THE RELATIONSHIP OF THE WATER PARAMETER TO THE GROWTH AND THE CARRAGEENAN QUALITY OF *Kappaphycus alvarezii* (DOTY) DOTY EX P.C. SILVA (1996) IN BELOPA, LUWU REGENCY, INDONESIA

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ABSTRACT

The research aims to determine the relationship of water quality parameters to the growth and carrageenan quality of red algae Kappaphycus alvarezii. This research was conducted in July November 2022 in the waters of Belopa sub-district, South Sulawesi, Indonesia. Water quality parameters measured were temperature, pH, salinity, brightness, depth, current velocity, dissolved oxygen, nitrate, and phosphate. The cultivation was conducted by longline method. There were 3 stations and each station had 3 stretched ropes with a length of 5 m as replicates. The growth was calculated by measuring the specific growth rate and the absolute weight growth. The quality of carrageenan was tested by yield, water content, and ash content. Water quality and growth data were collected every 10 days for 40 days. The effect of growth and quality of carrageenan on each location was analyzed through ANOVA and Kruskal Wallis tests. The relationship between parameters was analyzed through coefficient correlation tests (Pearson Simple Linear Correlation). The determination of characteristic parameters at each station was applied through the principal component analysis test. The results showed that the yield of carrageenan was impacted by phosphate. The water affected by nitrate and brightness. Ash content affected by temperature, pH, and current velocity. Different location did not significantly affect the growth and quality of carrageenan.

KEYWORDS: Kappaphycus alvarezii; growth, water quality, red algae; seaweed

INTRODUCTION

Indonesia has become the top producer of carrageenophyte seaweeds, with a particular focus on *Kappaphycus alvarezii* also known as cottoni in the industry (Simatupang *et al.*, 2021). It is a leading export commodity that has high economic value with broad market prospects to the international world (Ministry of Marine Affairs and Fisheries, 2020). Seaweed production continues to increase every year due to demand for the product and the wide variety of seaweed utilization (Sarmin *et al.*, 2021).

The *K. alvarezii* seaweed is among the most widely cultivated in Indonesia as a kappa-carrageenan producer that is used in various industries (Kambey *et al.*, 2020). The Food and Agriculture Organization of The United Nations (FAO) data provides that Indonesia is currently the number one producer of *K. alvarezii* seaweed with 84.28% of the world's supply (FAO, 2021).

South Sulawesi Province is the main producer of the largest seaweed production, reaching 3,422,076 tons in number. Luwu Regency is among the largest seaweed-producing areas in South Sulawesi with a total production of 615,401 tons in 2021 and utilization of 18,517.24 Ha of cultivated land (BPS Sul-Sel, 2022).

Many of the people of Luwu Regency who live in the coastal area are cultivating seaweeds as their livelihood. The prospect of seaweed cultivation is very profitable if the seaweed's growth and quality are good. However, there are often obstacles encountered in cultivating seaweeds (Atmanisa *et al.*, 2020). As stated by Ega (2016) Indonesia's seaweed is still undervalued in the international market because of the low quality of its product.

The growth and quality of seaweed depend on the oceanography factor, which is the physics factor, and the seawater chemistry along with the types of substrate (Priono, 2016; Arisandi *et al.*, 2011). The water quality factor is related to the selection of cultivation locations in supporting the growth of

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seaweed production which makes it a priority for seaweed farmers to pay attention to (Ministry of Marine Affairs and Fisheries, 2019). Physical, chemical, and biological factors of water become the determinants for successful seaweed cultivation (Akib *et al.*, 2015). Research Nur *et al.*, (2018) concluded that the most suitable seaweed planting location is at a distance of 500 m from the river estuary.

In order to improve the quality of seaweed production in Luwu Regency, research on the relationship between water quality and the growth and carrageenan quality of the *K. alvarezi* seaweed cultivation area must be conducted. For future development in a suitable seaweed growing activity, this research needs closely monitor location conditions.

