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GROWTH RESPONSE OF *Kappaphycus alvarezii* OF GREEN STRAIN SEAWEED CULTIVATED ON DIFFERENT SEASONS AND LOCATIONS IN INDONESIA

BADRAENI*, RADJUDDIN SYAMSUDDIN, HARYATI AND FARID SAMAWI
Aquaculture, Faculty of Marine Science and Fishery, Hasanuddin University, Makassar, Indonesia [BADRAENI, RS, HARYATI].
Marine Science, Faculty of Marine Science and Fishery, Hasanuddin University, Makassar, Indonesia [FS].
[*For Correspondence: E-mail: reniarfan@yahoo.com]

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ABSTRACT

Seaweed is one of the Indonesian commodity exports, which is mostly obtained from the cultivation activities. The seaweed cultivation activity is commonly performed by the coastal community in coastal area using a longline method. There are several problems occured in the coastal area, such as land usage conflict, high pollutant, and sedimentation that affects the cultivated seaweed. Offshore area is an alternative location for seaweed cultivation to provide better water quality for supporting the seaweed growth. This study was aimed to compare the absolute and specific growth rate of seaweed cultivated at inshore and offshore locations, examine the optimum growth rate of seaweed, and determine the maximum growth rate of seaweed cultivated on different seasons. This study was conducted at Punaga Village for one year (2018) using a long line method. We cultivated the *Kappaphycus alvarezii* green strain at two different locations, i.e inshore and offshore location for one year round. We measured the parameters three times for each season comprising transitional seasons (Apr – May and Oct – Nov) and dry season (beginning (May – July), peak (July – August) and end (August - Oct)). Parameters measured were the absolute and specific growth rate, as well as the water quality (nitrate, phosphate, ammonium, CO_2, calcium and magnesium). The results showed that the growth rate of seaweed and concentration of nitrate, CO_2 and calcium were higher at the inshore location than at the offshore location. Meanwhile, the offshore location showed high phosphate and magnesium concentration.

Keywords: Inshore and offshore location; *Kappaphycus alvarezii* green strain; season; absolute and specific growth rate of seaweed.

INTRODUCTION

Seaweed is one of the potentially developed commodities as utilized widely on various sectors. Seaweed has been utilized in the food and feed industries [1], cosmetic industries [2], pharmacies [1] and energy [3]. Seaweed in the fisheries sector is utilized as a commercial feed ingredient [4,5].

The seaweed production in Indonesia is mostly obtained through the cultivation activities. The seaweed cultivation is mostly performed by the community live in high primary productivity [6]. The seaweed types cultivated in Indonesia, especially in the eastern region, are *Kappaphycus alvarezii* of green and brown strains.

The seaweed production which is cultivated in nature extremely depends on the natural condition, therefore the harvesting results are varied on each cultivation period at the different season. The growth of *Kappaphycus alvarezii* in Saugi Island was reported higher on the rainy season than dry season [7]. Meanwhile, the production of *Sargassum* spp. was high at the warm temperature and low on the rainy season in Australia (Fulton et al. 2014). The water supply mass difference causes the water condition alteration, which influences high and low water productivity.

Environmental parameters hold an important role in determining the seaweed production (Harrison and Hurd, 2001). Water physical factors, such as light, temperature [7] and nutrients are the essential factors for an algae as often altered dramatically along with an altered season (Kain, 2007). The rainy and dry seasons which occur in Indonesia have great different characteristics, specifically on the light factor.

Besides water physical and chemicals, location factor can also influence on the seaweed growth. The location of seaweed cultivation is an offshore and inshore using a longline method. Offshore is deeper water area with a strong current [8], while inshore is characterized by the nutrient rich location with mangrove and seagrass ecosystem, as well as coral reef ecosystem, which give a benefit for the seaweed development, especially the thallus growth, besides protected from small islands and corals, having a relatively stabile current, therefore unable to destruct the seaweed and cultivation facilities (Holmer, 2013). In this study, we will report the growth rate of *Kappaphycus alvarezii* (Doty) green strain on different seasons and cultivation locations.

