Seaweed Productivity in Various Cultivation Systems

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ABSTRACT

The karaginophyte (which include Eucheuma spinosium, Eucheuma edule, Eucheuma serra, Eucheuma cottonii, and Eucheuma spp.), agarophytes (which include Gracilaria spp., Gelidium spp., and Gelidiella spp.) and alginophytes (which include Sargassum spp., Laminaria spp, Ascophyllum spp, and Macrocystis spp) species are among the many kinds of seaweed that are commonly cultivated, produced, and marketed in Indonesia. In general, the selection of the seaweed cultivation system is adjusted to the prepared cultivation location such as water conditions, material supplies for cultivation construction and the pros and cons of using this method. The method of cultivating seaweed in the field (field culture) can be done with three kinds of methods based on the position of the plant to the bottom of the water. The appropriate seaweed cultivation system will greatly affect the productivity it produces. In addition to the cultivation system, the productivity of seaweed cultivation is also influenced by climate and geography, such as sunlight, currents, pressure and water quality and salt content, which are in accordance with the biological needs and growth of seaweed.

Keyword: *cultivation method, culture system, growth, productivity, seaweed*

1. INTRODUCTION

With a sea area that can make up up to 75% of its total area and being the largest archipelago in the world, Indonesia is a country with a huge potential for marine resources. Indonesian waters are home to a variety of fish species that are abundant, but they are also habitat to a number of seaweed species that have lots of applications for industries, from food to bioenergy to pharmaceuticals, cosmetics, paper, feed, and fertilizer.

Seaweeds including Gracilaria, Gelidium, Eucheuma, Hypnea, Sargasum, and Tubrinaria can be found in Indonesian waters. The karaginophyte (which include *Eucheuma spinosium, Eucheuma edule, Eucheuma serra, Eucheuma cottonii,* and *Eucheuma* spp.), agarophytes (which include *Gracilaria* spp., *Gelidium* spp., and *Gelidiella* spp.) and alginophytes (which include *Sargassum* spp., *Laminaria* spp, *Ascophyllum* spp, and *Macrocystis* spp) species are among the many kinds of seaweed that are commonly cultivated, produced, and marketed in Indonesia which provide as sources of cranium (seaweed flour), gelatin and serve as raw materials for numerous industries as well

Seaweed's suitability for usage as a raw material for the food industry, taste modifier, avoiding ice cream crystallization, and medicine is defined by its high quantity of carrageenan, agar, and alginate. According to the biological requirements and growth of seaweed, as well as the cultivation system that is employed in a good and correct manner, the climate and geographical characteristics of Indonesia (sunlight, currents, pressure, and water quality and salt content) also have an impact on the good quality of seaweed. This paper will review several seaweed cultivation methods.

2. VARIOUS SEAWEED CULTIVATION SYSTEMS

Seaweed cultivation has several methods or systems. In general, the selection of the system is adjusted to the prepared cultivation location such as water conditions, material supplies for cultivation construction and the pros and cons of using this method. The method of cultivating seaweed in the field (field culture) can be done with three kinds of methods based on the position of the plant to the bottom of the water, namely:

2.1 Off-Bottom Method

This method is applied in locations where the bottom of the water is sandy rocky dead coral, clear water and strong and continuous current movement [1]. The off-bottom method is carried out by tying seaweed seeds to a stretch of nylon rope or net with wooden stakes on the bottom of the water [2].

a. Off-bottom-monoline method

The single-rope method was carried out using a nylon monofilament measuring "80 lb tst" and wooden stakes 1 m long. This method is done by tying seeds measuring between 100-150 g on raffia rope. Then tied or hung on nylon that has been stretched over the bottom of the water with wooden stakes [3].