MATERIAL AND METHODS

Location and Sample Collection

This study was done in July-November 2022 in seaweed cultivation waters of Belopa sub-district, Luwu Regency, South Sulawesi, Indonesia. Analysis of water quality and carrageenan was done at the Productivity and Water Quality Laboratory of Hasanuddin University.

The samples were collected from three cultivation locations based on the difference between each location. The first station (ST-1) in the north of the river estuary is coordinated in 3°22′32.93"S 120°24′17.89"T. The second station (ST-2) around the river estuary is coordinated in 3°22′59.79"S 120°24′16.21"T and the third station (ST-3) in the south of river estuary is coordinated in 3°23′21.54"S 120°24′22.54"T. Seaweed was cultivated approximately 500 m from the river mouth. The distance between the stations was approximately 1,700 m. The station points are depicted on the map of the sampling area (Figure 1).

Experimental Design

Longline cultivation method was applied, in which each station, 3 stretched ropes with a length of 5 m were applied as replicates. Plastic bottles were used between the rope as floats. The distance between the ropes were 5 m. In the stretched ropes, there were other ropes located at 10 separate points. The distance between points were 20 cm. A 50 g weight was initially tied to the tiller rope. The repetition of 3 streched ropes were placed in the right, in the middle, and in the left corner.

Water parameters

Water quality parameters such as pH, temperature, salinity, brightness, depth, and current velocity were measured directly in the field (in situ). Meanwhile, parameters of dissolved oxygen, nitrate, and phosphate were analyzed in the laboratory. Dissolved oxygen was determined using the Winkler method based on SNI 06-6989.14-2004. The nitrate and phosphate contents were measured by spectrophotometrically according to the method SNI 06-2480-1991 and SNI 06.6989.31-2005. Water samples were collected every 10 days over a 40-day period at approximately 11:00 AM.
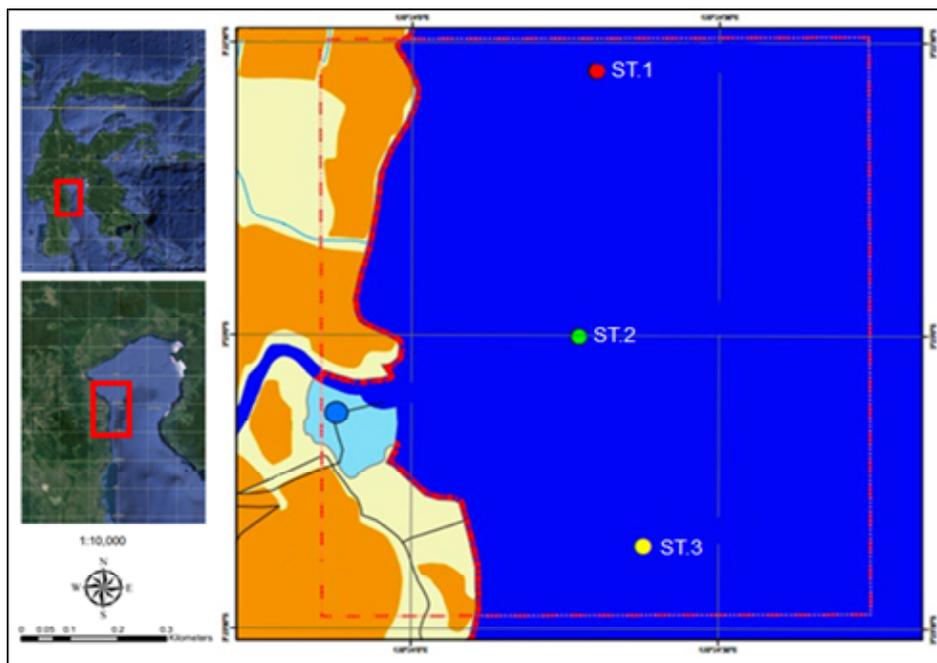

Figure 1. Research Location (ST-1 = the north of the river estuary, ST-2 = around the river estuary, ST-3 = the south of the river estuary).