MATERIALS AND METHODS

Description of the Study Sites

This study was conducted in Malelayya Village, Punaga Village, Mangarabombang Subdistrict, Takalar Regency, South Sulawesi. This study was performed in a year, which divided into five cultivation periods, namely the rainy to dry transitional season (April-May), beginning of dry season (May-June), mid dry season (July-August), end of dry season (September-October), and dry to rainy transitional season (October-November). All cultivation periods were performed for 45 days by calculating the absolute growth and specific growth rate (SGR). The seaweeds were cultivated at two different water locations, i.e water location near the shore (inshore) and water with steep slope in its base (offshore), using a longline method (Kasim and Mustafa, 2017). Seaweed growth and water quality data were collected during the study.

SGR is presented as the daily growth percentage based on the formula of Luhan and Sollesta (2010): $SGR = (\ln W_t/\ln W_0)/t \times 100\%$, as SGR is the specific growth rate (% wet weight per day), Wt is the weight after t day; Wo is the initial weight; t is time in days as obtained from each 15 days per cultivation period. Temperature, salinity, brightness, pH, and current speed was measured directly in the cultivation locations (*in* situ), while NO_3, NH_4, PO_4, CO_2, Mg, and Ca parameter were analyzed in the laboratory of water quality, Hasanuddin University, Makassar.

Statistical Analysis

Growth data were statistically analyzed using Mann-Whitney test with SPSS version 36.0, while the water quality was descriptively analyzed.

RESULTS

Kappaphycus alvarezii Green Strain Growth at the Inshore and Offshore Area

K. alvarezii green strain seaweed cultivated at the inshore and offshore area showed a different production. The growth rate of seaweed at the inshore showed higher value than offshore as the absolute growth of seaweed on the inshore and offshore area was 108.6 g: 5.44%, while the specific growth rate was 53.4 g: 3.9%.

Mann-Whitney test results showed the average growth of *K. alvarezii* green strain indicated a higher absolute growth and specific growth rate on the inshore area than offshore area (<0.05) (Fig. 1).

Kappaphycus alvarezii Green Strain Growth at the Inshore on Different Seasons

K. alvarezii green strain seaweed cultivated at the inshore area showed a different growth rate on dry and rainy season. The highest seaweed growth was obtained from the rainy to dry transitional season with 153; 142 g and at the dry to rainy transitional season with 6,11; 6,26%, as well as at the end of dry season before entering the dry to rainy transitional season with 97 g and 5,30% and the last was at the beginning and mid dry season with 77; 74 g and 4,77; 4,75% respectively. The Mann-Whitney test showed that the seaweed growth at the transitional seasons had no significant difference (>0,05). This was different from the seaweed growth at the dry season with the transitional season, showing a significant difference (<0,05), while the growth rate at the end of dry season had no significant difference (>0,05) (Fig. 2).

Kappaphycus alvarezii Green Strain Growth at the Offshore on Different Seasons

K. alvarezii green strain seawood cultivated at the offshore area on rainy and dry season showed that the seaweed strain green can be cultivated annually as same as the inshore area (Fig. 3). The highest growth rate of seaweed at the offshore was found on the dry to rainy transitional season with 95 g and 5.23% and rainy to dry transitional season with 56; 64 g and 4.47; 4.30%. The lowest value was obtained from the seaweeds cultivated on the dry season with 22; 30 g and 2.57; 3.06%. The Mann-Whitney test indicated that the seaweed cultivated on the transitional seasons from dry to rainy season had the highest growth rate (0<0.05) compared to other seasons. Meanwhile, the growth of seaweed on the rainy to dry transitional season showed higher value than at the end of dry season (0.05).

Water Quality

The water quality parameters that support the seaweed growth on each cultivation location are presented on Tables 1 and 2. The following results indicated that physical parameters, salinity, temperature, pH, or brightness had a relatively same value on either inshore or offshore area. Meanwhile, the chemical parameters, such as NH_4, NO_3, and PO_4, as well as chlorophylls presented a higher concentration at the inshore area than the offshore. Moreover, the content of CO_2, Ca, and Mg which played the roles in the photosynthesis process had a relatively same value.

