results that are less than 2% /day.

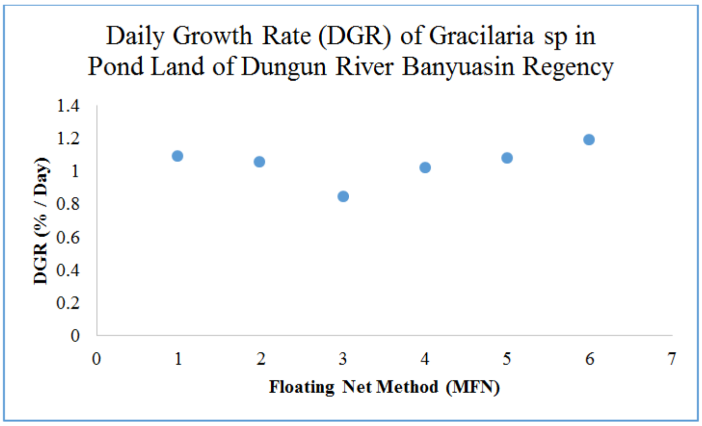

Figure 2 Daily Growth Rate (DGR) of *Gracilaria* sp

Table 5 Daily growth rate (DGR)

No	Wo	Wt	DGR
1	5,000	7,890	1.09201
2	5,000	7,782	1.05884
3	5,000	7,120	0.84515
4	5,000	7,656	1.01957
5	5,000	7,830	1.07364
6	5,000	8,215	1.18922

Gracilaria sp growth is weight gain and increases in a number of the thallus. The weight will increase and the number of thallus will experience the growth of number, length, and weight. The growth rate in this study is not good for the growth rate of *Gracilaria* sp. A good growth rate is when the weight gain > 2% /day. This is in accordance with an opinion (Ask and Azanza, 2002; Anggadiredja et al., 2006), the growth rate is said to be good if the daily growth rate is more than 2% /day.

There are several factors that affect the growth rate of *Gracilaria* sp. (Lombardi et al., 2006), the brightness affects growth, and the sediment attached to the thallus will block the penetration of sunlight required for photosynthesis. According to Susilowati et al. (2012) and Widowati et al. (2015), light intensity, nutrient supply, depth affect the seaweed growth rate. Semenatar (Kune, 2007), depth is one of the decisive factors in the rate of seaweed growth with increasing depth of planting, the lower the penetration of the light, and the lower the oxygen circulation, besides the daily growth rate is also affected by the treatment time current and wave affect the rate of growth(Susanto, 2005). Weak current causes attached substrate to seaweed. The substrate attached to the thallus will block out the sunlight and the absorption of nutrients.

Pratiwi and Ismail (2004) added that seaweed cultivation should pay attention to the season to avoid crop failure because during the seaweed transition period susceptible to disease. At the time of the study, there is a transition from the dry season to the beginning of the rainy season, temperature, pH, nutrient will change and fluctuate at any time. In addition, rain will bring water and sediment that will enter the pond and affect the brightness of the water. The disturbance of seaweed growth is seen in the number of thallus disease.

5.4 Data analysis of the effectiveness of seaweed growth

Comparing the growth rate of seaweed in each sample is done to test the effectiveness of the relative growth rate. Data normality test is previously done before testing the comparison of each sample.

Based on Shapiro Wilk normality test results show normally distributed data, with sig value > 0.05. Further data is processed by using ANOVA test. The result of ANOVA test shows that F value is smaller than F table (F hit 0.191 <F tab 2.08). The above data indicate that H1 is rejected with the H0 consequence received or no effect of depth level (BRL) on seaweed growth.

Furthermore, there is also the further test of honestly significance difference (HSD). Based on the results of further tests there is no significant data based on depth level, BRL 1 - BRL 10. Decision making by looking at significant value and symbol (*) contained in the mean difference. The symbol used in the form of letters a, b, c, and so on. The above data does not show significance. This means that there is no effect of depth level (BRL 1 - BRL 10) on the growth rate of *Gracilaria* sp in the water of Kelagian Island. The result of data analysis shows that the effect of depth level on *Gracilaria* sp growth rate is supported by the average growth rate of each depth level > 2%/day. According to Ask and Azanza, (2002), Anggadiredja et al. (2006) and Syahlun (2013), growth rate > 2% /day is the best growth rate and is recommended for seaweed cultivation.

6 Conclusion and Recommendation

6.1 Conclusion

The conclusions of this research are:

Parameters of the aquatic environment in the pond location are still within the tolerable limit for the growth of seaweed cultivation *Gracilaria* sp.