Growth measurement

The measured growth data were specific growth rate (DGR) and absolute growth (G). Specific growth was the weight gain measured every 10 days from the beginning until the end of the research. Three clumps were taken and the average calculated. The DGR was calculated using the formula of Dawes *et al.* (1994).

$$DGR = \frac{(L_nW_1 - L_nW_0)}{t} \, x \, 100$$

where :

DGR = average specific growth rate (%/day)

W_1 = average weight of seaweed at each measurement (g)

W_0 = average weight of seaweed at the beginning of cultivation (g)

t = observation period (days)

Absolute growth is measured at the beginning and the end of the research, which is calculated using Effendi (1997) formula.

$$G = W_1 - W_0$$

where :

G = absolute growth (g)

W_1 = weight of the seed at the end of the cultivation (g)

W_0 = weight of the seed at the beginning of the cultivation (g)

Analysis of carrageenan

Carrageenan quality testing parameters included yield, water content, and ash content. Weight of the wet sample about 500gr was used. The extraction of carrageenan yield was analyzed based on procedures from SNI 2354.12:2013. The analysis of water content used the method SNI 01-2354.2-2015, and ash content by SNI 01-2354.1-2010.

Statistical Analysis

Data on water quality, growth, and carrageenan were analyzed and explained descriptively. The statistical analysis was performed using the SPSS 22 Version and Minitab 19 version. Growth rate analysis were analyzed by *Microsoft Excel* 2010. Water quality, growth, and carrageenan data were processed using the normality test first, then continued with the ANOVA test to determine the effect of different locations. However, in the normality tests, there are found abnormal grades, which makes the testing to be carried out with the nonparametric *Kruskal Wallis*. The relationship of water quality parameters on the growth and quality of the carrageenan was analyzed by conducting a correlation coefficient test (*Pearson's Simple Linear Correlation*). Determination of characteristic parameters at each station was carried out using the *Principal Component Analysis* (PCA) test.

RESULT AND DISCUSSION

Water Quality

Table 1 shows the results of water quality parameter measurements in the cultivation location over 40 days.

An appropriate condition of water quality parameters determines the ecological feasibility of aquaculture cultivation (Wafi *et al.*, 2021). pH concentration ranged around 7.65 - 7.68 and still in the decent range for the growth of *K. alvarezii*. It means that pH in these stations has almost the same value. BSN (2010) states that the optimal pH for seaweed cultivation is around 7.00 – 8.50. Pong-masak & Sarira (2015) also reported that the range pH optimal for the cultivation of seaweed *K. alvarezii* was 7.30 – 8.20.

Table 1. Value (mean ± std; n=4) of waters quality parameter measurement

Parameter	ST-1	ST-2	ST-3
pH	7.68 ± 0.21	7.65 ± 0.20	7.67 ± 0.15
Temperature (°C)	29.40 ± 1.35	29.60 ± 1.50	29.80 ± 0.86
Salinity (g.L^{-1})	29.20 ± 1.86	29.00 ± 1.41	29.67 ± 0.97
Brightness (m)	1.27 ± 0.86	2.14 ± 1.04	3.05 ± 1.04
Depth (m)	3.31 ± 0.32	4.43 ± 0.36	4.42 ± 0.71
Current velocity (m/s)	0.30 ± 0.01	0.100 ± 0.001	0.20 ± 0.01
Dissolved oxygen (mg.L^{-1})	6.52 ± 1.37	7.15 ± 1.37	6.60 ± 1.60
Nitrate (mg.L^{-1})	0.014 ± 0.007	0.012 ± 0.006	0.010 ± 0.006
Phosphate (mg.L^{-1})	0.024 ± 0.004	0.021 ± 0.003	0.020 ± 0.004

Station location ST-1 (the north of the river estuary), ST-2 (around the river estuary), ST-3 (the south of the river estuary).

