The impact of different coastal locations on the growth and Land suitability tissue culture on the Lampung Coast, Indonesia

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Abstract. This research was conducted at three different locations in the coastal waters of Lampung Indonesia, namely Hurun, Ruguk, and Pahawang, for one- month (March – April) 2021. The cultivation method used is the Long Line method, consisting of 20 points across four lines, with an initial weight of 50 g of seedlings per planting point. A land suitability analysis was conducted by scoring method (23–45), followed by observation of seaweed growth in each location. The result of observation and assessment of land suitability shows that the waters of Ruguk with a score of 38 and the waters of Hurun with a score of 34 are appropriate criteria for seaweed cultivation while the waters of Pahawang are less suitable criteria by the score of 28. receiving a score of only 28. The growth of seaweed, characterized by weight gain, absolute growth, and specific growth rate, was different among locations. The best results were obtained in Ruguk, which achieved a total production of 26,700 g/m and a daily growth rate per month of 8.54%, followed by Hurun, with a total production of 13,680 g/m, and an average daily growth rate per month of 6.32%. Pahawang had the lowest production yield of 9,900 g/m, with an average daily growth rate per month of 5.35%. The assessment of land suitability analysis is very important in land planning and management so that land use can be sustainable and by local environmental characteristics.

1 Introduction

One of Indonesia's sea-based export products is seaweed and has contributed a large amount of income to the national economy. One type of seaweed cultivated by the community is Eucheuma cottonii (*Kappaphycus alvarezii*) [1]. This type is widely cultivated because the required production technology is relatively easy to use. Like other marine organisms, optimal environmental conditions are important for the proper growth and reproduction of [†]seaweed. The more precise the aquatic environmental conditions, the better the growth of seaweed [2]. The optimal environmental capacity for seaweed growth is greatly influenced

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by the choice of location [2]. Considering that the availability of nutrients and environmental conditions at the sea is very difficult to modify, the growth of seaweed is completely dependent on the accessibility of nutrients and ecological factors [3]. The quality and quantity of seaweed cultivation production are influenced significantly by the seaweed seed and the method. One of the methods that can be used to trigger growth is by using the tissue culture method [4]. Tissue culture is a method that isolates part of the plant and fosters it in an aseptic condition in a closed container, so that the part can multiply and generate a complete plant likewise its parent, to increase the results of tissue culture is to cultivate them in floating rafts in the sea [4]. *Kappaphycus alvarezii* cultivation has been widely carried out but still relies on vegetative seeds, the use of seaweed from tissue culture is still limited because the number of tissue culture seed stocks is still inadequate [5]. One approach developed to mitigate these effects is the optimization of tissue culture techniques aimed at producing a large quantity of high-quality *K. alvarezii* seed stock for nursery purposes [4].

Lampung is one of the producers of seaweed of the *K. alvarezii* type because it has relatively calm waters and is protected by many small islands. The areas that are the centers of seaweed cultivation are Pesawaran, Pahawang Island, Legundi Island Waters, and South Lampung [6]. The coastal area of South Lampung is suspected to have different environmental quality conditions and physical characteristics [6]. The physical characteristics of coastal waters vary depending on many factors, including geography, climate, and human industrial activities, as well as the management of natural resources in the surrounding area. The level of pollution and water quality can also vary, these physical characteristics contribute to the uniqueness of each coast and affect the vegetation and organisms that can live in the area [8]. The physical characteristics of the waters play an important role in determining the suitability of the area for seaweed cultivation and are interrelated [9]. Factors such as nutrient concentration, water clarity, and environmental conditions significantly affect the growth and productivity of seaweed [10].

The development of seaweed cultivation is highly determined by the availability of superior seeds in large, massive, timely, and continuous quantities [11]. The provision of seaweed seeds has great potential for business development because technically the cultivation is easy and cheap, short harvest cycles, with regards to harvest, and post-harvest, and absorbs a lot of labor [11]. With the existence of tissue culture seaweed, the next step is the propagation of tissue culture seaweed in the F1 stage in the field or the procurement of tissue culture seaweed gardens around the seaweed cultivation location [12].

