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Application of the Off-Bottom Methods in Supporting the Growth of Seaweed *Turbinaria ornata*

Muhamma Irfan*, Nursanti Abdullah

Aquaculture Departement, Faculty of Fisheries and Marine Science, Khairun University, Jl. Jusuf Abdurrahman, Gambesi, Ternate 97719 Ternate, North Maluku, Indonesia

***Corresponding Author:** ifan_fanox@yahoo.co.id

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ABSTRACT

One type of potential seaweed that is quite abundant is *Turbinaria ornata*, nevertheless, it has not been widely developed through cultivation in Indonesia. *Turbinaria ornata* has a very important role in the industrial world as an alginate raw material. This study aimed to determine the application of the off-bottom method cultivation through spacing in supporting the growth (absolute weight growth and relative growth) of seaweed *T. ornata*. The construction of seaweed *T.ornata* cultivation is a rectangle measuring 25m x 10m, made of polyethylene ropes fixed with concrete anchors. In the cultivation construction, there are five stretch ropes. Each stretch rope is installed at a distance of 25cm. Placement of seaweed *T.ornata* cultivation containers, using the off-bottom method, was carried out at a water depth of 1 meter. The data analyzed are absolute weight growth data and relative growth rate. The results showed that plant spacing had a significantly different effect on the growth of absolute weight and relative growth of seaweed *Turbinaria ornata*. A spacing of 35cm gave the best results for absolute weight growth and relative growth of seaweed *Turbinaria ornata*

INTRODUCTION

Macroalgae have played an important role in coastal communities for centuries. In the past, they have been harvested and gathered from shorelines around the world for traditional uses, such as food, animal feed, and crude fertilizer (marine manure) **(Lazarus, 2015)**. Today, seaweeds are used in a multitude of applications with expanding global industries based on hydrocolloids, cosmetics and food supplements, as well as a potential biofuel source. Seaweeds or marine macro algae are the renewable living resources which are also used as food and feed fertilizer in many parts of the world **(Makkar *et al*., 2016)**.

Seaweeds are of nutritional interest since they constitute low calorie food but are rich in vitamins, minerals, and dietary fibers **(Sekar & Kolanjinathan, 2015)**. The importance of seaweed lies in the need for its development in cultivation businesses **(Arjuni *et al*., 2018)**.

Seaweed cultivation is one type of cultivation that has the opportunity to be developed in the fisheries sector. Seaweed cultivation has an important role in efforts to increase fishery production to meet food and nutritional needs and meet market needs both domestically and abroad, expand employment opportunities, increase farmers' income and welfare, in addition to maintaining the preservation of aquatic biological resources **(Iskandar, 2019)**.

The development of aquaculture, especially the cultivation of various types of seaweed, continues to be improved from year to year, especially in waters that have great potential for seaweed development. North Maluku Province has a large potential for diversity of seaweed species; however until now, it has not been optimally developed. This is due to the lack of scientific information that reveals the existence of this type of seaweed and cultivation techniques. Therefore, it is necessary to explore detailed information for the sustainable development of this commodity. One type of potential seaweed that is quite abundant is *Turbinaria ornata*, however it has not been widely developed through cultivation in Indonesia.

Turbinaria ornata is a group of brown macroalgae (Phaeophyta). *Turbinaria ornata* has a very important role in the industrial world as a raw material for alginate. However, this macroalgae species is not included in the category of superior seaweed commodities by the Ministry of Maritime Affairs and Fisheries, such as *Kappaphycus*, *Gracilaria* and *Gelidium* **(Handayani, 2018)**. *Turbinaria* is one of the brown macroalgae with bioactive polysaccharides which are used for the pharmaceutical industry **(Oktaviani *et al*., 2019)**.

T. ornata type seaweed can be developed through various cultivation methods such as the off-bottom and bottom methods (**Handayani, 2018**) and longline method **(Iskandar, 2019)**. However, until now, there has been no information on the development of cultivating this type of seaweed using various methods, and it remains unknown which method provides optimal results. Based on this description, it encouraged us to conduct this research.

T.ornata is abundant in North Maluku waters, especially in Ternate City, but the development of its cultivation has not been carried out. The cultivation of *T. ornata* seaweed using the off-bottom method is expected to provide information related to the growth rate of the seaweed, and the suitability of the method to be used, serving as a reference for information in the sustainable development of this cultivation.

