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Research Article

The Use of Selected seed on the Growth, Production and Carrageenan Content (*Kappaphycus alvarezii*) in Tesabela, Kupang Regency, NTT Province, Indonesia

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ABSTRACT

Prior to getting high production, seaweed farm owners or workers should understand cultivation methods. They involve cultivation technique, place, species of seaweed, methods for selecting seed, growth, resistance against plant disease, spacing, appropriate time to start planting, control and supervision, harvesting and also marketing. The objective of the study was to describe growth, production and carrageenan of *K.alvarezii* grown using selected seed that is phenotype (F4) seed. The study lasted for 45 days. The experimental study consisted of 2 treatments, pre- and post-sexual seed. The parameters were growth and production. The cultivation method used was long line method. The data analysis was student t-test. The absolute growth of seaweed using selected (F4) seed was 334, 8 ± 0, 12 g-874, 8 ± 0, 14 g while that using seeds from cultivator was 105, 0 ± 0, 06 g-454, 8 ± 0, 06 g. The Specific Growth rate selected seed (F4) seed was 3.25 ± 0, 13–6.34 ± 0, 14 % day-1, and seeds from cultivator was 2.05 ± 0, 03-2.49 ± 0, 05 % day-1. Seaweed production using selected seed (F4) seed was 604.00 g and seeds from cultivator was 302.45g. Carrageenan yield of the selected seed (F4) seed was 57.32% day-1 and that of the seeds from cultivator was 19.17% day-1. Selected seed (F4) seed had significant influence towards growth and production of *K.alvarezii*. Selected seed (F4) seed resulted in the highest rate of growth and production in *K.alvarezii*. Quality of water was within adequate range to grow *K.alvarezii*.

Keywords: *Kappaphycus alvarezii* ; Growth; Production; Selected seed; Carrageenan

INTRODUCTION

East Nusa Tenggara consists of 1,192 small islands and its coastline is 5,700 km. As the result, the province has 15,141,773.10 hectares of marine fisheries and beaches. The area is also used for marine aquaculture. From the total of 15,141,773 hectares, meagerly 929.9 hectares or less than 0.006 % used for production in which potential production was 51,500 tons/year (Department of Fisheries of East Nusa Tenggara, 2018). Seaweed culture, particularly *K.alvarezii*, has spiked recently. The province has 51,870 hectares of land or 5% of the coastline for seaweed cultivation but farmers only use 5,205.70 hectares with potential production of 1.7 million tons of wet seaweed or 250,000 tons of dehydrated seaweed annually. The government has program aiming for community empowerment. One of the targeted audience is people living near the sea; majority of Indonesian people live by the sea or rely on the sea as source of income. The program invites the society to start grouper fish, shrimp and seaweed farm. Out of the three commodities, seaweed becomes the main priority due to its high demand, affordable and easy cultivation technology, simple post-harvest procedures and short harvest age. Some factors are keys to successful seaweed production. Those factors are qualified seeds, suitable cultivation technique and harvest as well as post-harvest procedures [1,2]. In the last few years, seaweed production in East Nusa Tenggara, mainly Kupang, is decreasing. *K.alvarezii* production in 2017 was 15% less than it was in 2016, 15 % of the total production in 2017 (Department of Fisheries of East Nusa Tenggara, 2019). It happened due to a type of disease known as ice-ice causing damage to the thallus and many of the plants were wilted. The disease was the result of interaction between biotic and non-biotic (environment) and the seed that