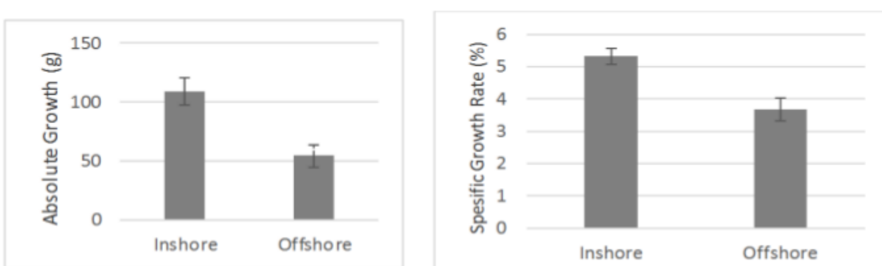

Fig. 1. Growth of *K. alvarezii* of green strain at inshore and offshore. Absolute growth (a); Specific growth rate (b)

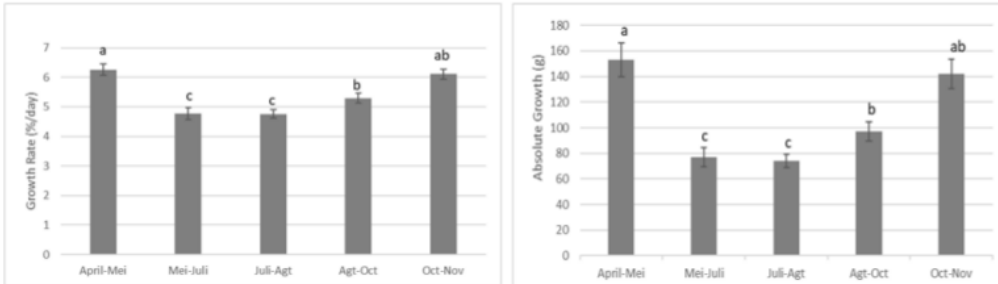

Fig. 2. Growth of *K. alvarezii* of green strain at inshore on different seasons. Absolute growth (a); Specific growth rate (b)

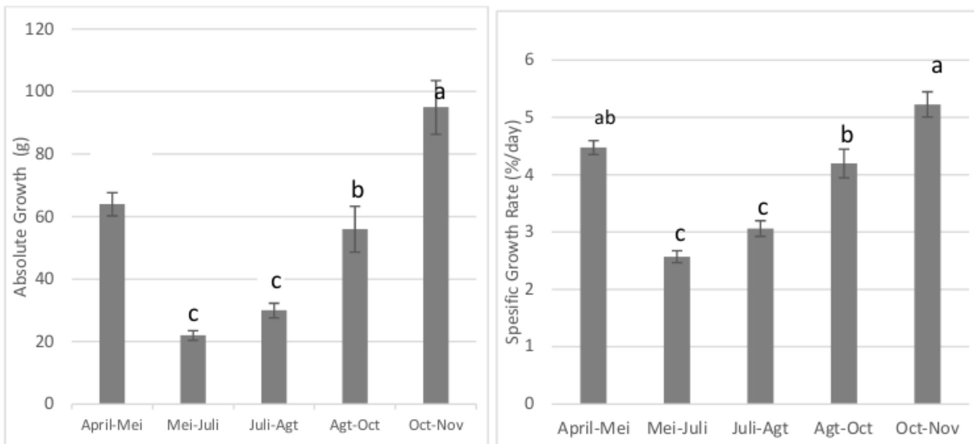

Fig. 3. Growth of *K. alvarezii* green strain at the offshore area on different seasons. Absolute growth (a); Specific growth rate (b)

Table 1. The water concentration of salinity, temperature, pH, and brightness on different locations and seasons

Parameter	Unit	Location	Season				
			I	II	III	IV	V
temperature	°C	inshore	28.5-30.5	30.0-31.0	30.0-31.5	30.0-31.0	29.0-30.5
		offshore	29.0-31.0	30.0-31.5	30.1-31.5	30.5-31.1	30.0-31.1
salinity	ppt	inshore	33.9-35.1	34.5-35.0	33.5-35.5	33.0-34.0	31.1-33.0
		offshore	33.5-35.5	35.0-35.5	33.9-35.0	33.0-34.5	31.5-33.0
Brightness	%	inshore	100	100	100	100	100
		offshore	100	100	100	100	100
pH	-	inshore	7.53-7.64	7.53-8.3	7.65-8.2	7.9-8.0	7.53-8.1
		offshore	7.83-7.97	7.89-7.97	7.89-8.1	7.5-7.9	7.53-7.9
Current speed	cm/s	inshore	5.8-6.5	4.5-6.5	4.5-5.5	4.0-5.5	5.5-6.46
		offshore	6.5-7.5	5.0-6.5	5.4-6.8	6.5-7.5	7.8-8.5