The weekly growth of *Gracilaria* sp in the first week was highest in the fifth MFN with a weight of 5,540 grams and the lowest is in the second MFN with 5,425 grams. At the second week, the highest growth of third MFN (6,021 grams) and the lowest is in fourth MFN (5,797 grams). At the third week, the highest growth of third MFN (6,625 grams) and at the lowest is in fourth MFN (6,380 grams). At the fourth week, the highest growth of third MFN (6,950 grams) and lowest is in second MFN (6,864 grams). At the fifth week, the highest growth of first MFN (7,450 grams) and the lowest is in third MFN (7,010 grams) and the sixth week, the highest growth is in sixth MFN (8,215 grams) and lowest is in third MFN (7,120 grams).

The highest growth rate at sixth week with the added weight of 895 grams (sixth MFN), while the lowest in the fifth week with the addition of weight amounted 60 grams (third MFN). The highest average growth rate occurred at third week with an average weight increase of 3,653 grams and the lowest at fifth week (2,193 grams).

Absolute Growth Rate is highest in the sixth MFN with a final weight of 8,215 grams and the absolute growth rate of 3,215 grams. While the lowest weight in the third MFN with the weight of 7,120 grams and growth rate of 2,120 grams. There was an increase of 1,424 - 1,643 times of the weight from the initial weights of planting.

The daily growth rate ranges from 0.84515 - 1.189% /day. The DGR value is highest in the sixth MFN with the value of 1.18922 and the lowest is in the third MFN of 0.84515% /day. All methods (MFN) show DGR results of <2% /day.

6.2 Recommendation

The recommendations of this research are:

Gracilaria sp seaweed can be cultivated in shrimp pond area in Dungun River of Marga Sungsang Village Banyuasin Regency of South Sumatera.

The pond used should have a water column depth of > 150 cm to avoid fluctuations in temperature, salinity, and striking pH.

Water supply should not go directly into the pond to avoid excessive substrate entry into the pond.

Authors' contributions

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Reference

Abreu M.H., Pereira R., Buschmann A., Sousa-Pinto I., and Yarish C., 2011, Nitrogen uptake responses of *Gracilaria vermiculophylla* (Ohmi) Papenfuss under combined and single addition of nitrate and ammonium, Journal of Experimental Marine Biology and Ecology, 407(2): 190-199 https://doi.org/10.1016/j.jembe.2011.06.034

Aguirre-von-Wobeser E., Figueroa F., and Cabello-Pasini A., 2001, Photosynthesis and growth of red and green morphotypes of *Kappaphycus alvarezii* (Rhodophyta) from the Philippines, Marine Biology, 138(4): 679-686 https://doi.org/10.1007/s002270000506

Anggadiredja J., Zatnika A., Purwoto H., and Istini S., 2006, Rumput Laut

Ask E.I., and Azanza R.V., 2002, Advances in cultivation technology of commercial Eucheumatoid species: a review with suggestions for future research, Aquaculture, 206(3): 257-277 https://doi.org/10.1016/S0044-8486(01)00724-4

Aslan L.M., 1998, Rumput Laut, Yogyakarta: Kanisius

Atmadja W., Kadi A., and Sulistijo R., 1996, Pengenalan jenis-jenis rumput laut Indonesia

Bold H., and Wynne M., 1985, Introduction to the algae, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA, pp.720

Bulboa C.R., de Paula E.J., and Chow F., 2007, Laboratory germination and sea out-planting of tetraspore progeny from *Kappaphycus striatum* (Rhodophyta) in subtropical waters of Brazil, Journal of Applied Phycology, 19(4): 357-363 https://doi.org/10.1007/s10811-006-9142-7

Erpin, Rahman A., Ruslaini, 2013, Pengaruh umur panen dan bobot bibit terhadap pertumbuhan dan kandungan karaginan rumput laut (Eucheuma spinosum) menggunakan metode long line, Jurnal Mina Laut Indonesia, Vol 03, No. 12 Sep, 2013: 156-163

FAO, 2017a, The state of world fisheries and aquaculture

FAO, 2017b, The state of world fisheries and aquaculture, http://www.fao.org/fishery/en

Gerung G.S., and Ohno M., 1997, Growth rates of *Eucheuma denticulatum* (Burman) Collins et Harvey and *Kappaphycus striatum* (Schmitz) Doty under different conditions in warm waters of Southern Japan, Journal of Applied Phycology, 9(5): 413-415 https://doi.org/10.1023/A:1007906326617

Gorman L., Kraemer G.P., Yarish C., Boo S.M., and Kim J.K., 2017, The effects of temperature on the growth rate and nitrogen content of invasive *Gracilaria vermiculophylla* and native *Gracilaria tikvahiae* from Long Island Sound, USA, Algae, 32(1): 57-66 https://doi.org/10.4490/algae.2017.32.1.30

