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# Determination of Cultivation Method Based on the Quality of Seaweed *(Kappaphycus alvarezii)* in Sumenep District

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***Abstract***

The planting method greatly affects the growth and carrageenan content of *Kappaphycus alvarezii* seaweed. In addition, the planting method will also affect the physico-chemical conditions of the waters which are closely related to the growth of *K. alvarezii*. This study aims to determine the appropriate method of seaweed cultivation so that it can be used as a reference for *K. alvarezii* farmers to pay more attention to appropriate and appropriate cultivation methods in cultivating *K. alvarezii* so as to improve the quality of seaweed. This study begins with observations at the sampling location, taking water samples and samples of *K. alvarezii* seaweed. The research data was processed using SPSS (Statistical Product and Service Solution) version 16.0 software with analysis of variance (One Way ANOVA) to obtain parameters that affect the quality of seaweed so that the appropriate planting method can be determined. The results obtained from this study, the appropriate method for planting *K. alvarezii* in Palasa using a floating raft, in Lobuk and Padike using the bottom method, while in Tonduk using the long line method.



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## INTRODUCTION

*Kappaphycus alvarezii* is a seaweed with high carrageenan content that can be used as a source of raw materials for the food industry, namely thickeners, gelling agents, and food stabilizers (Mustapha, 2011; Van de Velde, 2002; Campo, 2009; Neish, 2003; Hurtado, 2008).

Therefore, in Indonesian waters, K. alvarezii is one of the favorite seaweeds that are widely cultivated (KKP, 2010; Wulandari, 2016; Sahabuddin, 2008). However, the production of *K. alvarezii* in Indonesian waters is still fluctuating, this occurs due to seasonal changes, susceptibility to disease, pests, and infections (Hurtado, 2000; Wilson, 2013) resulting in a decrease in carrageenan quality and even causing crop failure (Tokan, 2009). ; Mendoza, 2002).

In Madura, Sumenep Regency, especially in Lobuk, Padike, Palasa and Tonduk villages, the waters are widely used as *K. alvarezii* cultivation areas. The type of K. alvarezii cultivated in the village is *K. alvarezii* green. Cultivation of K. alvarezii in these four locations is a source of income for the local community, planting of *K. alvarezii* in Lobuk, Padike, Palasa and Tonduk villages does not recognize the season, so it is carried out every month and the quality produced is different. The quality of seaweed in Lobuk and Palasa villages is relatively low, while the quality of seaweed produced in Padike and Tonduk villages is somewhat better (KKP, 2010).

The quality of seaweed itself depends on several factors, one of which is the physico-chemical parameters of the waters (Harun, 2013). Water physico-chemical parameters greatly affect the growth and carrageenan content of seaweed (Ohno, 1993; Hayashi, 2007; Hung, 2008; Wijayanto, 2011). Water physico-chemical parameters that are closely related to *K. alvarezii* include temperature, current, pH, salinity, Disolved Oxygen (DO), nitrate and phosphate (Effendi, 2003; Rani, 2012; Fikri, 2015; Syamsuddin, 2014).

Studies on the determination of cultivation methods based on the quality of *K. alvarezii* seaweed have not been widely reported, so in this study an exploration of the cultivation methods based on the quality of *K. alvarezii* seaweed was carried out in the villages of Lobuk, Padike, Palasa and Tonduk. The information obtained in the study can be used as a reference for *K. alvarezii* farmers to pay more attention to planting methods in cultivating *K. alvarezii* so as to improve the quality of *K. alvarezii* seaweed.

## METHODS

### Time and Research Site

This research was conducted in January-June 2022. Field data collection activities, water samples and *Kappaphycus alvarezii* samples were carried out in Lobuk Village, Padike, Palasa and Tonduk, Sumenep, Madura in the range of 10.00-14.00 WIB. Measurement of dry biomass, extraction and measurement of seaweed carrageenan levels were carried out at the Basic Science Laboratory of the Islamic University of Lamongan. The analysis of phosphate and nitrate content was tested at the Laboratory of Research and Industrial Standardization Center (Baristand), Surabaya. The location map in this study can be seen in Figure 1.

