Environmental Factors in *Kappaphycus alvarezii* Seaweed Cultivation (a Review)

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ABSTRACT

Kappaphycus alvarezii is one of the varieties of seaweed that is most frequently cultivated. This is because the production technology for this kind of seaweed is quite inexpensive and easy to use, and because handling this kind of seaweed after harvest is also rather simple. Red algae, also known as Rhodophyta, are multicellular and large-sized algae. The pigment phycoerythrin is what gives the algae their characteristic red hue. The sustainability of the culture business is also influenced by the site and cultivation technique chosen, which in this case can boost seaweed growth and production. The production of K. alvarezii seaweed is highly influenced by elements such as nutrients and the physical characteristics of the waters, such as temperature, salinity, light, and water movement (current). Carrageenan is produced primarily by K. alvarezii, and it finds widespread use in the food, cosmetics, pharmaceutical, microbiological, and medical industries as well as in fertilizers and packaging additives in the paper, textile, photography, shoe polish, pasta, and fish and meat canning industries.

Keyword: *environmental factor, Kappaphycus alvarezii, nutrient, Rhodophyta, seaweed*

1. INTRODUCTION

Seaweed is one of the important commodities in marine fisheries activities (mariculture). One of the most widely cultivated types of seaweed is *Kappaphycus alvarezii*. This is due to the production technology of this type of seaweed is relatively low-cost and simple to implement, in addition, post-harvest handling of this type of seaweed is relatively uncomplicated. *K. alvarezii* is the main source of carrageenan production whose applications are widely used in the food, cosmetic, pharmaceutical, microbiological and medical industries, fertilizers and packaging additives in the paper, textile, photography, shoe polish, pasta and fish/meat canning industries [1], [2], [3]. Another use of *K. alvarezii* seaweed is as a source of kappa carrageenan and has hydrocolloids that are widely used by various industries as gelling and thickening agents [4], [5]. Considering the high market demand for this seaweed, it is necessary to continue the production of cultivated seaweed from sustainable aquaculture development.

2. BIOLOGICAL CHARACTERISTICS OF *Kappaphycus alvarezii*

Seaweed is the name in national trade for benthic marine algae Seaweed or algae are classified as low-grade plants, generally grow attached to certain substrates, do not have actual roots, stems or leaves but only have stems called thallus [6]. The classification of *Kappaphycus alvarezii* according to [6], is as follows:

Phylum : Hallophyta
Class : Rhodophyceae

Order : Gigartinales
Family : Solieriaceae
Genus : Kappaphycus
Species : *Kappaphycus alvarezii*

The morphological characteristics of *K. alvarezii* according to [6] are having a cylindrical thallus, smooth surface, green, yellow, gray or red color. The appearance of the thallus varies from simple to complex. Branching appear in various directions with the main branches coming out close to each other to the basal area (base). The first and second branches grow by forming a thick clump with a special characteristic pointing towards the direction of the sun's rays. Meanwhile, according to [7], the morphology of *K. alvarezii* is an upright, cylindrical thallus with two sides that are not the same width, there are bulges (nodules) and spines (spine), the thallus is cylindrical or flat, branching irregularly (Figure 1).

Figure 1. *Kappaphycus alvarezii* algae
Source: [7]

Furthermore, it is explained that the pigments contained in the seaweed thallus can be used to distinguish various classes. This pigment can also determine the color of the thallus according to the pigments in the classes Chlorophyceae, Phaeophyceae, Rhodophyceae, and Cyanophyceae. The difference in the color of the thalli causes the different characteristics of algae, such as green algae, brown algae, red algae, and blue algae. But in reality, it is sometimes difficult to determine one class based solely on the known color of the thallus because red algae are sometimes yellowish-green, blackish-brown or yellow-brown in color. The state of the color cannot always be used to determine its class. Color changes often occur simply due to changing environmental factors. This event is a modification process, namely changes in shape and phenotype that are not permanent as a result of environmental influences, including climate and oceanography which are relatively large. According to [6] seaweed (algae) is an organism with chlorophyll, the body is a thallus (unicellular or multicellular), has reproductive organs which are generally single cells and there are several algae whose reproductive organs are composed of many cells. Algae are divided into several divisions, including Cyanophyta, Chlorophyta, Bacillariophyta, Pyrrophyta, Phaeophyta and Rhodophyta. One of the divisions that will be discussed is Rhodophyta.