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the farmers have been using. Most of the farmers have been using repeated seeds which may have been infected with the disease [3]. Manhitu (2008) stated that carrageenan content of dehydrated *K.alvarezii* in Tablolong was pretty low, 9.8% [4]. Such low carrageenan content was the result of repeated seeds, less than 45 day harvest time and environmental factor. Atmadja and Sulistijo (1977) explained that carrageenan content of *E.cottonii* is between 54% and 73% while that of *K.alvarezii* grown in Indonesia is between 61.5%-67.5% [5]. These will affect food security that has become one of the main issues in East Nusa Tenggara. Food supply is highly affected by weather and season. Even though the local government has promoted farming production and adopted certain methods to prevent lack of food supply, the growth of agricultural sector is lower than trade and service sector. Nowadays, there is such a high demand of seaweed and therefore, farmers need to meet the demand in effective, efficient and economic method. Besides that, seaweed these farmers produce should be safe for consumption. Therefore, in order to produce qualified and safe seeds, a study on asexual reproduction to increase growth rate and production of *K.alvarezii* in Kupang, East Nusa Tenggara is needed. The objective of the study was to describe whether or not asexual reproduction prevented ice-ice disease, as well as increase growth and production rate of seaweed.

MATERIAL AND METHODS

Materials used

The material used in this study is *Kappaphycus alvarezii* seaweed as much as 1000 kg.

Equipment needed: Long-line construction measuring 100 meters 2 units, 1 dozen scissors, 2 life jackets, 2 sets of masks, thermometer, DO meter, pH meter, refractometer, 1 meter threaded guess ball (measuring current speed), schi disk (water brightness), blender, aquades, potassium hydroxide, Ethanol. The process of making seeds F4 (Figure 1).

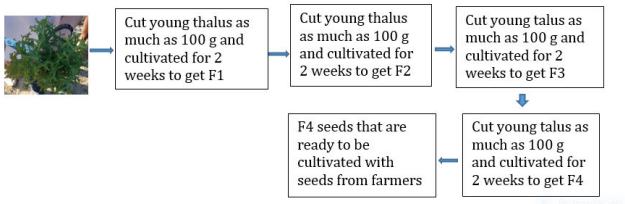

Figure 1: The process of making selected seeds

Methods

Growth: Dawes (1994) formula was adopted to measure absolute growth of the seaweed.

G = Wt – Wo ..... (1)

Description:

G=Absolute growth (g/day)

Wt = Average weight of seaweed at the end of the experiment (g)

Wt = Average weight of seaweed at the beginning of the experiment (g)

t1 and t2=Observation time.

The following formula was used to describe specific growth rate of the seaweed:

$$SGR = \left[\frac{Wn}{Wo}\right]\frac{1}{t} - 1 \times 100\%$$

Description:

SGR=Growth rate per day (%day)

Wn=*Kappaphycus alvarezii* weight on day n

Wo=The initial weight of *Kappaphycus alvarezii*

t=Age in days.

Seaweed Production: Samawi dan Zainudin (1996)'s formula was adopted to measure production rate of the seaweed.

$$Pr = \frac{(Wt-Wo)B}{A} \quad \text{..... (2)}$$

Description:

Pr=Production (g/m)

Wo=Weight of *Kappaphycus alvarezii* at the beginning of the experiment (g)

Wt=Weight of *Kappaphycus alvarezii* at the end of the experiment (g)

A=Rope length (m)

B=Number of planting spot

Carrageenan content: *K.alvarezii* harvest after 45 days in was sun-dried for 3 days. The dried algae were then pretreated by removing visible foreign matters such as sand, stones and dried sea animals. The algae were further washed with running deionized water for 5 min to reduce salt content that might affect the final gelling property of the carrageenan. Then, the pretreated algae were dried in an oven at 60°C until a constant weight was achieved to fully remove the excess moisture. The dried pretreated algae were kept in the clean, anhydrous state before carrageenan extraction was performed. Extraction was carried out by adding 10 g of dried *K. alvarezii* to 8% KOH solution. The yield of carrageenan calculated based on the ratio between the weight of the carrageenan produced and the weight of the dry algae used [6]. The formulations used are as follows.

$$\text{Carrageenan content} = \frac{Dry\ weight\ of\ extracted\ carrageenan\ (g)}{Weight\ of\ dry\ seaweed\ used} \times 100$$