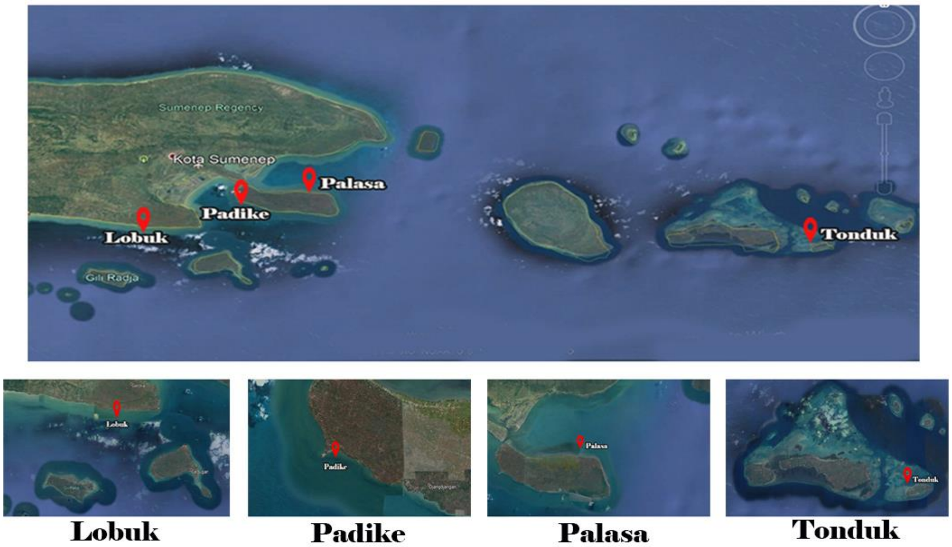



**Figure 1.** Map of research locations in Lobuk Village, Padike, Palasa and Tonduk, Sumenep

### Determination of Sampling Station

Sampling of seaweed in Lobuk, Padike, Palasa and Pulau Raas villages was carried out at K. alvarezii cultivation sites. The sampling station in Lobuk Village was carried out at coordinates 7$^{o}$08´09´´S 113$^{o}$49´34´´E, Padike Village at coordinates 7$^{o}$05´18´´S 113$^{o}$56´37´´E, Palasa Village at coordinates 7$^{o}$04´18´ S 114$^{o}$01´49´´E, while in Tonduk Village it is carried out at coordinates 7$^{o}$09´25´´S 114$^{o}$40´28´´E.

### Water Sampling and *K. alvarezii* Sampling

Water samples at *K. alvarezii* cultivation sites were taken using aseptic methods (Largo, 1995) in the sea waters of Lobuk Village and Raas Island. Water sampling was carried out at the depth of *K. alvarezii* cultivation at the cultivation site using glass bottles that had been sterilized using 70% alcohol then immediately closed with a lid, then water samples in glass bottles were stored in a coolbox. The water samples obtained were then taken to the laboratory for analysis of the phosphate and nitrate content. Sampling of *K. alvarezii* was carried out by taking *K. alvarezii* at the beginning of planting (15th day), mid-planting (30th day) and soon to be harvested (45th day) ± 1,000 grams then put in a ziplock and stored in the coolbox. Samples of *K. alvarezii* were then taken to the laboratory to be analyzed for carrageenan and biomass content.

**Taking Data of Character of Oceanographic Physics and Chemistry**

The waters' Oceanographic physics-chemical character measured was temperature using thermometer, acidity (pH) using a pH meter, salinity using a handsalino refactometer, current velocity using cork (styrofoam) associated with a 1-meter thread, then the cork was released in seawater waters. The time taken by the cork to reach a distance of 1 meter was determined using a timer. Furthermore, The speed of the current was recorded in units of cm/second (Pinet, 2000). Whereas dissolved oxygen (DO) was measured using a DO meter.