Many studies have been conducted, especially on *K. alvarezii* [9], but research is still focused on maintenance and planting methods to increase production at only one cultivation location [13]. Studies have shown that different locations exhibit varying suitability in terms of growth for seaweed cultivation [14] In addition, tissue culture seeds produce better growth compared to conventional seedlings [15] Therefore, conducting multi-site testing taking these factors into account can help determine the most suitable environment for tissue culture seaweed cultivation [16], which will ultimately support the existence of nursery gardens on the coast of Lampung. This study aims to determine the growth of tissue culture seaweed in each cultivation location and can produce biomass in large quantities and in a short time as well as the suitability of land that will support the existence of tissue culture seaweed seed gardens on the Lampung coast.

2 Materials and methods

2.1 Period and Sites

The study was Carried out for 30 days in March – April 2021 in three sites, namely 1. Ruguk

Village, South Lampung Regency, 2. Pahawang Village, Pesawaran Regency and 3. Hurun Bay, Pesawaran Regency. This location is used as a place for seaweed cultivation by coastal communities Fig. 1.

Fig. 1. The stree sites study

2.2 Tools and Materials

The tools needed during the study were used to quantify the growth rate of seaweed.in three multi planting locations are a refractometer, Secchi disk, litmus paper, thermometer, DO meter, bottles, plastic baskets, digital scales, stationery, underwater camera, rope, iron, scissors, knife, tie cable, styrofoam, hammer, bamboo, and labels. Meanwhile, the material needed at the time of research is *K. alvarezii* seaweed seeds from tissue culture derived from seaweed cultivation around the site.

2.3 Research methods

A completely randomized design was used to assess seaweed growth. The planting method uses the long line method with four rows, each row consists of 20 points with a distance between the points of 20 cm. The initial weight of the seedlings used at each point is 50 g. All treatments were repeated 3 times. The period of study to keep the seeds is one month or 30 days.

2.4 Data Collection Method

At the data collection stage, 10 individual seaweed samples were weighed per raft as well as on repeat rafts. The total number of samples for each sampling is 30 for each location. Sampling is carried out every seven days. At the end of the research, a total weighing was carried out to determine the biomass in each raft. Water quality measurements were carried out in situ and in the laboratory**.**

2.5 Data analysis

2.5.1 Analysis of Land Suitability

Land suitability classification is carried out by compiling a conformity matrix by assigning a score to the limiting parameters of seaweed cultivation [1]. The analysis of the level of land suitability was carried out by dividing each parameter into three classes, namely: suitable (score 3), less suitable (score 2), and not suitable (score 1). Parameters that can exert a stronger influence are given higher weight than parameters that have a weaker influence. The total score is then used to determine the level of land suitability. The maximum value of seaweed cultivation land suitability is 45. The value is obtained from the maximum score multiplied by weight, while the minimum value of 15 is obtained from the minimum score multiplied by weight. The land suitability value (Table 1) and the class interval (Table 2) are determined by using the formula:

$$I = \frac{N\ Maks - N\ Min}{\sum k} \quad (1)$$

Note:
I = Class interval
K = Number of desired land suitability classes
Nmax = maximum final value
Nmin = minimum final value

2.5.2 Growth Analysis

The daily growth rate is calculated using the formula [15] as follows:

$$SGR\% = [(Wt/Wo)^{1/t} - 1\} \times 100 \quad (2)$$

Note:
SGR = Specific growth rate (%/day)
Wo = Weight of the beginning of seaweed seedling (g)
Wt = Weight of the end of seaweed seedling (g)
t = Maintenance time

Table 1. Land suitability criteria

Score	Criteria
34-45 Fits 23-32 Less suitable < 23 Not suitable	Appropriate Less Suitable Not Suitable

Absolute growth in weight can counted with equation [15] as follows:

$$W = Wt - Wo \quad (3)$$

Note :
W = Absolute growth in weight (g)
Wt = Average end weight of seaweed seedling (g)
Wo = Average beginning weight of seaweed seedling (g)