The average value of water temperature from the three stations was around 29°C. The high temperature obtained is likely due to measurements taken during the day which can raise the surface temperature. However, it is still within the optimum range as Pong-masak & Sarira (2015), the optimal water temperature for seaweed growth is between 26 – 30°C. Meanwhile, BSN (2010) states the optimal standard temperature is 26 – 32°C. The temperature affects the physiological processes of the seaweed, such as photosynthesis, respiration, and metabolism which may affect the growth (Erwansyah *et al.*, 2021).

The measured salinity content was 29.20 – 29.67 g.L^{-1}. According to BSN (2010), the salinity for seaweed growth is around 28 – 34 g.L^{-1}. The difference in salinity is caused by several factors, such as water circulation, river flow, vaporazations and rainfalls (Akib *et al.*, 2015). Salinity is related to the cell wall's osmoregulation progress. The difference in concentration inside and outside the cell can affect isotonic equilibrium in algae. It needs more energy so that it can have an impact on inhibiting the growth and development of *K. alvarezii* algae (Abdullah *et al.,* 2020; Aris *et al.,* 2021).

Water brightness is the amount of light in the waters needed for the photosynthesis of algae. ST-1 had the lowest average brightness of 1.27 m, while ST-3 had the highest average brightness of 3.05 m. Mud content, plankton density, and other dissolved materials are all factors that can impact brightness (Pauwah *et al.,* 2020). The ideal water brightness for algae growth is 5 m or if the sunlight can still penetrate to a depth of 10 m (Irfan *et al.*, 2021; Rahmayanti *et al.*, 2018). While Serdiati & Widiastuti (2010) and Aris & Muchdar (2020) provided a wider range of 1.5 m is suitable for seaweed growth.

The depth water level was 3.31 – 4.43 m, the highest was at ST-2 and the lowest was at ST-1. The depth of the water is related to the penetration of sunlight intensity which can cause differences in thallus growth. As the water depth increases, the intensity of sunlight entering the water decreases, thus reducing the rate of the photosynthesis process in plants (Akmal *et al.,* 2017). Good depth conditions for the growth of seaweed range from 2-15 m (Aris & Muchdar. 2020).

The highest current velocity measurement result was at ST-1 which was 0.3 m/s. According to Mudeng *et al.* (2015), the ideal current velocity range is 0.2 – 0.4 m/s. Strong current movements can multiply and facilitate nutrient diffusion to the thallus (Hamzah *et al.,* 2021; Mutalib & Rahman, 2018). Current velocity is a factor that causes the water mass to be homogeneous and allows nutrients to be transported smoothly, it also plays a role in cleaning the algae of attached dirt. Sufficient water movement prevents dirt from accumulating on the thallus, preventing large fluctuations in the salinity and temperature of the water (Pauwah *et al.*, 2020).

The dissolved oxygen content of the three stations is around 7.15 - 6.60 mg.L^{-1} with the highest average at ST-2 and the lowest at ST-1. Based on the statement of Irawan *et al.* (2020), dissolved oxygen with suitability criteria for seaweed cultivation *K. alvarezii* above 4 mg.L^{-1}. ST-2 has higher dissolved oxygen possibly due to higher water current movement than other stations. Dissolved oxygen in the waters is the product of photosynthesis carried out by phytoplankton and aquatic plants living at the water column's bottom. Dissolved oxygen also comes from air diffusion which is the water movement that makes oxygen from the air come into the waters (Erwansyah *et al.*, 2021). Increased water temperature, respiration, an oil layer above the sea surface, and biodegradable organic decomposed into the marine environment are all factors that reduce oxygen levels in seawater (Atmanisa *et al.*, 2020).