***K. alvarezii* Dry Biomass Analysis**

Measurement of dry biomass was carried out because there was a relationship between carrageenan content and dry biomass of *K. alvarezii* seaweed. The dry biomass of *K. alvarezii* is the ratio between the yield (wet seaweed) and dry seaweed expressed as a percent. The drying process was carried out using a laboratory scale oven, the drying process was carried out at 60 °C for ± 15 hours. Measurement of changes in sample mass is carried out every 1 hour and is stopped after the sample mass reaches a constant weight (Fithriani *et al.*, 2016). The dry biomass of *K. alvarezii* can be calculated using the equation:

$$Dry\ biomass = \frac{Weight\ of\ dry\ seaweed}{Weight\ of\ we\ seaweed}\ x100\%$$

***K. alvarezii* Sample Extraction and Carrageenan Content Analysis**

The seaweed samples were weighed, then washed thoroughly from salt and dirt, then cut into pieces. *K. alvarezii* carrageenan extraction was carried out according to the SNI 03-70 (1990) method. A total of 5 g of seaweed that has been washed and cut into small pieces, then added ± 100 ml of distilled water until all submerged, then allowed to stand for 24 hours. After that, rinse thoroughly in running water. The seaweed was then put into a beaker containing distilled water and added 1% NaOH solution, then heated over a water heater at a temperature of 70–90ºC for 3 hours, until the seaweed was crushed and became a gel. The gel is then filtered in a hot state with gauze. The filter results were collected in a plastic container, then transferred to a cup of known weight in an oven at 60ºC for 24 hours. After cooling the cup is weighed. To determine the level of carrageenan used the formula Munoz, *et al.*, (2004), namely:

$$Carrageenan\ level\ (Cl) = \frac{Wc}{Wm}\ x100\%$$

Information: Cl = Carrageenan level (%)
Wc = carrageenan extract weight (g)
Wm = Weight of dry seaweed (g)

## RESULTS AND DISCUSSION

## Oceanographic Character Sampling Location

The physico-chemical oceanographic character of the waters is a requirement for seaweed growth (Gaol & Sadhotomo, 2007; Arifin, 2014). Therefore, complete and accurate information about the oceanographic character of a waters is needed for this research. Oceanographic character data at the sampling location can be seen in table 1.

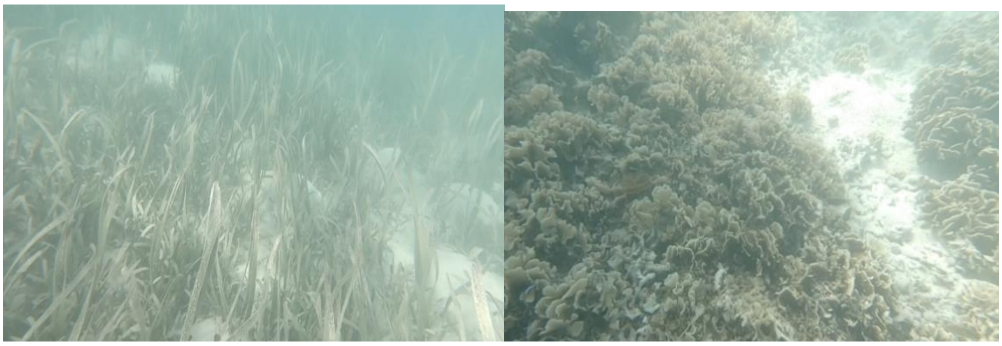
**Table 1** Table of Oceanographic Characters at Sampling Locations