I = Rainy to dry transitional season (April-May)
II = Beginning of dry season (May-June)
III = Mid dry season (July-August)
IV = End of dry season (September-October)
V = Dry to rainy transitional season

Table 2. The supporting parameter concentration of growth and photosynthesis process on different locations and seasons

Parameter	Unit	Zone	Parameter				
			I	II	III	IV	V
NH_4	ppm	inshore	0.001-0.002	0.001-0.002	0.001-0.002	0.002-0.003	0.002-0.003
		offshore	0.001-0.002	0.001-0.002	0.001-0.002	0.002-0.003	0.002-0.003
PO_4	ppm	inshore	0.5-0.71	0.2-0.4	0.4-0.49	0.49-0.60	0.5-0.72
		offshore	0.6-0.72	0.2-0.4	0.4-0.69	0.69-0.72	0.71-0.78
NO_3	ppm	inshore	0.4-0.46	0.19-0.25	0.15-0.25	0.15-0.27	0.43-0.5
		offshore	0.2-0.58	0.1-0.2	0.1-0.2	0.15-0.2	0.35-0.41
CO_2	ppm	inshore	15.34-22.76	22.76-29.97	27.95-29.97	25-96-27.95	22.50-25.96
		offshore	23.95-28.45	21.97-28.45	21.97-31.96	31.95-31.96	28.45-31.95
Ca	ppm	inshore	920-1023	920-1041	1041-1282	1281-2403	1023-2403
		offshore	920-1024	920-1041	1041-1401	1401-2121	1024-2121
Mg	ppm	inshore	4861-4909	4861-5637	3020-5637	3020-3911	3911-4681
		offshore	4822-4884	4822-5504	2634-5504	2634-3707	3707-4822

I = Rainy to dry transitional season (April-May)
II = Beginning of dry season (May-June)
III = Mid dry season (July-August)
IV = End of dry season (September-October)
V = Dry to rainy transitional season

DISCUSSION

Based on the results, the highest growth was obtained from the inshore area on the rainy to dry transitional season, as well as dry to rainy season. The different seawed growth was caused by the existence of water quality characteristic differences as cultivation media. The nutrient content in water near the shore is higher than water far from the shore [9].

Nutrient requirements for the optimal seaweed growth is very important in the production system [10]. The same condition was also explained by [11], when the seaweed nutrient requirement is greater than the available nutrients in water, therefore the nutrients will become a limitting growth factor or the unfulfilled term of minimum nutrient requirement that will limit the seaweed growth rate. Besides minimum requirement, growth is also affected by the interaction of balanced nutrient required by the seaweed, i.e phosphate and nitrate [12].

The main nutrients required by the seaweed to improve growth and production system are NO_3, PO_4 and CO_2 [13]. The NO_3 content showed higher value at the inshore area. Nitrogen in the form of NO_3, NH_4, and phosphate are naturally the nutrients as whenever unavailable, they will limit the seaweed growth. These nutrients can be available with the help of seawater movement under the thermocline layer or upwelling [10]. Moreover, water movement can also clean the seaweed from dirts that can inhibit the photosynthesis process, therefore seaweed can perform the photosynthesis process well.

Water mass mixing at the inshore area happens thermally on the transitional season, then will form a thermal stratification when entering the dry season and water stirring happens on the next transitional season [14]. The existence of water mass circulation impacts on the nutrient distribution contained in the water. High nutrien contents during the transitional season was caused by the water stirring occured marked from high current speed. The same condition was also stated by [15] that temperature alteration happens during the transitional season, whereas the temperature surface would induce or reduce randomly or the temperature surface would reduce rather drastically, impacting the nutrient circulation perfectly.

CONCLUSION

Based on the study results and analysis described, it can be concluded that *K. alvarezii* can be cultivated annually either on the rainy or dry season. The best growth rate was seen on the seaweed cultivated on the transitional season, either rainy to dry or dry to rainy season. Meanwhile, a cultivated location selection between inshore and offshore presented a higher growth at the inshore than offshore. This difference can not be separated from the supplied nutrients and nature condition in the field.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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