The average value of nitrate content obtained was at ST-1 compared to other stations. It thought to be due to the influence of current speed. Algae obtain nutrients from organic matter carried by ocean currents. The more current movement will cause the accumulation of nitrate and phosphate to be carried well. In general, the value is below the optimum range for algae growth. According to BSN (2010), nitrate content >0.04 mg.L^{-1} is the optimal standard for seaweed growth. Pong-masak & Sarira (2015) gave a higher range of 0.95 – 3.5 mg.L^{-1}. If nutrients are available, a high nitrate concentration in the water can stimulate the growth of water organisms. In general, these values are below the optimum range for algae growth.

Phosphate content from the three stations of 0.020 – 0.024 mg.L^{-1} are still within the standard range. A good phosphate in water for *K. alvarezii* productivity are 0.02 – 1 mg.L^{-1} (Lutfiati *et al.*, 2022; Pong-Masak & Sarira, 2015). Meanwhile, Pauwah *et al.*, (2020) provide a lower range which > 0.017 mg.L^{-1} is good enough to support seaweed cultivation activities. Phosphate in waters that can be utilized by seaweed is in the form of orthophosphate, an essential nutrient that seaweed needs for its growth (Erwansyah *et al.*, 2021).

Seaweed growth

The specific growth rate of seaweed at the three stations (Figure 2) shows a relatively smaller growth

rate on the 10th day compared to the next day. This is likely due to the seaweed adapting to new environmental conditions and are in the process of healing wounds due to the cutting when they are made into seeds (Antari *et al.*, 2021). However, day 20th shows that the average specific growth rate at each station has increased. Similar to the research Ardiansyah *et al.* (2022), which reported that the highest specific growth rate happens on the 20th day, then decreases on the 30th and 40th day. The decrease in the growth rate is due to competition in obtaining nutrients and absorption of sunlight for the photosynthesis process, so the thallus weight gain is low as the age of cultivation increases (Mutalib & Rahman, 2018).

ST-1 showed the highest average value in a specific growth rate of 3.05% day^{-1} and an absolute growth rate of 148 g. Good growth if percentage value of the growth rate exceeds 3% day^{-1} (Anggadiretja *et al.*, 2011). Meanwhile, according to Ariyati *et al.* (2016). Seaweed cultivation that grows more than 2% a day is categorized as proper. The specific growth rate in ST-2 is 2.44% day^{-1} and ST-2 is 2.15% day^{-1} still categorized as a proper growth. An optimal growth rate must be supported by a suitable water environment for growth (Hardan *et al.*, 2020; Safia *et al.*, 2020). The statistical analysis result (Table 2) showed no significant effect between station differences on specific growth and absolute growth of *K. alvarezii* seaweed.

The slow growth of the seaweed is suspected to be caused by water quality conditions and productive planting periods during specific months. But in this case, water quality was all in the good range, so another reason to suspect that the quality of the seed was responsible. This challenge is frequently encountered by seaweed farmers. It has been reported that initial seeding could stimulate the growth of seaweed (Irfan *et al.*, 2021). As the researched by Badraeni (2020), the value of water quality parameters showed different growth and carrageenan content by different values based on season and location. The highest growth in *K. alvarezii* brown strains is in the transitional season from rainy to dry season. The results of research conducted by Wenno *et al.* (2014) showed that most daily growth rates decreased with increasing water depth. According to the data, ST-1 exhibited greater growth with a water depth level of 3.31 meters.. Another suspected condition is that this research was conducted during the transition season from the dry season to the rainy season. Badraeni (2020) reported that the growth and quality of seaweed are strongly influenced by water quality. The value of water quality changes following seasonal changes and different locations. The highest growth was during the seasonal transition from the rainy season to the dry season. Unsupportive environmental conditions may cause seaweed to become stunted and attacked by diseases (Arisandi *et al.*, 2011). The growth rate is also influenced by maintenance time (Booy *et al.*, 2019).
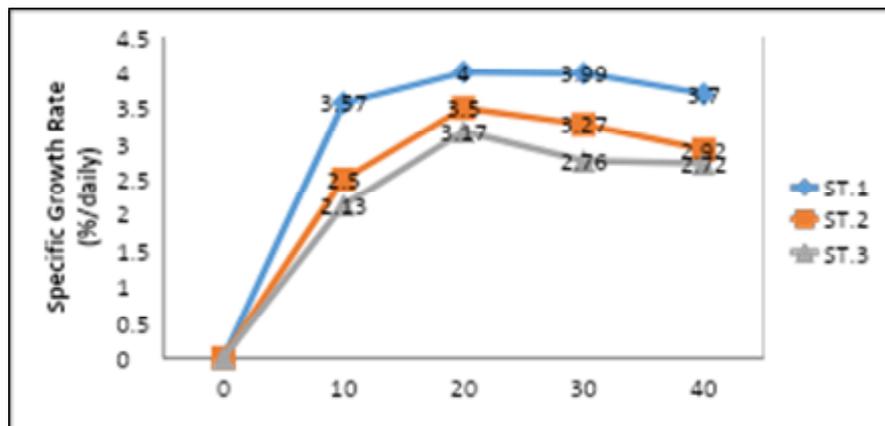