MATERIALS AND METHODS

This research was conducted in the coastal waters of Kastela, Ternate Island District, Ternate City, over a two month period from April- June 2023.

The construction of seaweed *T.ornata* cultivation is a rectangle measuring 25m x 10m, made of polyethylene ropes fixed with concrete anchors. In the cultivation construction there are five stretch ropes. Each stretch rope is installed with a distance of 25cm each. Placement of seaweed *T.ornata* cultivation containers, using the off-bottom method, was carried out at a water depth of 1 meter.

In this research, 3 different seed spacing treatments were employed, each with 3 replications. This plant distance treatment refers to the plant distance following the Indonesian National Standard guidelines, namely 15- 40cm. The treatments tried were:

Treatment A: Spacing 25cm; Treatment B: Spacing 30cm; and Treatment C: Seed spacing of 35cm.

The observation methods employed in this research included the absolute weight growth, relative growth rate, and water quality parameters, viz. temperature, pH, salinity, and current speed. Observations of the increase in weight of the seaweed *T.ornata* thallus were recorded at each stretch of rope. The condition of the parameters of the aquatic environment were obsereved once a week. The environmental parameters observed included, temperature, pH, salinity, and current speed. A water checker was utilized to measure the temperature, pH, and salinity, while the current speed was determined using a ping pong ball and a stop watch.

The absolute weight growth was calculated using the formula outlined by **Arjuni *et al*. (2018)**, as follows:

$$W = Wt - Wo$$

Where :
W = Growth (Growth in absolute weight) (grams)
Wt = Final weight (grams)
Wo = Initial weight (grams)

The growth rate (relative growth rate) was calculated using the formula referred by **Dharmawaty *et al*. (2016)**, as follows:

$$LPN = \frac{ln(W_t - W_0)}{t} \times 100\%$$

Where :
LPN = Growth rate (%)
Wo = *T.ornata* wet weight at the start of the study (grams)
Wt = *T.ornata* wet weight at the end of the study (grams)
t = maintenance time (45 days)

The design employed in this study was a completely randomized design (CRD). Data analysis was conducted using analysis of variance, following the methods outlined by **Steel and Torrie (1993**).

RESULTS AND DISCUSSION

1. Absolute weight growth

The average absolute weight growth of seaweed *Turbinaria ornata* based on planting distance is shown in Table (1).

Table 1. Average absolute weight growth (grams) of seaweed *Turbinaria ornata* in each treatment

Test	Treatment		
	A	**B**	**C**
1	30.3	31.6	39.1
2	33.6	35.4	42.3
3	36.3	38.9	40.2
Total	100.2	105.9	121.6
Average	33.4	35.3	40.5

Table (1) shows the growth of the absolute weight of seaweed *Turbinarai ornata* differently in each treatment, namely treatment A (25cm spacing) of 33.4 grams, treatment B (30cm spacing) of 35.3 grams, and treatment C (planting spacing 35cm) of 40.5 grams. Based on the average value of absolute weight growth, it shows that treatment C has an average value of absolute weight growth that is higher than treatments B and A. To see the differences in the effect of each treatment on growth in absolute weight of seaweed *Turbinaria ornata*, an analysis of variance was carried out, the results of which are shown in Table (2).

Table 2. Results of analysis of fingerprint analysis of absolute weight growth of seaweed *Turbinaria ornata*

Source of diversity	**Degrees of freedom**	**Squared sum**	**Middle square**	**F count**	**F Table**	
					0.05	**0.01**
Treatment	2	626.513	312.25	37.484**	5.14	10.32
Error	6	50.007	8.33			
Total	8					

Information : ** = very different indeed.

Table (2) shows that the calculated F value (37.484) > F table 0.05 and 0.01 significance levels. Therefore, the effect is very different on the absolute weight growth of seaweed *Turbinaria ornate*. The treatments applied have a considerable impact on the absolute weight growth of seaweed *Turbinaria ornata*. Due to the very significantly different effects, a LSD follow-up test was carried out, with the aim of knowing the differences in the effects of each treatment, the results of which are displayed in Table (3).

Table 3. LSD test results effect of each treatment on the growth of seaweed *Turbinaria ornata* absolute weight

Treatment	**Average**	**Difference**		**LSD**	
				0,05	**0,01**
C	40,5	-		6,82	10,33
B	35,3	5,2^{tn}	-		
A	33,4	7,1*	1,9^{tn}		

Information : *= real significantly , tn = not significantly different.