| **Oceanographic Character** | **Location** | | | | |
|---|---|---|---|---|---|
| | **Reference** | **Lobuk** | **Padike** | **Palasa** | **Tonduk** |
| Underwater | coral and sand (Wijaya, 2007) | Muddy Sand | Sand and coral sand | Mud and Seagrasses | Coral reefs |
| pH | 6-9 Optimum 7,5-8,5 | 7,5 | 8,5 | 7,5 | 8,1 |
| Temperature ($^0$C) | 26-33 Optimum 27-32 | 29 | 31 | 30 | 31 |
| Salinity (‰) | 30-38 Optimum 32-34 | 32 | 34 | 32 | 32 |
| DO (mg/L) | 3-8 Optimum 6,5-8 | 2,74 | 8,2 | 2,81 | 8 |
| Current (cm/s) | 10-30 Optimum 15-25 | 25 | 22,5 | 18 | 25 |
| Phosphate (mg/L) | 0,021-0,100 Optimum 0,050-0,075 | 0,25 | 0,068 | 0,18 | 0,074 |
| Nitrate (mg/L) | 1,00-3,2 Optimun 1,5-2,5 | 1,60 | 1,86 | 3,36 | 2,24 |

Reference Source: BSNI and SNI KKP No. SNI 01-6492-2010

Based on Table 1, the waters of Padike and Tonduk have a suitable bottom substrate compared to those in Lobuk and Palasa. In the cultivation of K. alavarezii the substrate plays a role in maintaining sediment stability which includes protection from water currents and a place to get nutrients (Dahuri, 2003; Edward, 2003; Bengen, 2001). in waters will affect the density and growth of *K. alavarezii* (Ain *et al.*, 2014). So that the substrate is one of the important components that play a role in the growth of seaweed (Indrawati *et al.*, 2009).

a. Lobuk (muddy sand) b. Padike (Slightly coral sand)



c. Palasa (Seagrass-Sand Mud) d. Tonduk (Coral)

**Figure 2. Waterbed Substrate at Sampling Location**

In addition, based on Table 1, it can be seen that the waters of Padike and Tonduk have physico-chemical oceanographic characters suitable for the growth of *K. alvarezii*. In Lobuk and Palasa waters, dissolved oxygen (DO) was below the specified standard of 2.74 and 2.81 mg/L, phosphate was above the standard of 0.18 and 0.25 mg/L and at Palasa waters have a fairly high nitrate of 3.36 mg/L.

Dissolved oxygen (DO) that does not meet the standards required for the growth of *K. alvarezii* in Lobuk and Palasa waters can be caused by high current velocities. The Directorate General of Aquaculture (2008) states that substrates that are not suitable for high current movement can affect aeration, nutrient transportation, and water agitation so that it affects turbidity and reduces DO value. In addition, the low DO in these waters is thought to be due to the entry of organic materials into the waters. The more organic wastes there are in the water, the less oxygen content is dissolved in it. According to Klein in Andriani (1999) that dissolved oxygen levels in a waters will decrease due to the process of decomposition of organic matter, respiration, and reaeration are hampered.

The high levels of phosphate in the waters of Lobuk and Palasa are caused by the presence of organic matter in the form of domestic waste (detergent), agricultural waste or the erosion of phosphorus rock by the flow of water (Effendi, 2003; Supriharyono, 2007; Brotowidjoyo *et al.*, 1995; and Hutabarat, 2008). In addition, as in Figure 3, the sociological character of the community such as densely populated settlements allows the entry of domestic waste because many residents throw garbage into the waters coupled with economic activities, transportation routes and the presence of fish factory waste disposal channels near the *K. alvarezii* cultivation area. (Karliana, 2009).

**Figure 3.** Densely Populated Residential Areas in Lobuk Waters

**Correlation of Oceanographic Characters to Seaweed Quality**

The oceanographic character of the waters is a special feature of a waters, where the character will support the quality of the seaweed produced (Gaol & Sadhotomo, 2007). Oceanographic characters can affect several physiological functions of seaweed such as photosynthesis, respiration, metabolism, growth and reproduction (Dawes, 1998). The quality of seaweed produced in different groups of oceanographic characters can be seen in Table 2.