Figure 2. Graphic of the specific growth rate of red seaweed on each station.

Table 2. Specific and absolute growth rate averages of *K. alvarezii* algae

Stations	Specific growth rate (g)	Absolute growth (g)
ST-1	3.05[a]	148.00[a]
ST-2	2.44[a]	116.67[a]
ST-3	2.15[a]	108.67[a]

Station location ST-1 (the north of the river estuary), ST-2 (around the river estuary), ST-3 (the south of the river estuary). Mean followed by the same superscript letters within columns means no significant differences (p>0.05).

Carrageenan quality

The highest yield value was obtained at ST-1; 64.97%. The yield values at stations 2 and 3 are not much different and still meet the quality standards set. The high value of carrageenan is also influenced by the growth rate. Seaweed with a higher growth rate also contained a better carrageenan quality (Hurtado *et al.* (2008); Asikin & Kusumaningrum, 2019).

The yield test was conducted to analyze the percentage of carrageenan produced from the dried seaweed (Bunga *et al.,* 2013). The yield value can indicate the good and bad quality of processing seaweed into carrageenan (Saputra *et al.,* 2021). The quality standard for carrageenan yield set by BSN is 18%, FAO and FCC 25%. All three stations are above the quality standard.

Carrageenan quality and quantity are influenced by cultivation location, planting time, and duration. Carrageenan is a product of photosynthesis, so the quantity and quality is highly dependent on the length of the process and the length of carrageenan accumulation in the thallus cells. Therefore, it is certain that the quantity and quality of carrageenan is influenced by the time of seaweed harvest (Hurtado, Critchley, & Trespoey, 2008; Widyastuti, 2010). In addition, the presence of epiphytes on the seaweed thallus can affect the photosynthesis process, which will inhibit the carrageenan formation process (Mulyaningrum *et al.*, 2019).

The results of the ANOVA test indicated no significant effect among the three stations on carrageenan yield. Likewise, the results of the Kruskal Wallis nonparametric test statistical analysis (Table 3) showed that location differences did not significantly affect the water content and ash content of the carrageenan.

Table 3. The result of the carrageenan quality test

Stations	Yields (%)	Water content (%)	Ash content (%)
ST-1	64.97[a]	14.79[a]	17.56[a]
ST-2	60.91[a]	13.89[a]	20.90[a]
ST-3	60.92[a]	12.80[a]	19.74[a]

The same superscript letters within a column mean no significant differences (p > 0.05).

Water and ash contents are critical indicators of seaweed quality (Oedjoe *et al.,* 2020). Carrageenan quality is determined by its water content, the more water content contained the worse the quality of carrageenan. The water content test results have not yet met the quality standards set by FAO and FCC at a maximum of 12%. According to Saputra *et al.* (2021), the average value of water content in Indonesia still needs to meet the standard of FAO, FCC and ECC.

