The Application of Smart Fish Method Cultivation for Seaweed *Kappaphycus alvarezii* to Increase in Production in the Waters of Seribu Island, Indonesia

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Abstract

Cultivation of *Kappaphycus alvarezii* with the long line method is not fully effective because in certain seasons of extreme weather its production decreases due to loss of thallus during cultivation. This study aims to determine the performance of *Kappaphycus alvarezii* cultivation using local seed and tissue culture seeds methods with different spacing. The experimental design used was a factorial completely randomized design, in which there were factor A (different seeds) and factor B (different spacing). Based on the results of the study, the average DGR of *K. alvarezii* with different seed origins in each treatment at different distances, there was no difference. The results showed that the extreme weather factor of waves affected the growth of seaweed because in the planting season from May to July the waves and waves were very strong. Therefore, the long line cultivation method is not feasible to be applied to improve the performance of seaweed cultivation.

Keywords: Daily growth rate, Longline, production, thallus.

Introduction

Indonesia, which has an ocean area of 6.4 million km2, a coastline of 110,000 km, and a tropical climate is an area suitable for the growth of various types of seaweed (Lestari et al 2020). There are about 555 species of seaweed from around 8,642 species in the world that can grow and live well in Indonesian waters (Zainuddin et al 2019). As one of the major seaweed producers in the world, the wet weight of seaweed production reached 11.6 million tons in 2016 (FAO 2018). The highest production is *Kappaphycus alvarezii* (Aslan et al 2020) and *Gracilaria* spp. Indonesia must take advantage of the geographical conditions that support the development and increase of seaweed production. Although Indonesia is the world's main producer of seaweed, it turns out that Indonesian seaweed production is not optimal. This is indicated by the productivity of Indonesian seaweed cultivation which is still lower than the productivity of other countries.

According to Gultom et al (2019), Indonesia's dry seaweed productivity is still very low (1.14 tons km-1), lower than several other countries, such as the Solomon Islands (4.55 tons km-1), the Philippines, Tanzania, and India (1.61 tonnes km-1).

Seaweed is one of the important potential commodities in the marine and fisheries sector. Has the ability to bind air is quite high. Seaweed is one of the coastal vegetation that can utilize CO2 through photosynthesis for application into biomass. One of the important factors in seaweed cultivation activities is to produce high quality and productivity, which can be seen from the way it is planted. Proper cultivation techniques (eg distance and seed source) in the air will produce high productivity seaweed. To improve the quality of seaweed. productivity and production can be applied with an approach with the aim being to produce high quality and quantity without high costs.

The low performance and undeveloped management of seaweed cultivation indicate that although seaweed is a potential commodity, this sector has not developed optimally. One of the factors thought to influence the low productivity of seaweed cultivation is cultivation methods and techniques that often cause crop failure. According to Hendri et al (2018); Abdullah et al (2020), one of the factors that affect the growth of seaweed is the competition between thalli in obtaining nutrients and the presence of predatory pests that eat seaweed thalli. Generally, *Kappaphycus alvarezii* is cultivated by the long-line method. The use of this method has not been fully effective because in certain seasons when the weather is extreme, production decreases due to pest attacks. The development of wounds on the thallus will trigger a secondary infection by bacteria and cause the thallus to become brittle so that it is easy to detach and detach from the rope (Azizi et al 2018).

Seaweed needs shelter to protect itself from pests and grow well. One method that has been applied in several areas such as Takalar, South Sulawesi, and Madura, East Java, is the Smart fish (Sustainable Market Access Through Responsible Trading of FISH) method. The smart fish method is to maximize the growth of the thallus by maintaining the spacing and the continuous process of cleaning the thallus at least 3-to 4 times a week. The maintenance of seaweed in the Seribu Islands is constrained by the quality of local seeds, therefore in this study, we will compare tissue culture seedlings and local seedlings with the SMART FISH method

Materials and Methods

The research was conducted for 50 days from May to July 2021 in the waters of Panggang Island, Seribu Islands. The research location is watered with a depth of 350 cm at the highest tide and 50 cm at the lowest low tide. The tools used include refractometers, pH meters, thermometers, Secchi disks, digital scales, drifters, stopwatches, meters, plastic bottles, and scissors/knives. The materials used were K. alvarezii seeds, monofilament net bags, Polyethylene (PE) ropes, plastic bottle floats, and wooden stakes.