Based on Table 2, there is no difference in overall dry biomass at the four sampling locations, but the four sampling locations have differences in carrageenan levels that are quite clearly visible. When viewed per sampling location, it can be said that dry biomass and carrageenan content of Lobuk waters have decreased, biomass and carrageenan content of Padike waters have increased, dry biomass and carrageenan content of Tonduk waters produced are stable, while the ratio of dry biomass and carrageenan content of Palasa waters in winter Planting I and II were not visible because during the second planting season there was a high current that caused all *K. alvarezii* seedlings to be swept away by the current. When compared with the minimum standard of carrageenan content set by the Ministry of Trade (1989) in Wenno (2009) of 68.3%, the carrageenan content of *K. alvarezii* in Padike and Tonduk waters meets the specified standard.

**Tabel 2.** Tabel Kualitas rumput laut *K. alvarezii* pada Lokasi Sampling

| **Dry biomass (%) *K. alvarezii* in sampling location** | | | | |
|---|---|---|---|---|
| Days | Lobuk | Padike | Palasa | Tonduk |
| 0 | 12,86 | 11,97 | 11,92 | 12,73 |
| 15 | 13,05 | 12,68 | 12,62 | 13,35 |
| 30 | 14,38 | 14,08 | 13,89 | 14,96 |
| 45 | 16,06 | 15,97 | 15,58 | 17,53 |
| **Carrageenan level (%) *K. alvarezii* in sampling location** | | | | |
| Days | Lobuk | Padike | Palasa | Tonduk |
| 0 | 8,95 | 11,95 | 10,42 | 12,67 |
| 15 | 19,41 | 23,88 | 21,64 | 24,63 |
| 30 | 29,86 | 40,29 | 38,82 | 41,03 |
| 45 | 52,24 | 75,37 | 65,67 | 75,50 |

Information: ND=Not Determined

The correlation analysis of oceanographic characters with the quality of *K. alvarezii* seaweed is shown in Table 3.

**Tabel 3.** Table of Correlation of Oceanographic Characters to the Quality of Seaweed *K. alvarezii*

| Oceanographic characters | Lokasi | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lobuk | | Padike | | Palasa | | Tonduk | |
| | Dry Biomass | Carr level | Dry Biomass | Car level | Dry Biomass | Carr level | Dry Biomass | Carr level |
| **pH** | 0,051 | -0,115 | 0,988 | 0,998 | 0,300 | 0,310 | 0,113 | 0,071 |
| **Temperature** | 0,454 | 0,399 | 0,324 | 0,243 | 0,366 | 0,346 | 0,423 | 0,387 |
| **Salinity** | 0,151 | 0,267 | 0,732 | 0,663 | 0,366 | 0,346 | 0,414 | 0,439 |
| **DO** | -0,856 | -0,776 | 0,526 | 0,508 | -0,687 | -0,708 | 0,425 | 0,424 |
| **Current** | -0,601 | -0,699 | 0,111 | 0,203 | -0,717 | -0,693 | 0,284 | 0,243 |
| **Phosphate** | -0,875 | -0,924 | 0,268 | 0,280 | -0,630 | -0,643 | 0,109 | 0,038 |
| **Nitrate** | -0,822 | -0,732 | 0,495 | 0,449 | -0,891 | -0,879 | 0,403 | 0,424 |

Based on Table 3, current velocity, phosphate and nitrate in Lobuk and Palasa waters are negatively correlated with dry biomass and carrageenan content with a fairly high correlation value (> 0.5), this correlation shows that if current velocity, phosphate and nitrate increases, dry biomass and the resulting carrageenan content will decrease.

The results of the negative correlation of current velocity on the quality of seaweed in the waters of Lobuk and Palasa are in accordance with the results of research by Hung *et al.* (2008) and Orbita & Arnaiz (2014), high current velocity can have an effect on seaweed such as the occurrence of adaptive mechanisms.