RESULTS

The experiment lasted for 45 days and every 7-12 days, the researchers took some random sampling and weighed it. The

random sampling collection was conducted four times (40 days) and the initial weight of each sampling was ± 100 grams. The weight of *K.alvarezii* in the first 7 days was 334, 8 ± 0, 12 g (Selected seed (F4) and 105, 0 ± 0, 06 g (Seeds from cultivator) in which growth of *K.alvarezii* from F4 seed was faster than seeds from cultivator. It showed that there is different average weight between the two types of samples in the first seven days. The evidence was the level of significance was α>0.05. It showed that both types of seeds had different growth rate, or T value>T table (T value= 1.901 and T table=1.85955). On the 14th day, the weight of *K.alvarezii* from F4 seed was 171.38 g and that from seeds from cultivator was 164.50 g. The weight of the samples on the first 13 days was different from that on the second 12 days. *K.alvarezii* from the phenotype (F4) seed grew faster than that from seeds from cultivator. The data showed that the weight of both samples from the second ten days was different. It was shown that the level of significance was α >0.05 indicating that both species had different growth rate, T value>T table (T value was 1.911 and T table was 1.85955). On the 35th day or the third 10 days, absolute growth rate of *K.alvarezii* from F4 seed was 217.39 g while that from seeds from cultivator was 200.04 g. T-test showed α >0.05 which means both types of seeds had different absolute growth rate, T-value (1.9143)>T-table 1.85955. Observation on the 46th day revealed that absolute growth rate of *K.alvarezii* from F4 seed was 540g while that from seeds from cultivator was 349.8 g. T-test showed α > 0.05 which means both types of seeds had different absolute growth rate, T-value (1,905)>T-table 1.85955 or P-value<0.05, which means there is different growth rate between the growth rate of *K.alvarezii* from F4 seed and seeds from cultivator.

Abslolute growth

Absolute growth rate refers to increase in weight and length in 45 days/until harvest time [7]. Table 1 described the average absolute and daily growth rate of *K.alvarezii*.

Figure 2: Growth of selected seed (F4)

Specific growth rate: There is difference between specific growth rate of *K.alvarezii* from selected seed (F4) reproduction and seeds from cultivator. Based on the observation towards the specific growth rate, there was increase in the average weight of *K.alvarezii*. In the first sampling (the first 13 days), the daily growth rate of *K.alvarezii* using selected seed was 3.25%/day-1 while that using seeds from cultivator was 3.05% day-1. In the second sampling on day 25 (the second 12 days) the specific growth rate of *K.alvarezii* using selected seed was 4.45% day-1 while that using repeated seed was 3.42% day-1. In the third sampling on day 35 (the third 10 days), the average specific growth rate of *K.alvarezii* using selected seed was 5.96% day-1 while that using seeds from cultivator was 3.49% day-1. Furthermore, on day 45 (the fourth 10 days), the average specific growth rate of *K.alvarezii* using selected seed was 6.34% day-1 or faster than that of that using seeds from cultivator, which was 3.45% day-1. Table 1 shows that there is an effect of seed selection (F4) on the daily growth rate of *K. alvarezii*, this is presumably due to the use of seeds (F4) with a selection process using young thallus so that vegetative growth where cell division and cell elongation are more active in accelerate the growth rate.

Production of *Kappaphycus alvarezii*: Selected seed (F4) is an important step to control ice-ice disease. Selected seed (F4) results in higher productivity compared to seeds from cultivator. The productivity of the seaweed using selected seed (F4) was 604.00g kgs/m^2 while that using the seeds from cultivator was far lower or 30.245 g due to ice-ice disease.