The seaweed cultivation method applied according to SOPs of SMART FISH for *K. alvarezii* production with a long line method. It's using a 9 mm PE rope as the main rope, which is made in a rectangular shape measuring 25 × 50 m with wooden stakes and buoys installed at each corner. The number of ropes used is 10 ropes, each of which is 25 m long and stretched on the main rope.

Local seeds of *K. alvarezii* were obtained from seaweed cultivators around the study site, while tissue culture seedlings from Lampung had been nursed for 20-25 days. The seed criteria refer to the criteria according to WWF (2014), namely: 25-30 days old seedlings, many branches, no spots, not peeling, fresh and flexible, not diseased, not overgrown with moss or competing for biota, and has a lot of young thalli. Before being used, the seaweed seeds were weighed using a digital scale (accuracy 1 g). Seedlings weighing 100 g each for tissue culture seedlings with a spacing of 10 cm (KJ10) and spacing of 20 cm (KJ20) and local seedlings weighing 100 g with a spacing of 10 cm (LK10) and local sedling weighing 100 g with a spacing of 20 cm (LK20), all treatment were planted at two different site location.

The daily growth rate was sampled every 7 sampling days at 5 replications that had been marked or numbered on each PE rope and measured. Absolute growth was observed at the end of the seaweed cultivation period by weighing the average weight at each point on the PE rope and subtracting the initial seedling weight from the average weight. Water quality parameters consisting of temperature, salinity, pH, water brightness, and water velocity were measured every two days in the morning. Measurements were made at 3 points at each replicate location.

This research was conducted by an experimental method using Completely Randomized Design (CRD), which consists of 2 factors, namely, Factor A (local seeds and tissue culture seeds) and factor B (distance between seedlings).

The parameters observed in this study were daily growth rate, absolute growth, seaweed production, and water quality.

Daily Growth Rate (DGR).

The daily growth rate is the percentage ratio between the initial weight of seaweed and the final weight of seaweed each day.

$$Daily\ Growth\ Rate = \frac{LnWt - LnWo}{t} \times 100\ \%$$

Where: Wt = Weight of seaweed at time t (g), Wo = Initial fresh weight of seaweed (g), t = Observation period (days).

Absolute Growth.

Absolute growth is the weight growth (g) of seaweed that is obtained by calculating the difference between final and initial weights. Absolute growth can be calculated using the formula according to Damayanti et al (2019) as follows:

$$W = Wt - Wo$$

Where: W = Absolute growth (g), Wt = Final weight of seaweed (g) Wo = Initial weight of seaweed (g).

Seaweed Production.

Seaweed production is calculated using the formula from Serdiati & Widiastuti (2010) as follows:

$$Pr = \frac{(Wt - Wo)B}{A}$$

Where: Pr is production (kg m^{-2}), Wt is the final weight of seaweed (g), Wo is the initial weight of seaweed (g), A is the length of rope (m), and B is the number of planting points.

Water Quality.