Phosphate requirement for optimum growth of *K. alvarezii* is also very influential on seaweed growth (Wulandari, 2020; Andarian, 1992 in Patadjai, 2007; Erari *et al.*, 2012), Ask and Asanza (2001) explained that phosphate levels were too high. high or less than the optimum limit for growth will cause a decrease in biomass. Phosphate and nitrate are the main nutrients for plant and algae growth so that their presence affects seaweed production (Hayashi *et al.*, 2010), but if phosphate and nitrate levels in the waters are high, they will become limiting factors and affect seaweed production (Silalahi *et al.*, 2017).

Correlation analysis based on Table 3 shows that pH and salinity are positively correlated to dry biomass and carrageenan content in Padike waters with a high correlation value (> 0.7), this correlation indicates if pH and salinity in Padike waters increase it will also be followed by an increase in biomass. dryness and carrageenan content of *K. alvarezii.*

According to Prajapati (2007), the acidity (pH) of waters contributes to carrageenan levels, the correlation between the two is a positive correlation. In addition, Borlongan *et al.* (2016) in his research found that at pH 8, the photosynthetic rate of *K. alvarezii* was higher. If the process of photosynthesis increases, the production of seaweed carrageenan also increases.

Besides pH, salinity in Padike waters is also positively correlated with biomass and carrageenan content. This is in accordance with the research of Naguit *et al*. (2009); Widyastuti (2010); Orbita & Arnaiz (2014) found that seaweed growth and carrageenan content had a positive correlation with salinity. High salinity affects the osmosis process, due to high salinity making the cells denser, so that the overall fluid concentration in the explants is lower (Lobban and Harisson, 1994).

While correlation analysis in Tonduk Waters shows that the correlation of physico-chemical oceanographic characters is very low on dry biomass and carrageenan content of *K. alvarezii* (<0.5), this correlation indicates that if the physico-chemical character of oceanography in Tonduk waters increases, dry biomass and Carrageenan levels will also increase. Because the correlation value in Tonduk waters is very low, this causes an increase in biomass and carrageenan levels which are less clearly seen in table 3.

Meanwhile, high nitrate concentrations in Palasa waters are influenced by the sociological character of people who do not use toilets, animal feces, urine and carcasses in the waters, causing anthropogenic pollution (Effendi, 2003; Vinneras, 2006; Seitzinger, 1988). The nitrate concentration in Lobuk waters is low when compared to Padike and Tonduk waters, but the nitrate concentration in Lobuk waters is still at the optimum standard required by *K. alvarezii*. The low nitrate concentration in Lobuk waters is influenced by the entry of nitrate concentrations from river flows, where this river flow carries decaying plant and animal residues, disposal of industrial waste, feces and animal waste that contains a lot of ammonia (Mondoringin, 2013; Dahuri, 2003; Tambaru, 2008). River flows near cultivation sites can affect nitrate concentrations, this is due to the decomposition of organic matter on land transported by river flows and into the sea (Rompas, 2010; Anggadinedja *et al*, 2006). This statement is in accordance with the geographical position of the Lobuk waters (Table 4.1) which is near 2 river mouths, namely Saroka and Muangan.

**Cultivation Method based on Quality of Seaweed *K. alvarezii***

Based on the results of the correlation of physicochemical oceanographic characters on biomass and carrageenan content, an appropriate *K. alvarezii* cultivation method is needed. So that the large seaweed development potential of 5,870 ha in Sumenep Regency can be directed to the appropriate location (Fatmawati and Wahyudi, 2015). The cultivation method is related to the geographical location of the cultivation location, the geographical location of the cultivation location can be seen in Table 4.

**Tabel 4** Geographical Location of Cultivation Location

| Location | Geographic Description | Aerial Map |
|---|---|---|
| **Lobuk** | Cultivation of *K. alvarezii* in Lobuk waters is located at 7°08´09´´S 113°49´34´´E. It is a shallow water protected from strong currents, because the location of seaweed cultivation is opposite two islands, namely: Gili Raja and Gili Genting. There are 2 streams to the right of the cultivation location with a distance of ± 800 m |   |

| | | |
|---|---|---|
| **Padike** | Cultivation of *K. alvarezii* in Tonduk waters is located at 7º05´18´´S 113º56´37´´E. Padike is a shallow water in the form of a bay which is located in Talango District |  |
| **Palasa** | Cultivation of *K. alvarezii* in Palasa waters is located at 7º04´18´´S 114º01´49´´E. Palasa is a shallow water in the strait between Poteran and Madura |  |
| **Tonduk** | Cultivation of *K. alvarezii* in Tonduk waters is located at 7º09´25´´S 114º40´28´´E. is a shallow water located in an atoll area (a collection of coral reefs / corals in a circular or almost circular shape resembling a ring). |  |