Gorman M., and Zucker I., 1997, Environmental induction of photo non responsiveness in the Siberian hamster, *Phodopus sungorus*, American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 272(3): 887-895

Guiry M., and Guiry G., 2014, AlgaeBase, World-wide electronic publication, National University of Ireland, Galway

Hartanto N., and dan Gunarso D., 2001, Rekayasa teknologi pertumbuhan rumput laut *Eucheuma cottonii* (W. V. B) dengan perbedaan jumlah thallus setiap rumpun, Makalah Hasil Penelitian, Lembaga Budidaya Laut, Batam

Hayashi L., de Paula E.J., and Chow F., 2007, Growth rate and carrageenan analyses in four strains of *Kappaphycus alvarezii* (Rhodophyta, Gigartinales) farmed in the subtropical waters of São Paulo State, Brazil, Journal of Applied Phycology, 19(5): 393-399 https://doi.org/10.1007/s10811-006-9135-6

Hori K., Nang H.Q., and Kha T., 2009, Seasonal changes in growth rate, carrageenan yield and lectin content in the red alga *Kappaphycus alvarezii* cultivated in Camranh Bay, Vietnam, Journal of Applied Phycology, 21(3): 265-272 https://doi.org/10.1007/s10811-008-9360-2

Indriani H., and Sumiarsih E., 2005, Rumput Laut, Jakarta: Penebar Swadaya

Indriani H., and Suminarsih E., 2005, Budidaya, Pengolahan, dan Pemasaran Rumput Laut

Insan A.I., Widyartini D.S., and Sarwanto S., 2013, Posisi tanam rumput laut dengan modifikasi sistem jaring terhadap pertumbuhan dan produksi *Eucheuma cottonii* di perairan Pantura Brebes, Jurnal Litbang Provinsi Jawa Tengah, 11(1): 125-133

Johnson K., and Ladefoged P., 2014, *A course in phonetics*: Nelson Education

Johnson R.B., Kim J.K., Armbruster L.C., and Yarish C., 2014, Nitrogen allocation of Gracilaria tikvahiae grown in urbanized estuaries of Long Island Sound and New York city, USA: a preliminary evaluation of ocean farmed Gracilaria for alternative fish feeds, Algae, 29(3): 227
https://doi.org/10.4490/algae.2014.29.3.227

Kim J.K., Mao Y., Kraemer G., and Yarish C., 2015, Growth and pigment content of Gracilaria tikvahiae McLachlan under fluorescent and LED lighting, Aquaculture, 436: 52-57
https://doi.org/10.1016/j.aquaculture.2014.10.037

Kim J.K., and Yarish C., 2014, Development of a sustainable land-based Gracilaria cultivation system, Algae, 29(3): 217
https://doi.org/10.4490/algae.2014.29.3.217

Kim J.K., Yarish C., and Pereira R., 2016, Tolerances to hypo-osmotic and temperature stresses in native and invasive species of Gracilaria (Rhodophyta), Phycologia, 55(3): 257-264
https://doi.org/10.2216/15-90.1

Klionsky D.J., Abdelmohsen K., Abe A., Abedin M.J., Abeliovich H., Acevedo Arozena A., Adachi H., Adams C.M., Adams P.D., and Adeli K., 2016, Guidelines for the use and interpretation of assays for monitoring autophagy, Autophagy, 12(1): 1-222
https://doi.org/10.1080/15548627.2015.1100356
PMid: 26799652
PMCid: PMC4835977

Kune S., 2007, Pertumbuhan rumput laut yang dibudidaya bersama ikan Baronang, Jurnal Agrisistem, 3(1): 7-9

Lombardi J.V., de Almeida Marques H.L., Pereira R.T.L., Barreto O.J.S., and de Paula E.J., 2006, Cage polyculture of the Pacific white shrimp *Litopenaeus vannamei* and the Philippines seaweed *kappaphycus alvarezii*, Aquaculture, 258(1): 412-415
https://doi.org/10.1016/j.aquaculture.2006.04.022

Masyahoro dan Mappiratu, 2010, Respon Pertumbuhan Pada Berbagai Kedalaman Bibit dan Umur Panen Rumput Laut *Eucheuma cottonii* di Perairan Teluk Palu, Media Litbang Sulteng, 3(2):104-111, ISSN: 1979-5971

Mtolera M.S., Collén J., Pedersén M., and Semesi A.K., 1995, Destructive hydrogen peroxide production in *Eucheuma denticulatum* (Rhodophyta) during stress caused by elevated pH, high light intensities and competition with other species, European Journal of Phycology, 30(4): 289-297
https://doi.org/10.1080/09670269500651071

Oliveira E.C., Alveal K., and Anderson R.J., 2000, Mariculture of the agar-producing Gracilarioid red algae, Reviews in Fisheries Science, 8(4): 345-377
https://doi.org/10.1080/10408340308951116