Some of the water quality parameters that were measured are presented in Table 1 below:

Table 1. Water quality parameters

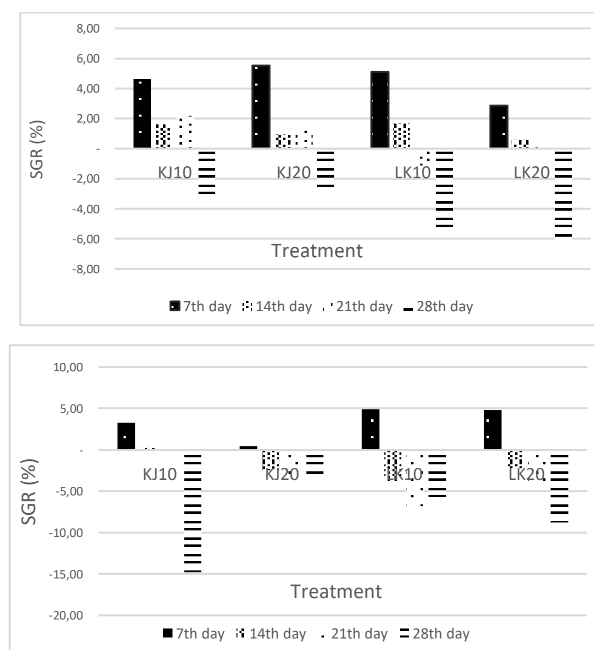
No	Parameters	Tools used	Data collection method
1	Temperature (°C)	Thermometer	In situ
2	Salinity (ppt)	Refraktometer	In situ
3	pH	pH meter	In situ
4	Water transparency (cm)	Sechi disc	In situ
5	Water velocity (cm $second^{-1}$)	Current meter and stopwatch	In situ

Data Analysis

All the parameters in the form of daily growth rate, absolute growth, seaweed production, and water quality parameters were presented descriptively.

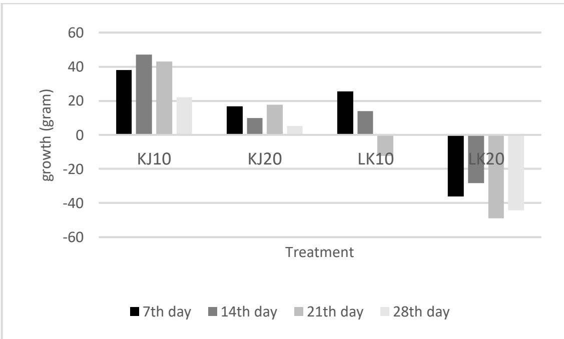
Results

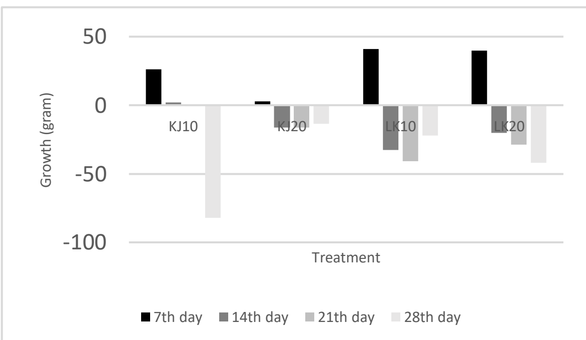
The daily Growth Rate (DGR) and Growth rate (GR) of *K. alvarezii* cultivated in Pulau seribu were obtained in this research are presented in the graph (Picture 1, Picture 2).



a b

Picture 1. Daily growth rate (%) of *K. alvarezi* cultivation in Pulau Seribu at 2 locations (a,b).





Picture 1. Growth Rate (GR) of *K. alvarezi* cultivation in Pulau Seribu at 2 locations (a,b)

In general, the results indicated that at the initial plantation DGR was higher for KJ20 (tissue culture, 20 cm distance) ie: 5,5% (KJ20), 5,11% (LK10), 4,6% (KJ 10), at location a, 4,91% (LK10), 4,81% (LK20) 3,3% (KJ10), at location b, respectively. In contrast resulted for LK20 (2,8%) at location a and KJ 20 (0,42%) at location b. In addition, the growth reduces gradually due to the increasing day of culture (picture 2). As shown in the picture, KJ10 and KJ20 exhibited positive growth within 3 weeks (21st day), and LK10, LK20 was 2 weeks (14th day).