Table (3) shows that treatment C to B has no significant different effect, however treatment C to A is significantly different. Additionally, treatments B to A were not significantly different. The results of the LSD test also showed that treatment C gave the best results on the growth of absolute weight of seaweed *Turbinaria ornata*.

Planting distance is related to the unit area of land. The spacing used not only affects the movement of water but also avoid the accumulation of dirt in the thallus, aiding in aeration. This, in turn, facilitates the process of photosynthesis needed for the growth of seaweed **(Pongmasak & Sarira, 2018)**. According to **Abdan *et al*. (2013)**, competition between thallus in terms of the need for sun, nutrients and space for movement greatly affects the growth of seaweed.

The high growth in absolute weight in treatment C (35cm spacing) was caused by a spacing of 35cm, which significantly affected the growth weight of seaweed from the aspect of nutrient supply. Seaweed planting distance can influence competition for nutrients. The nutrients obtained by seaweed for its growth, include sulfur, silicon, phosphorus, calcium, iron, iodine, and bromine. This is supported by **Aditia and Ilham (2015)** statement which states that seaweed growth is influenced by the spacing of seeds. **Darmawati *et al*. (2016)** in their study elucidated that, spacing affects the traffic of water movement and avoids the accumulation of dirt in the thallus, aiding in airing, hence the photosynthesis process needed for the growth of seaweed can take place and prevent large fluctuations in salinity and water temperature.

At a spacing of 25cm, seaweed *Turbinaria ornata* relatively showed growth in absolute weight which tended to decrease. **Depaak *et al*. (2017)** postulated that, the wider the planting distance, the wider the movement of water carrying nutrients for increasing the growth of the seaweed. This statement is in line with the research results obtained where the wider the planting distance, the higher the absolute weight growth achieved.

The low absolute weight growth of *Turbinaria ornata* at a planting distance of 25cm was due to the fact that at this planting distance and after three weeks of maintenance, the thallus of *Turbinaria ornata* were intertwined. This entanglement affected the movement of water carrying nutrients, thereby disrupting the proper nutrient absorption process. It can be observed that at a planting distance of 25cm, there are many micro plants (moss) and mud attached to the ris rope and the presence of animals attached, resulting in slow growth since there is competition for nutrients between micro plants (in the form of moss) and seaweed plants. This condition is in accordance with the view of **Aditia and Ilham (2015)**, who stated that, the plants around cultivated plants are competitors, thereby disrupting the growth of seaweed.

2. Relative Growth

The results of the relative growth analysis of *Turbinaria ornata* seaweed are exhibited in Table (4).

Table 4. Average relative growth (%) of seaweed *Turbinaria ornata* in each treatment

Test	Treatment		
	A	B	C
1	1.0511	1.0866	1.2822
2	1.1422	1.1888	1.3622
3	1.2111	1.2777	1.3111
Total	3.4044	3.5531	3.9555
Average	1.1348	1.1843	1.3185

Table (4) reveals that the relative growth value of seaweed *Turbinaria ornata* varies. Treatment A (planting distance 25cm) had an average relative growth value of 1.1348%; treatment B (planting distance 30cm) was 1.1843%, and treatment C (planting distance 35cm) was 1.3185%. From the average relative growth in each treatment, treatment C (planting distance 35cm) proved to have the highest value of 1.3185% compared to treatments B and A. To detect the differences in the effect of each treatment, an analysis of variance was carried out which is shown in Table (5).

Table 5. Results of relative growth variation analysis of seaweed *Turbninaria ornata*

Source of diversity	Degrees of freedom	Squared sum	Middle square	F count	F table
					0.05
Treatment	2	0.0548	0.0274	9.5636*	5.14
Error	6	0.0344	0.00573		
Total	8				

Information : * = real different.

Table (5) shows that the calculated F value (9.5636) > F table 0.05 (5.14), thus providing a significantly different influence on the relative growth of the seaweed *Turbinaria ornata*. The LSD test was employed to find out the differences in the effect of each treatment, and the results of which can be seen in Table (6).