Seaweed production is calculated using the following:

$$Pr = \frac{(Wt - Wo)\ B}{A} \quad (4)$$

Note:
Pr = production (g/m)
Wo = initial weight of seaweed seedlings (g)
Wt = final weight of seaweed seedling (g)
A = rope length (m)
B = number of planting points

Table 2. The physical characteristics and criteria for land suitability for seaweed cultivation

Parameters	Score	Weight
Protection		
Sheltered	3	3
Adequately protected	2	
Open	1	
Current velocity (m/s)		
0.2-0.3	3	2
0.1-0.19 or 0.31-0.4	2	
<0.1 or >0.4	1	
Depth		
5-10	3	2
1-4 or 11-15	2	
<1 or >15	1	
Basic substrate		
Sand/coral fragments	3	2
Muddy sand	2	
Mud	1	
Water brightness (m)		
>3	3	2
1-3	2	
<1 or >3	1	
Salinity (ppt)		
28-34	3	2
18-27 or 35-37	2	
<18 or >37	1	
Temperature (0C)		
27-30	3	1
20-26 or 31-36	2	
<20 or >36	1	
pH		
6,5-8,5	3	1
5-6.4 or 8.6-9	2	
<5 or >	1	

Source: Puja *et al.* (2010), Utojo *et al.* (2004), Neksidin *et al* (2010).

3 Result

3.1 The Growth

Table 3 shows that the best Body weight gain was treatment A (445 g), with a significant difference (p<0.05) from treatment B (165 g), and treatment C (228.6 g), treatment B is significantly Multi (p<0.05) from treatment A and treatment C, Likewise, treatment C is significantly Multi (p<0.05) from treatment A and treatment B. The same trend was seen in the absolute growth rate, which displayed a significant difference (p<0.05) between treatment A (14.84 g) with treatment B (5.5g) and treatment C (7.6 g). Likewise, treatment A had the best specific growth rate (8.54%), with a significant difference (p<0.05) from treatment B (5.35%), and treatment C (6.32%).

Table 3. Weight gain, Absolute growth rate, and Specific growth rate (SGR) of *K. alvarezii* from tissue culture in the three study sites

Parameters	Ruguk (A)	Pahawang (B)	Hurun (C)
Initial weight (g)	50	50	50
Final weight (g)	495.33 ± 11.68^{a}	215 ± 9.64^{c}	278 ± 3^{b}
Body weight gain (g)	445 ± 11.68^{a}	165 ± 9.64^{c}	228 ± 3^{b}
Absolute growth rate (g)	14.84 ± 0.39^{a}	5.5 ± 0.32^{c}	7.6 ± 0.1^{b}
Production (kg/m)	26.7^{a}	9.9^{c}	13.68^{b}
Spesific growth rate/ SGR (%)	8.54 ± 0.34^{a}	5.35 ± 0.30^{c}	6.32 ± 0.15^{b}

Different superscript letters in the table signify a significant treatment effect ($p < 0.05$)

Measurements of weight gain of *K. alvarezii* from tissue culture at three sites can be seen in (Figure 2).

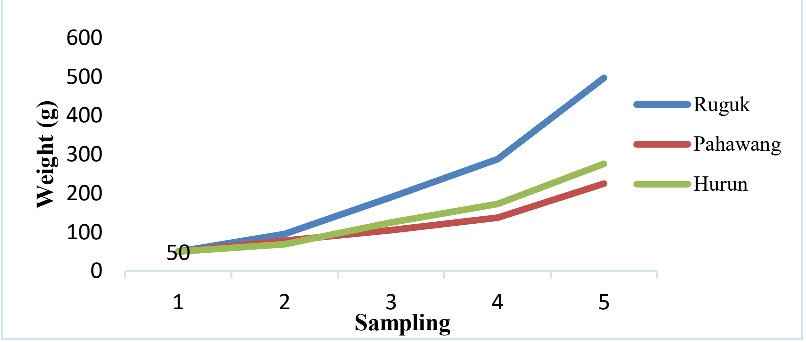

Fig. 2. Weight gain *K. alvarezii*

Measurements of absolute growth rate of *K. alvarezii* from tissue culture at three sites different in (Figure 3).