As compared to locations a and b, the 1st location (a) has shown higher values of DGR and GR. Unfortunately, the 2nd location (b) has shown that the growth (DGR, GR) was lower than the 1st location.

a

b

c

Picture 3. A fouling organism at seaweed body (red arrow, a), predation by rabbitfish (red circle, b), and weed as a competitor (c).

We investigated during the cultivation, the seaweed body was attached by fouling organisms (Picture 3a), competitor (Picture 3c), and experienced predation by rabbitfish (*Siganus sp*) (picture 3 b).

The daily growth rate between treatments of seed weight and spacing of the same K. alvarezii cultivation showed values that were not significantly different. The daily growth rate of K. alvarezii using 100 seed weight cultivation method with 20 cm spacing was 6.58 ± 0.19%, significantly higher (P<0.05) than other daily growth rates. The results showed that differences in seedlings and plant spacing and the interaction of these two factors did not affect the daily growth rate of K. alvarezii (P>0.05). The daily growth rate of *K. alvarezii* which was cultivated at the beginning of the maintenance showed growth development but until the age of 20 days until harvest, there was a slowdown and the thallus broke. *K. alvarezii* cultivation method can not be separated from the interference of other organisms or pests.

The daily growth rate between treatments of seedling spacing on the same *K. alvarezii* cultivation method showed significantly different values. The daily growth rate of *K. alvarezii* with local seedlings was 1.58 ± 0.19%, significantly higher (P<0.05) than the daily growth rate using tissue culture seedlings. The daily growth rate was not significantly different, this indicates that seedling weight did not affect the consistency of seaweed growth as long as the main factor did not change. The main factors that affect the growth of seaweed are thallus condition and age, water quality, nutrient supply, and the presence of predatory pests.

Water Quality

Therefore, it is necessary to measure water quality to determine the criteria of water quality that can still support the growth of *K. alvarezii*. The water quality parameters are temperature, salinity, pH, water transparency, and water velocity, all of which were measured in situ, while nitrate and phosphate parameters were examined in the laboratory. The results of water quality measurements during the research are presented in Table 2 below:

Table 2. Water quality parameters observed during the research

No	Parameter	Measurement Results	Standard according to Literature
1	Temperature (ºC)	28.75–30.50	26 – 32 (SNI, 2010)
2	Salinity (ppt)	29–33.50	15 – 32 (WWF, 2014)
3	pH	7.00–8.62	7.00 –8.5 (WWF, 2014)
4	Water transparency (cm)	40–200	> 40 (SNI, 2010)
5	Water velocity (cm $second^{-1}$)	24.73–59.84	15–30 (WWF, 2014)

Discussion

Cultivation of *K. alvarezii* cannot be separated from disturbances of other organisms, such as pests and marine plants, other contaminants that cause growth disturbances so that *K. alvarezii* requires protection to grow properly (Mantri et al 2017; Mako et al. al

2018). In addition, there is a strong current, along with the west monsoon at the study site.

The difference in the daily growth rate of *K. alvarezii* with different seedling weights faster growth because the available nutrients are well absorbed by the thallus and there is no competition for nutrients. The daily growth rate was not significantly different, this indicates that seedling weight did not affect the consistency of seaweed growth as long as the main factor did not change. The main factors that affect the growth of seaweed are thallus condition and age, water quality, nutrient supply, and the presence of predatory pests. Seaweed growth is strongly affected by the conditions and quality of the aquatic environment (Glenn & Doty 1990). indicated that the seedling weight affected the growth of *K. alvarezii*. Tiwa et al (2013) stated that a smaller seedling weight will result in

Conclusion

Based on the study results, the sea wave height of about 1 m that occurred in May - July has the potential to damage the long line construction so that it cannot be used as infrastructure for seaweed cultivation. The growth of seaweed in this month is not significant. Specific Growth Rate (SGR) of *K. alvarezii* with different seedling origin at and spacing between 10 - 20 cm is significantly different from the result ranged from 5,5% to 3,3% at 1st location and 2,8% to 0,42% at 2nd location.

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