The highest water content value was at ST-1, which was 14.79% and the lowest was at ST-3, which was 12.80%. The high water content will cause the carrageenan quality to be low. Carrageenan requires a long storage time, so it needs a lower water content (Irawan, 2021). The high water amount is suspected to be influenced by the dry rate of the sample in the beginning. Oedjoe *et al.* (2020) concluded that there is a relationship between transportation time and the quality of carrageenan produced.

The ash content shows the amount of mineral contained in an unroasted carrageenan in the ashing process (Bunga *et al.,* 2013). Quality standard for ash content set by FAO is 15-40% and FCC is 18-40%. The three stations have met the quality standards set. The ash content values obtained were 20.90%; 19.74; 17.56% at each ST-2, ST-3 and ST-1. The low ash content is probably caused by the lack of minerals contained in the cultivating location. In addition, there are several factors that affect the low ash content. namely the solvent used during extraction, the seeds used, and the time of planting the seeds. Oedjoe *et al.* (2020) stated that seedlings planted after 6-24 hours should be extracted using KOH solvent. K^+ compounds that react with carrageenan can produce high ash content. The higher the ash content, the more minerals contained in the algae.

Relationship of water quality parameters to seaweed growth and quality of carrageenan

Table 4 shows that water quality parameters (brightness, depth, nitrate, and phosphate) significantly correlated with specific growth. The pH, temperature, brightness, current velocity, and nitrate significantly correlated with the quality of carrageenan.

The results of water quality measurements at the three stations did not show an extreme difference, but correlation coefficient analysis showed that there was a correlation in several parameters between water quality to the growth and quality of carrageenan. This shows that although the difference in the value of water quality parameters for the three stations is small, it can affect the growth and quality of carrageenan.

Brightness and depth parameters are significant correlate negatively with growth rate. Brightness is measured by the amount of light that comes into the water, which is needed by the seaweed to supply the nutrients and the photosynthesis processes. Photosynthesis results are used as a source of energy for growth, so if the brightness level is low, it will impact the growth rate.

Brightness and depth are interrelated parameters that determine factors in seaweed growth rate. The increasing planting depth will cause lower light penetration and lower oxygen circulation (Booy *et al.*, 2019). Algae can grow in various depths, but generally, growth is better in shallow places because this is related to the high intensity of the sunlight. Even so, the depth should be manageable because it will easily cause the waters to cloud turn muddy (Aris & Muchdar, 2020).

Nitrate and phosphate concentration determine the fertility of the waters that algae need for growth (Erwansyah *et al.*, 2021; Patahiruddin, 2020). Nitrate and phosphate that is contained in the waters take roles in metabolism processes, reproduction, algae quality, and the making of reserved food such as carbohydrate, protein, and fat (Burhanuddin, 2012; Manurung *et al.*, 2021; Pong-masak & Sarira, 2018). If the concentration of nitrate in the water is lacking, it can cause inhibition of growth, metabolism, and reproduction (Fanni *et al.*, 2021). Meanwhile, if there is a lack of phosphate, it will accumulate fat in cells in large quantities (Erwansyah *et al.*, 2021).

PCA analysis results presented in Figure 3 provide an overview of the characteristics of each station. ST-1 is characterized by high growth, yield, and water content with associated water quality parameters of nitrate, phosphate, current velocity, and pH. ST-2 and ST-3 are characterized by high ash content and associated water quality parameters of temperature, dissolved oxygen, salinity, brightness, and depth with high ash content.