Table 1: Average absolute growth and specific growth rate

Parameter	Seed	10 days	22 days	34 days	46 days
Average absolute Growth (g)	Selected seed (F4) (100 g)	334,8 ± 0,12	483,7 ± 0,12	555,6 ± 0,14	874,8 ± 0,14
	Seeds from cultivator (100 g)	105,0 ± 0,06	215, 0 ± 0,05	353,4 ± 0,05	454,8 ± 0,06
Specific Growth rate (%day-1)	Selected seed (F4)	3,25 ± 0,13	4, 45 ± 0,11	5,96 ± 0,13	6,34 ± 0,14
	Seeds from cultivator	2,05 ± 0,03	2,42 ± 0,05	2,45 ± 0,06	2,49 ± 0,05

Table 1 shows that the absolute growth of *K. alvarezii* using seed selection (F4) was (334.8 ± 0.12 g-874.8 ± 0.14 g) and that using seeds from cultivators (105.0 ± 0.06 g- 454.8 ± 0.06 g). Likewise for the specific growth rate, which uses seed selection (F4), (3,25 ± 0,13% day-1-6,34 ± 0,14%day-1) the results are greater than seeds from cultivators (2,05 ± 0,03% day-1-2,49 ± 0,05% day-1 (Figure 2). This is in accordance with what said that the selected seeds grew faster than those without selection.

Carrageenan Content

Carrageenan is widely used in food preparations, pharmaceuticals and cosmetics as a gelling agent, thickener or stabilizer (Food Marine Colloids Corporation, 1977). The carrageenan content of the Tesabela waters is as shown in Table 2.

Table 2: Average absolute growth and specific growth rate

Treatment	Carrageenan (%)
Selected seed (F4)	57,32
Seeds from cultivator	23,17

Table 2 showed carrageenan content in the seed from F4 seed was 57,32 ± 0,14 and that from repeated seed from cultivator was 23,17%. Type of seed influenced different carrageenan level. Selected seed (F4) takes 25 days to produce qualified seed for cultivation. Besides that, there is meristem tissue in young thalus. Meristem tissue is pivotal for plant growth and development. It is supported by Satriani (2017) that young thallus is influenced by meristem tissue which consists of cell for cell division [4,8,9].

Quality of water

Based on the 45-day observation, the temperature of the water in Tesabela water is between 28˚C and 32˚C and the average temperature is 31˚C. There was tendency that temperature was increasing from day 1 to day 45 (29˚C-32.8˚C). Water temperature was relatively stable with mild increase in the morning (09:30-10:30 a.m.) and late afternoon (3:30-4:30 p.m.). Sunlight and water clarity cause the increase. The water temperature (28˚C-32˚C) is suitable for *K.alvarezii* Therefore, based on the observation towards water temperature, Tesabela water is a suitable place for *K.alvarezii* cultivation because temperature fluctuation is lower than 27˚C.