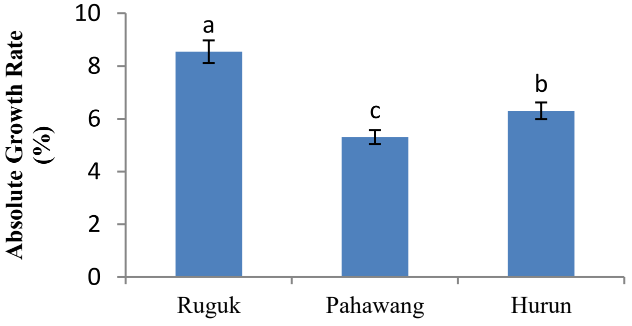

Fig. 3. Absolute growth in weight of *K. alvarezii* among the three study sites

Similarly, spesific growth rate of *K. alvarezii* different significantly among the study (Figure 4).

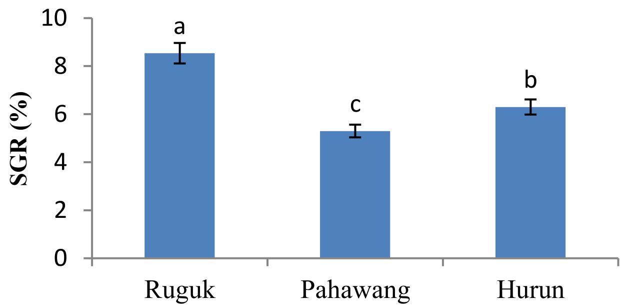

Fig. 4. Specific growth rate of *K. alvarezii* among the three study sites

3.2. *Land Suitability*

Based on the land suitability analysis, it was found that the Ruguk location had a better score than the Pahawang and Hurun locations. The total score obtained was 38 with Appropriate criteria, followed by the Hurun location with a total score of 34 with the same criteria as the Ruguk location but not the Pahawang location which obtained a score of 28 with less suitable criteria (Table 4).

Table 4. Land suitability analysis data from three different locations

Parameters	Ruguk	Pahawang	Hurun
Protection	9	6	9
Current Velocity (m/s)	6	4	4
Depth (m)	6	4	4
Substrate	4	2	4
Brightness (m)	4	3	4
Salinity (ppt)	3	3	3
Temperature(°C)	3	3	3
pH	3	3	3
Total Score	38	28	34
Criteria	Appropriate	Less Suitable	Appropriate

3.3 Parameter Water Quality

Table 5 lists the range values of the ten common water quality parameters measured for each treatment. The average dissolved oxygen at the beginning of maintenance is low but increases at the end of maintenance. Ruguk is a location with a high dissolved oxygen content compared to Hurun and Pahawang. Salinity, temperature, and pH for the three treatments were relatively stable, as well as the values of nitrite and ammonia concentrations for each location were still within the quality standard limits, the concentration of Nitrate in all locations was above the quality standard and the Pahawang location showed a higher Nitrate concentration compared to Ruguk and Hurun.

Table 5. Water quality of *Eucheuma cotooni* from tissue culture at three sites different

No	Parameters	Unit	Site Location			Standards
			Ruguk	Pahawang	Hurun	
1	pH	-	8.19 – 8.26	7.88 – 8.17	7.94 – 8.17	7 - 8.5*
2	DO	mg/l	6.88 – 7.13	4.12 – 5.31	6.77 – 7.31	> 4*
3	Temperature	°C	29.9 – 32	29.6 – 30.2	28.6 - 29.6	Natural
4	Salinity	ppt	31 – 32	32 – 34	32 – 34	33 - 34 *
5	Nitrite (NO2)	mg/l	0.02 – 0.03	0.04 - 0.14	0.02 – 0.04	0.05**
6	Nitrate (NO3)	mg/l	0.35 – 0.4	0.55 – 1.76	0.4 – 0.6	0.008
7	Ammonia (NH3)	mg/l	0.05 – 0.08	0.08 - 0.33	0.08 – 0.24	0.3*
8	Phospate (Po4)	mg/l	0.3 – 0.39	0.46 – 0.54	0.32 – 0.48	Waters: 0.015*
9	Current velocity	m/s	0.24 - 0.28	0.11 - 0.18	0.21 - 0.24	