Table 6. LSD test results effect of each treatment on the relative weight growth of seaweed *Turbinaria ornata*

Treatment	Average	Difference		LSD	
				0,05	0,01
C	1.3185	-		0.150	0.226
B	1.1843	0.134 tn	-		
A	1.1348	0.183*	0.049 tn		

Information : * = real different , tn = not significantly different.

Table (6) shows that treatment C to treatment B is not significantly different, while treatment C to A is significantly different. Treatment B to treatment A was significantly different, hence treatment C gave the best results on the relative growth of seaweed *Turbinaria ornata*.

The highest relative growth was in treatment C (planting distance 35cm) compared to treatment B (planting distance 30cm) and treatment A (planting distance 25 cm). The highest relative growth was in treatment C (planting distance 35cm), which had the highest average relative growth value of 1.3185%; this means that the relative growth of seaweed *Turbinaria ornata* increased by 1.3185% every day.

3. Water quality

The results of observations of water quality parameters during the research are presented in Table (7).

Table 7. Water quality during research

Parameter	Range
Temperature (°C)	29 - 32
Current speed (cm/det)	20 - 40
pH	7.5 - 7.8
Salinity (‰)	27 – 32

4. Temperature

Temperature has an important role in the process of growing seaweed. According to **Musadat and Afandi (2018)** the water temperature that is suitable for the needs of seaweed life ranges from 28– 32°C. A high increase in temperature causes the seaweed thallus to turn pale yellow and unhealthy.

The temperature of a body of water is affected by solar radiation, sun position, geographical location, season, cloud conditions, as well as the processes of interaction between water and air, evaporation, and wind gusts **(Nirmala *et al*., 2014)**. Furthermore, changes in temperature affect the physical, chemical, and biological processes of water bodies. The average temperature value at the study site ranged from 29– 32°C . The temperature range values obtained are still considered suitable for seaweed cultivation. **Handayani (2018)** reported that the water temperature for *Turbinaria* life is generally between 26- 34ºC.

5. Current speed

Current speed is an important factor in seaweed cultivation since it functions to deliver nutrients to the seaweed. The required current velocity must be suitable for seaweed life. According to **Musadat and Afandi (2018)**, good water currents will bring nutrients for seaweed to grow and clean dirt and adhering deposits. In addition, seaweed will also grow well since there is an opportunity to absorb nutrients (food) from the water and the photosynthesis process is not disturbed. Current speed that is too strong causes plants to have difficulty absorbing nutrients (food) that are useful for growth.

Current speed values in the range of 20– 40cm/ s are considered very conductive for supporting the growth of seaweed, while current velocity greater than 40cm/ s can destroy seaweed cultivation containers and can break seaweed branches **(Pongmasak & Sarira, 2015)**. The current velocity measured in this study was around 20– 40cm/ sec, hence it still supports the growth of the seaweed *Turbinaria ornata*.

6. pH water parameter

pH is a limiting factor in the life and existence of a plant. Even though seawater has a relatively stable pH value, it can be influenced by photosynthetic activity, temperature, and industrial waste. The optimal water pH for seaweed cultivation is generally 7.3– 8.2 **(Pongmasak & Sarira, 2015)**.

Cultivated organisms have adaptations to pH values. The measured pH is around 6.9– 7.2. The optimal pH for *Turbinaria* cultivation ranges from 7.5– 8.**4 (Handayani, 2018)**. Thus, the pH value obtained still supports the growth and survival of the cultivated seaweed *Turbinaria ornata*.

7. Salinity

Salinity is a water quality parameter that is quite influential on organisms and plants living in marine waters. The ideal water salinity for use as seaweed cultivation land is one that has high water salinity in the range of 32– 34ppt. However, if the fluctuations are outside the ideal range, it will cause low growth and fast aging of the seaweed thallus. To obtain salinity in this range, cultivation locations should not be close to river estuaries or other fresh water sources **(Pongmasak & Sarira, 2018)**.

Optimal salinity for *Turbinaria* is around 28- 35ppt **(Handayani, 2018)**. The salinity obtained during the research ranged from 27- 32‰. From the salinity values obtained, the salinity range obtained still supports the feasibility of growth and survival of *Turbinaria ornata*.

CONCLUSION

Given the results of this study, it can be concluded that, plant spacing has a significantly different effect on the growth of absolute weight and relative growth of seaweed *Turbinaria ornata*. The spacing of 35cm gives the best results for absolute weight growth and relative growth of seaweed *Turbinaria ornata*.

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