Based on Table 4, it can be seen that the cultivation location already has a suitable geographical position. This is based on the 2014 WWF where *K. alavrezii* seaweed cultivation is best carried out in bays, straits, and shallow seas protected from strong waves that can damage the construction of K. alavrezii cultivation so that the water conditions are relatively calm. The four cultivation sites are in shallow waters (< 200 m), the cultivation sites are also located far away (± 500 m) from the coast with the aim of getting less influence from wind and sea waves ( Selamat, 2015; Wantesan, 2012; Trono, 1988).

Even though it has a suitable geographical position, there are other factors that must be met to be used as a seaweed cultivation location, such as a cultivation location far from river flows and the oceanographic character of the cultivation location (Fakhrudin *et al.*, 2002).

Determination of the cultivation method of *K. alvarezii* was obtained from the correlation analysis of physicochemical oceanographic characters on biomass and carrageenan content with the geographical position of the sampling location. So based on the data in Tables 3 and 4 it can be determined the appropriate cultivation method used, namely:

1. in Palasa is to use a floating raft, this is related to the bottom subtract of Palasa waters, namely seagrass-muddy which if using the floating raft method will make it easier for *K. alvarezii* to get sunlight and avoid *K. alvarezii* thallus covered with mud due to speed high currents that can cause ice-ice disease (Wulandari, 2020). Ice-ice disease itself can cause a decrease in carrageenan levels and even cause crop failure. (Tokan, 2009; Mendoza *et al.*, 2002) as is often the case in Palasa.
2. The bottom method is suitable for use in Lobuk and Padike, this is also related to the bottom substrate owned by Lobuk and Padike waters, namely sandy and also salinity. The deeper

the water, the higher the salinity (Oviantari and Parwata, 2007). With the basic method *K. alvarezii* in Lobuk and Padike will get a salinity that is positively correlated to the biomass of *K. alvarezii* as shown in table 3, high salinity affects the osmosis process, due to high salinity it makes the cells denser, so naturally the overall fluid concentration in the explants was lower (Lobban and Harisson, 1994).

3. While the long line method is suitable for use in Tonduk, this is related to the stability of the biomass and carrageenan content of the Tonduk waters. Extensive coral assemblages (atolls) are wave absorbers and strong currents in the cultivation area, but the calm water conditions and slow currents at the cultivation site cause the nutrient circulation needed for *K. alvarezii* to be less than optimum (Ricohermoso *et al.*, 2007; Kankan, 2006; Syamsuddin, 2014).

## CONCLUSION

The conclusions from the research on the correlation of oceanographic characters on the quality of seaweed (Kapaphycus alvarezii) in Sumenep Regency are:

1. Current velocity, DO, phosphate and nitrate were negatively correlated with a fairly high correlation value (> 0.5) on the quality of K. alvarezii seaweed in Lobuk and Palasa waters.
2. pH and salinity were positively correlated with a high correlation value (> 0.7) on the quality of K. alvarezii seaweed in Padike waters.
3. The physico-chemical oceanographic character in the Tonduk waters has a positive correlation with a low correlation value (> 0.5) on the quality of K. alvarezii seaweed.

Meanwhile, from the results of the correlation analysis of physicochemical oceanographic characters on biomass and carrageenan content with the geographical position of the sampling location, the appropriate cultivation method carried out in Palasa is floating rafts, in Lobuk and Padike it is suitable to use the bottom method, while in Tonduk it is suitable to use longlines method.

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