Rhodophyta or commonly called red algae are multicellular algae and have a large size. The color that causes red in the algae is due to the presence of the pigment phycoerythrin. One species of seaweed division Rhodophyta, namely *K. alvarezii*. According to [8], *K. alvarezii* is a type of red seaweed (Rhodophyceae) and changed its name from *K. cottonii* to *K. alvarezii* because the carrageenan produced belongs to the kappa-carrageenan fraction, so this species is taxonomically called *K. alvarezii* [8]. The regional name *cottonii* is generally better known and commonly used in the world of national and international trade.

The main habitat of *K. alvarezii* is coral reef flats, and requires sunlight for photosynthesis. Therefore, generally this species grows well in areas that are always submerged in water and attached to the basic substrate in the form of dead coral, live coral and mollusk shells. In nature this type of seaweed usually gathers in one community where this community seems to be very important, especially in terms of dispersal of *K. alvarezii* spores which prefer small daily temperature variations. *K. alvarezii* grows in shallow coral reef flats to a depth of 6 meters, attached to coral rocks, shells and other hard objects. [9] further explained that the most common substrate for seaweed to live in is lime or other forms of calcium carbonate because this material has a high fertility rate, is easily

eroded and is brightly colored so that sunlight is reflected. Furthermore, [10] also suggested that the best type of substrate for seaweed growth is a mixture of coral sand and coral fragments because waters with such a substrate are usually traversed by currents suitable for seaweed growth. Factors that greatly influence the growth of this species are sufficient currents and stable salinity (salt content), which ranges from 28 - 34 per mile. Therefore, this type of *K. alvarezii* will live well if it is far from the river mouth. This species has been cultivated by being tied to a rope so that it does not need to be attached to coral substrates or other objects [11].

Seaweed reproduction is generally carried out in three ways, namely generative (sexual) with gametes, vegetative (asexual) with spores, and fragmentation (through cutting). Vegetative reproduction is by utilizing the nature of vegetative reproduction. Seedlings will be selected from the tip of the plant because this section consists of young cells and tissues that will provide normal growth. Reproduction by fragmentation occurs in unicellular algae, namely by cell division, while in multicellular algae, the thallus will be broken into smaller parts and then each part will grow into a new individual as in *K. alvarezii* and *Gracilaria* sp.

3. ENVIRONMENTAL FACTORS IN SEAWEED CULTIVATION PRODUCTION

Cultivation business carried out by considering the factors needed by seaweed will give good results, and its success is influenced by several environmental factors, both physically, chemically and biologically. Besides that, the selection of the location and the method to be used also determines the success of the cultivation business in this case it can increase the growth and production of seaweed. According to [10], among all factors, environmental factors are very influential in the process of seaweed reproduction. The environmental factors in question are nutrients and water environmental conditions, including: temperature, salinity, light, water movement (current).

3.1 Aquatic Nutrient

Seaweed production is largely determined by water nutrients. Changes in water production is a determining factor of seaweed production and quality. Nutrients that play a role in growth consist of two parts, namely macro-nutrients that are needed in large quantities and micro-nutrients that are needed in small amounts. Nitrogen (N) is a macro element that is useful for stimulating the growth of a plant so that it can grow rapidly. N deficiency will inhibit the growth of seaweed because it is an element used in the photosynthesis process. According to [12], Nitrogen is one of the main elements that make up organism cells in the formation of protoplasm. The amount of N in the waters is 13 cm^3/liter of seawater. Nitrogen is needed as an energy source in the process of photosynthesis. Among the macronutrient elements, nitrogen and phosphorus are limiting factors for the growth and development of seaweed, especially in the process of photosynthesis [13]. Further explained, elemental nitrogen can be absorbed in the form of nitrate and phosphorus is absorbed in the form of phosphate. The range of phosphate found in the sea is 0.021 – 0.201 ppm and surface sea water contains lower dissolved phosphate than deeper sea waters. The optimum phosphate content in waters for seaweed cultivation should be in the range of more than 0.005 ppm [14] and nitrate concentration of 0.9 – 3.0 ppm, both of which are very suitable criteria for seaweed cultivation. In addition to the two macro nutrients nitrogen and phosphate, potassium is also one of the macro nutrients needed in large quantities by plants. According to [16] potassium is used by plant cells during the process of assimilation of energy produced by the photosynthesis process. Lack of potassium (K) can cause plants to wither, thallus becomes weak and susceptible to disease. In addition, a lack of K elements can result in slow photosynthesis and growth as well as an increase in the respiration process [17].