Papalia S., and Arfah H., 2013, Macroalgae biomass productivity in Ambalau Island water, South Buru District, Jurnal Ilmu dan Teknologi Kelautan Tropis, 5(2): 465-477

Pereira R., Kraemer G., Yarish C., and Sousa-Pinto I., 2008, Nitrogen uptake by gametophytes of Porphyra dioica (Bangiales, Rhodophyta) under controlled-culture conditions, European Journal of Phycology, 43(1): 107-118
https://doi.org/10.1080/09670260701763393

Pereira R., and Yarish C., 2008, Mass production of marine macroalgae, Encyclopedia of Ecology, Ecological Engineering, Elsevier, 3: 2236-2247

Pratiwi E., and Ismail W., 2004, Perkembangan budidaya rumput laut di Pulau Pari, Warta, 2: 11-15

Prud'homme van Reine W.F., and Trono G.C. Jr., eds, 2001, Plant Resources of Southeast Asia 15(1), Cryptogams: Algae. Backhuys Publishers, Leiden, the Netherlands

Qi Z., Liu H., Li B., Mao Y., Jiang Z., Zhang J., and Fang J., 2010, Suitability of two seaweeds, *Gracilaria lemaneiformis* and *Sargassum pallidum*, as feed for the abalone *Haliotis discus* Hannai Ino, Aquaculture, 300(1): 189-193
https://doi.org/10.1016/j.aquaculture.2010.01.019

Raikar S., Iima M., and Fujita Y., 2001, Effect of temperature, salinity and light intensity on the growth of Gracilaria spp.(Gracilariales, Rhodophyta) from Japan, Malaysia and India

Rasyid A., 2003, Alga Coklat (*Phaeophyta*) sebagai Sumber Alginat, Oseana, 28:33-38

Sahoo D., and Yarish C., 2005, Mariculture of seaweeds, Phycological Methods: Algal Culturing Techniques. Academic Press, New York, 219-237

Sujatmiko W., and Angkasa W.I., 2003, Teknik Budidaya Rumput Laut dengan Metode Tali Panjang, http://www.iptek.net.id/ttg/artlk/artikel 18.htm

Susanto A., 2005, Metode lepas dasar dengan model cidaun pada budidaya *Eucheuma spinosum* (Linnaeus) Agardh, Indonesian Journal of Marine Sciences, 10(3): 158-164

Susilowati T., Rejeki S., Zulfitriani Z., and Dewi E.N., 2012, The influence of depth of plantation to the growth rate of *Eucheuma cottonii* seaweed cultivated by longline method in Mlonggo beach, Jepara Regency, Jurnal Saintek Perikanan, 8(1): 7-12

Syahlun RAaR. 2013, Pertumbuhan rumput laut (*Kappaphycus alvarezii*) strain coklat dengan metode vertikultur, Jurnal Mina Laut Indonesia, 1(0): 1

Weinberger F., Buchholz B., Karez R., and Wahl M., 2008, The invasive red alga *Gracilaria vermiculophylla* in the Baltic Sea: adaptation to brackish water may compensate for light limitation, Aquatic Biology, 3(3): 251-264
https://doi.org/10.3354/ab00083

Widowati L.L., Rejeki S., Yuniarti T., and Ariyati R.W., 2015a, Efisiensi produksi rumput laut *E. cotonii* dengan metode budidaya long line vertikal sebagai alternatif pemanfaatan kolom air, Jurnal Saintek Perikanan, 11(1): 47-56

Widowati L.L., Rejeki S., Yuniarti T., and Ariyati R.W., 2015b, Efisiensi Produksi rumput laut *E.cottonii* dengan metode long line vertikal sebagai alternatif pemanfaatan kolom air, Jurnal Saintek Perikanan, 11(1): 47-56

Wu H., Huo Y., Han F., Liu Y., and He P., 2015, Bioremediation using *Gracilaria chouae* co-cultured with *Sparus macrocephalus* to manage the nitrogen and phosphorous balance in an IMTA system in Xiangshan Bay, China, Marine pollution bulletin, 91(1): 272-279
https://doi.org/10.1016/j.marpolbul.2014.11.032
PMid: 25561001

Yokoya N.S., Kakita H., Obika H., and Kitamura T., 1999, Effects of environmental factors and plant growth regulators on growth of the red alga *Gracilaria vermiculophylla* from Shikoku Island, Japan, Hydrobiologia, 398: 339-347
https://doi.org/10.1023/A:1017072508583

Yokoyama S., 1999, Molecular bases of color vision in vertebrates, Genes & Genetic Systems, 74(5): 189-199
https://doi.org/10.1266/ggs.74.189
PMid: 10734600