Source: *Based on Marine Water Quality Standards for Marine Biota, Ministry of Environment No.51 th 2004
**Marine Environmental Pollution Control, Government Regulation No. 24 of 1991

4 Discussion

Seaweed cultivation sites play an important role in the success of cultivation efforts, as they directly impact the technical feasibility and sustainability of seaweed cultivation activities. This study highlights that areas with water quality parameters that are the standards for seaweed growth and land suitability that have high scores, tend to support higher seaweed production and overall cultivation success. Mistakes in selecting seaweed cultivation locations will significantly influence the yield and quality of seaweed.

4.1 Suitability of Land for Seaweed Cultivation

Analyzing the suitability of coastal land for cultivating seaweed in Lampung, especially in the Ruguk, Pahawang, and Hurun areas showed quite positive results. This study assesses several parameters such as water quality, location, and seaweed growth. Based on the results of the conformity analysis in three different planting locations (Table 4), it shows that the location of Ruguk is the best location with very suitable suitability criteria for the cultivation of *Eucheuma cotonii* type of seaweed with a total score of 38 followed by the location of Hurun is included in the suitable criteria for seaweed cultivation with a total score of 34. Meanwhile, the Pahawang location shows criteria that are not suitable for seaweed cultivation with a total score of 28 [16].

The location of Ruguk is the best location for seaweed growth and has a high score value, it is suspected that the location of Ruguk is in an area that is free from pollution because it is far from pond cultivation activities or floating net cages, besides that it also has the most strategic location because it is quite protected from large waves. This is because there are small islands that protect cultivation sites such as Seram Island and Legundi Island from waves that come directly from the Sunda Strait. However, the location of Ruguk still has sufficient current movement, the existence of these currents and waves can accelerate the growth of new branches and accelerate the absorption of nutrients/nutrients that affect the growth of seaweed. Waves are needed by seaweed to accelerate the absorption of nutrients into the cells while currents are needed for growth because they carry nutrients for seaweed and wash away the impurities that are attached. The currents that carry the nutrient content from the bottom to the upper layers of the waters help meet the needs of seaweed to live. The movement of the current helps seaweed always be clean from impurities attached to the *thallus*, so it does not interfere with plant growth. Currents that are too strong can damage seaweed plants until they are blown away or *thallus* broken, but currents are also important because water masses can become homogeneous and the transport of nutrients takes place well and smoothly [17].

In contrast to the Ruguk location, the Pahawang location and the Hurun location in Lampung Bay have a lower score than the Ruguk location, this is suspected to be the waste burden from cultivation activities around Lampung Bay resulting in a decrease in water quality. In Hurun Bay, many floating net cages are used as a place to cultivate various marine commodities such as snapper, grouper (tiger grouper and duck grouper), pearl oysters, and abalone [6].

The decline in water quality due to fish farming activities can have several effects on the suitability of land for seaweed cultivation, including excess nutrient levels, namely waste that is rich in nitrogen and phosphorus. Although these nutrients can support the growth of seaweed, excessive levels can cause eutrophication, which has the potential to damage aquatic ecosystems, can lead to a decrease in biodiversity, reduce dissolved oxygen levels and affect the pH of the water, disrupt food tissues and ecosystems as a whole, affect other organisms that interact with seaweed [18].

4.2 Seaweed Growth

Seaweed planting locations with water quality parameters and land conditions suitable for seaweed tend to produce better growth. The growth of seaweed produced at the Ruguk Location was the highest, with a total seaweed production of 26,700 g/m with an average daily growth rate of 8.54±0.34%. Meanwhile, the Pahawang location is the planting location that has the lowest total seaweed production of 9,900 g/m with a daily growth rate of 5.35±0.30%. Hurun Location is a planting location with a total seaweed production of 13,680 g/m with an average daily growth rate of 6.32±0.15%.