3.2 Conditions of the aquatic environment

3.2.1 Water Brightness

Coral waters have a high brightness where high brightness allows the photosynthesis process to take place properly. The brightness of seaweed cultivation in general in the rainy and dry seasons ranges from 0.94 – 6.78 m and 1.65 – 7.35 m [18]. The brighter the waters, the less mud particles contained in the water column, thus allowing greater light to enter the waters, and subsequently with a sufficiently large intensity to support the photosynthesis process of seaweed. The increase in the photosynthesis process will cause the metabolic process to take place so as to stimulate the seaweed to absorb more nutrients which will support growth. The brightness of the waters is good for seaweed cultivation is 2.5 – 5 meters and the current speed is 20 – 40 cm/second [15].

3.2.2 Water current

The movement of water or currents plays a role in maintaining the circulation of nutrients that are useful for growth, because the nutrients needed by seaweed can be directly obtained from sea water through water

movement or commonly called currents. Nutrient elements are divided into 2 parts, namely macro nutrients and micro nutrients. Macro nutrients for algae include C, H, O, P, K, S, Ca and Mg while micro nutrients include Mn, Cu, Zn, Fe, and Mo.

3.2.3 Temperature

Seaweed grows and develops well in waters that have a temperature range of 26 - 33^{o}C, while according to [6], a good temperature for seaweed growth is 20-28^{o} C. The results of [18], showed that the temperature in the rainy season and dry season during the study ranged from 28 – 30.60^{o} C and 29, 90 – 31.50^{o} C, a good temperature that can stimulate seaweed growth in the rainy season is 28 – 30.60^{o} C. Furthermore, it is supported by the opinion of [19] which states that the maximum photosynthetic rate for *K. alvarezii* is at a temperature of 30^{o}C while at temperatures above 32^{o}C photosynthetic activity will be inhibited.

3.2.4 Salinity

Salinity is one of the important factors that affect the survival and growth of organisms. Most macroalgae or seaweeds have a low tolerance for changes in salinity. According to [20], high salinity can affect macroalgae photosynthesis, algae will deactivate the photosystem reaction center and inhibit electron transfer. Chlorophyll increased in the algae samples at 30 ppt salinity and reached a maximum at 35 ppt salinity. According to [21], optimum salinity can make seaweed grow optimally, because of the balance of cell membrane functions. Salinity is a chemical factor that affects the physical properties of water, including the osmotic pressure that exists in seaweed and the liquid in the environment. This balance will help the absorption of nutrients as nutrients, for photosynthesis, so that the growth of seaweed will be optimal. [22], the effect of salinity on plants is very complex. Salinity causes ionic stress, osmotic stress and secondary stress. Ionic stress due to high salinity is Na^{+} poisoning. Excessive Na ions on the surface of the thallus can inhibit the absorption of K^{+} from the environment, osmotic stress is caused by an increase in salinity which affects the high osmotic pressure so that it inhibits the absorption of water and elements that takes place through the process of osmosis. Ionic stress and osmotic stress due to high salinity will cause secondary stress, namely damage to cell structures and macromolecules such as lipids.

According to [23], salinity affects physiological and biochemical mechanisms, because the process of changing osmotic pressure is closely related to the role of cell membranes in the nutrient transport process. The effect of high salinity on growth and changes in the structure of algae, among others, is causing smaller stomata size, so that nutrient and water absorption is reduced which ultimately inhibits algae growth at the organ, tissue and cell levels. According to [20] stated that at salinity treatment of 20 ppt and 45 ppt only stolons were regenerated from branches, at salinity of 30-40 ppt had new branches with ramuli growing from stolons.

4. CONCLUSIONS

Based on the search results from various literatures, aquatic environmental factors including nutrients and physical conditions of the waters, such as: temperature, salinity, light, water movement (current), are important factors and greatly affect the productivity of *K. alvarezii* seaweed. These considerations become a strong recommendation for cultivators to carry out cultivation in accordance with water conditions that are in accordance with the needs of *K. alvarezii* seaweed.

5. REFERENCES

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