Table 4. *Pearson's Simple Linear Correlation* analysis result between the water quality parameter to the growth and quality of carrageenan

|	Absolute Growth	Specific Growth	Yields	Water Content	Ash Content
pH	0.073	-0.100	-0.079	0.545	-0.769*
Temperature	0.198	0.100	-0.075	-0.559	0.688*
Salinity	-0.385	-0.398	0.222	-0.446	0.162
Brightness	-0.608	-0.697*	-0.588	-0.680*	0.352
Depth	-0.619	-0.735*	-0.647	-0.468	0.461
Current velocity	0.336	0.345	0.229	0.468	-0.773*
Dissolved oxygen	-0.459	-0.382	-0.395	-0.033	0.126
Nitrate	0.597	0.693*	0.503	0.739*	-0.410
Phosphate	0.638	0.741*	0.696*	0.582	-0.353

*Correlation is significant (p<0.05)
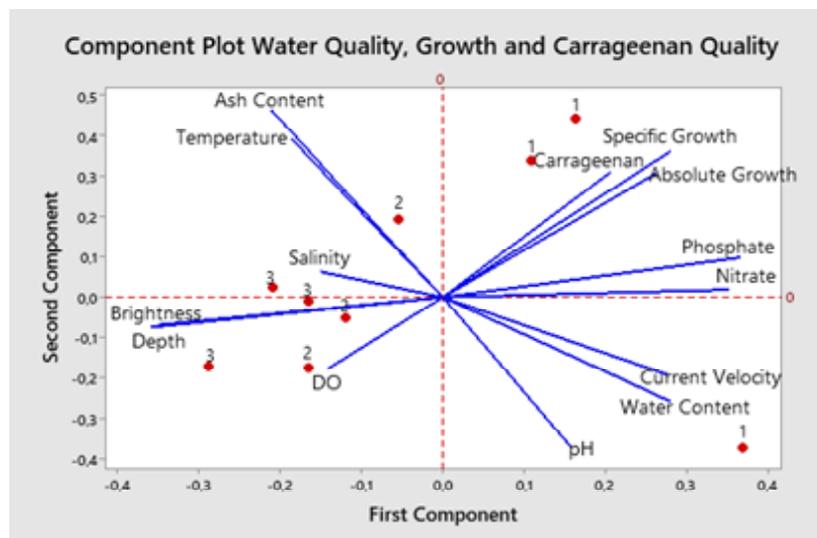
Figure 3. Biplot with *Principal Component Analysis* (PCA) statistic test.

Although there were no significant differences at the three station, the PCA statistic test results showed that the value of growth rate and carrageenan obtained depends on the ability of seaweed to absorb nutrients properly, in this case, nitrate and phosphate. Current velocity movement will cause the accumulation of nitrate and phosphate to be carried well, but the current velocity needed is also adjusted to the life requirements of cultivated algae. Irawan *et al.* (2020) explained that the lack of current movement at the research site lowered the water phosphate concentration. Current velocity and water mixing can transport phosphate from the bottom to the surface, thereby increasing its concentration in the water column.

Phosphate concentration is the primary environmental variable that controls the carrageenan value of *K. alvarezii* compared to other variables (Parenrengi *et al.*, 2020). In addition to increasing carrageenan production, phosphate is also necessary for respiration and growth. The seaweed uses phosphate as a constituent of the thallus structure and transfers energy during photosynthesis (Hamzah *et al.,* 2021).

Temperature, pH, and current are significantly correlated to ash content. Temperature, pH, and current are significantly correlated to ash content. Sufficient water movement will prevent large fluctuations in water temperature. High pH indicates a high photosynthesis process, resulting in decreased CO_2 and producing organic carbon so that the waters become alkaline. pH can bind alkaline compounds so that it can affect the ash content produced (Wulandari *et al.,* 2019).

CONCLUSION

Differences in water quality showed diverse responses to the growth and quality of carrageenan. Correlation coefficient analysis of water quality parameters significantly affected growth were brightness, depth, nitrate, and phosphate. Phosphate affected the yield of carrageenan. Brightness and nitrate affect the water content. Temperature, pH, and current affect ash content.

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