The optimal growth rate on a daily of seaweed *K. Alvarezii* was 3%/day. The results of the study showed that the daily growth rate in each location was between 5.35 to 8.54%/day. The high growth of seaweed is caused by several physical, chemical, and ecological conditions of the suitable planting location so it affects the growth of seaweed. Nitrate concentrations in all locations are suspected to be the cause of the growth rate. Nitrate is a limiting factor if the concentration is <0.1 ppm and >4.5. Nitrates affect seaweed production because nitrates are the main nutrients for plant and algae growth. The growth of seaweed increases with increasing nitrate levels in the waters. The range of nitrate concentrations in water suitable for seaweed fertility is 0.1-3.50 ppm. The lowest nitrate content for algae growth ranges from 0.3-0.9 ppm.

From table 3, it can be seen that each planting location shows a real difference, in each growth parameter this shows that different seaweed planting locations will produce different production. This is because each location has different characteristics and capabilities of the land as well as nutrient content that will affect the growth of seaweed.

Seaweed needs sunlight for photosynthesis. Locations that are exposed to direct sunlight at the appropriate depth tend to produce better growth [19]. Pollution, such as industrial or agricultural waste that enters the waters, can affect water quality. Locations that are far from pollution sources will usually have cleaner water, which has a positive impact on seaweed growth [1]. Human activities such as land use, development, and tourism can also affect planting locations. Locations close to human activities may be more affected by pollution and habitat degradation, thus affecting seaweed growth [20].

4.3 Water Quality

The growth of seaweed is greatly influenced by various water quality parameters. The three seaweed planting locations were still below the domestic standard threshold of water quality, the Decree of the Minister of Environment No. 51 of 2004 for Marine Biota, especially in the parameters of temperature, salinity, pH, DO, nitrite, and ammonia except for Nitrate and Phosphate parameters (Table 5).

The water temperature in the three seaweed cultivation sites is suitable for seaweed growth, which is in the range of 28.6 - 32 ^{0}C. The acceptable temperature for the growth of *K. alvarezii* is 27 - 28 °C [23]. The salinity of the waters in the three locations ranged from 31 to 34 ppt, still within the standard range for seaweed growth. A good salinity range for the growth of *K. alvarezii* is 28 -34 ppt.

The pH in the three locations was similar from 7 to 8. The optimum pH range to support the survival of *K. alvarezii* is 7 - 8.5. The pH values are good for the growth of *K. alvarezii*. species range from 7 to 9, with an optimal range of 7.9 to 8.3. Increasing pH will affect the life of seaweed and the waters tend to have an increase in acidity due to large amounts of organic waste input [26].

The current speed at Ruguk is higher than The Pahawang and Hurun. In contrast, at Hurun location, the current speed is reduced by cultivation activities around the seaweed planting location, which blocks the flow of water that carries nutrients. The availability of Nutrients for seaweed comes from a good water flow [24]. The ammonium concentration during the study, which is around 0.05 - 0.08 ppm, is still much lower than the standard tolerance limit for ammonia in waters. The ammonium content remains viable for marine organisms at 0.5 ppm [27].

Phosphate is an element of the protoplasm (an essential part of living cells) that plays a role in reducing abortion (stopping organ growth), formation of meristem tissue, stimulating cell division, and repairing damaged tissue. Phosphate concentrations in the three locations ranged from 0.3 - 0.4, which is still within the range for optimal seaweed growth of 0.051 – 1.00 ppm [28].

5 Conclusion

The impact of different tissue culture seaweed planting locations on the growth and suitability of the land to support nursery gardens on the coast of Lampung is that each planting location has various environmental characteristics, such as salinity, temperature, current, and availability of nutrients that affect the growth and suitability of the land.

The Ruguk site and the Hurun site have better conditions for the growth of tissue culture seaweed, with a higher growth rate, making it more suitable for nursery garden development. More productive tissue cultures, are important for the sustainability and efficiency of cultivation efforts in nursery gardens. The cultivated seaweed species and their adaptation to local conditions also play an important role in determining the most suitable location for tissue culture and nursery garden development.

The selection of the location must consider the results of research that show the best performance of seaweed growth and land suitability in a particular planting location, increase the success of coastal cultivation of seaweed of Lampung, and support the sustainable development and productivity of nursery gardens in the region.

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