DISCUSSION

The seaweed from seeds from cultivator had slower or stagnant growth rate because the seeds were infected with ice-ice disease. The growth of *K.alvarezii* with seed selection looks fresher, lush and young talus appears. This was presumably because *K. alvarezii* experienced the growth of cells at the end of the thallus which were arranged and always actively dividing, causing more lush and tall growth. In addition, the selected seeds are carried out by picking the tips of the thallus which are still young and fresh, so that it is easier for them to absorb nutrients during cultivation as explained by Reddy (2003) [10]. As described by Satriani (2017) that young talus there is meristem tissue. The meristem tissue found at the end of the thallus accelerates growth to become bigger, longer and more branched [11]. While the growth rate of seedlings originating from cultivators has decreased or remained constant. According to Cokrowati (2018) this is presumably because the age of seedlings from cultivators is older and not uniform in age, resulting in competition between the thallus to absorb nutrients and light in terms of photosynthesis, which is getting bigger, causing slower cell development consequently the growth rate of *K.alvarezii* decreased or remained [7]. This is in accordance with what was explained by Sangkia (2018) that the daily growth rate of seaweed is influenced by the ability to absorb nutrients or food in the waters [12]. Meanwhile, based on several research results, such as Fadillah (2014) reported that selected *K.alvarezii* seedlings had higher growth than those without going through this selection due to the presence of the hormone kinetin of 15.52%. Pongmasak (2015) explained that the selected *K.alvarezii* seaweed seeds increased the growth rate by 32%-40% so that they could be used as superior seeds with an indicator of an increase in day growth rate of 22.3% [13]. Based on the findings, the average specific growth rate of *K.alvarezii* using selected seed was higher than the seeds from cultivator. The highest daily growth rate of *K.alvarezii* using asexual seed for 45 days was 6.34% g per day. *K.alvarezii* from F4 reproduction grew faster than one from seeds from cultivator. It happened due to quality of the selected seed and quality of water. The selected seed used in the study came from good, shady and fresh thallus branch while the water where it was grown was clear. According to Cokrowati (2018) the optimum growth rate for *K. alvarezii* seaweed is above 3%/day, also supported by Erpin and Ruslaini (2013) who stated that seaweed cultivation is profitable if the daily growth rate exceeds 3%/day [7,11]. Atmadja and Sulistijo (1977) and Atmadja (1996) argued that clarity of water contributed to 1.5 to 2.5 meters growth in seaweed since clear water facilitates maximum photosynthesis (Soenardjo, 2008.) The result of photosynthesis is needed for plant growth and development [12-15]. In addition, qualified seed is another factor that determines successful cultivation [6]. Fritzgal (2009) described that the average biomass productivity during cultivation was 108.65 g/day-664.76 g/day and the growth was 2.15%-6.86% day-1. In Tesabela waters, West Kupang District, seaweed production was 302.45g-604.00g. These were affected by parameter of seeding, qualities water for seaweed cultivation. Adytia and Ruslan (2003) explained that quality of seaweed seed strongly determines productivity, product quality and resistance towards ice-ice disease [13]. The carrageenan content in the study is higher than those in, which is 44.068%. Ridwan (2019) explained that E. spinosum carrageenan content was 47.59%[16,17]. Some factors affecting different carrageenan content was growing time, type of seed, extraction method and raw material for extraction carrageenan [18]. Hayashi (2007) stated that seaweed has the highest carrageenan content when cultivation day is 45 days and Freile-Pelegrin (2006) described the factors affecting carrageenan content are foreign object, season, light, nutrient, temperature and salinity level which may decrease quality of seaweed [17]. Carrageenan content and quality of cultivated seaweed are varied depending upon species, age of seaweed, sunlight, nutrient, temperature and salinity level [19]. Nurdin (2013) stated that 60-day cultivation of *K.alvarezii* resulted in 95% of carrageenan level while 45-day of cultivation resulted in 87.68% of carrageenan level [20]. It shows that the time and duration of *K. alvarezii* cultivation has an effects carrageenan content [15]. According to Harun (2013) carrageenan's are used to gel, thicken, or suspend; therefore they are used in emulsion stabilization, for syneresis control, and for bodying, binding and dispersion [16]. Major uses are in foods,

like to milk applications [21-34]. According to Hayashi (2007), the quantity and quality of carrageenan produced from mari culture varied due to variety or species difference, age of planting, sunlight intensity, temperature, nutrients, and salinity. Tuvikene (2006) the quantity and quality of carrageenan produced from marine cultivation varies due to differences, planting age, sunlight intensity, temperature, nutrition, and salinity [35].

CONCLUSION

Selected seed (F4) can prevent ice-ice disease and increase seaweed productivity. Selected seed (F4) requires shorter time to grow compared to seeds from cultivator. Seaweed growth from Selected seed (F4) is between 334.8 g – 874.8g while that from seeds from cultivator was between 105.0g – 454.8g. Production seaweed seed from F4 seed is 604.00 g while that from seeds from cultivator was 302.45 g. Carrageenan content of seaweed from selected seed is and 57%, 32% that from seeds from cultivator was 33%, 17%. Selected seed (F4) seed had significant influence towards growth and production of *K.alvarezii*. Selected seed (F4) seed resulted in the highest rate of growth and production in *K.alvareziii*. Quality of water was within adequate range to grow *K.alvarezii*. Selected seed (F4) are suitable alternative for *K.alvarezii* cultivation. Moreover, supply is needed to overcome shortage of qualified seaweed seed. Finally, seaweed farmers should use correct methods and procedures.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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