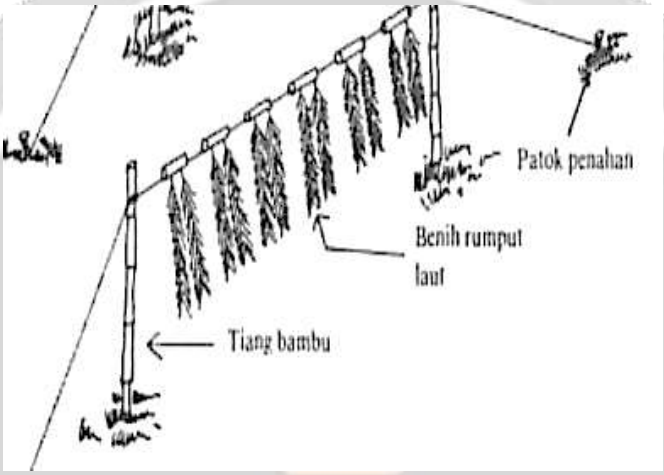

Figure 1. Off-bottom-monoline seaweed cultivation method
Source: [4]

b. Off-bottom-net method

The off-bottom netting method is carried out on a standard 2.5 x 5 m^2 net or net with an eye width of one foot. Then in each net there are 127 knots to tie plants or seeds to be cultured [3].

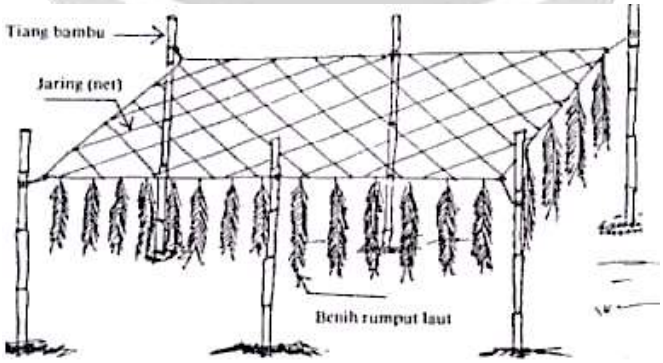

Figure 2. Off-bottom-net seaweed cultivation method
Source: [4]

c. Off-bottom-tubular-net method

The off-bottom tubular net method is carried out by inserting plant seeds into tubular nets or tubular nets with mesh width and tube diameter adjusted to the size of the thallus and the type of seaweed being cultured [3].

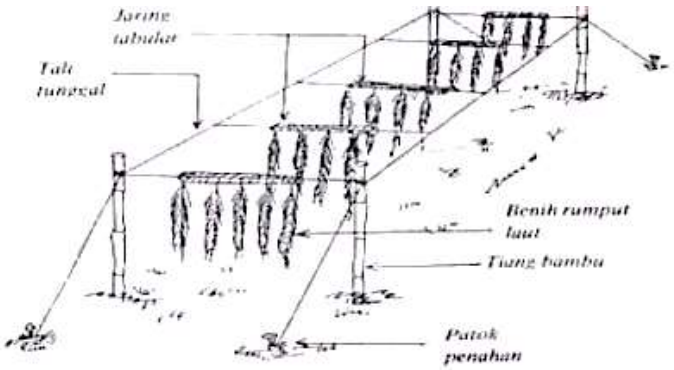

Figure 3. Off-bottom-tubular-net seaweed cultivation method
Source: [4]

2.2 Bottom Method

The bottom method is a method of cultivating seaweed with certain seeds that have been tied and spread to the bottom of the waters or before seeding the seeds are tied with coral rocks [2].

a. Broadcast method

The distribution method or broadcast method is carried out in a way in which plant seeds are scattered in the desired waters. Seaweed seeds that have been collected first are cut into pieces until they weigh 20-25 grams. Then the pieces of seed are spread in waters with a rock bottom [3].

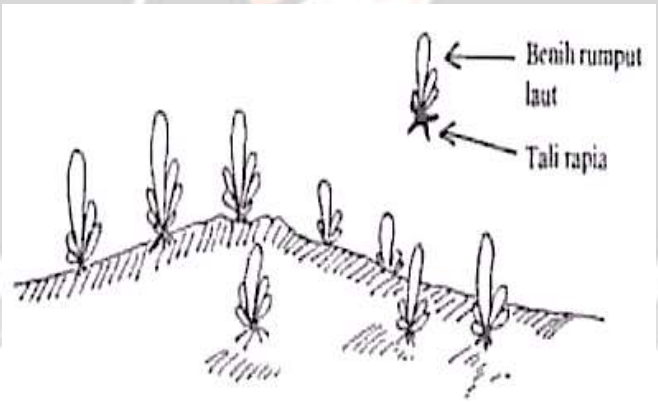

Figure 4. Broadcast seaweed cultivation method
Source: [4]

b. Bottom farm method

The seabed cultivation method or bottom farm method is carried out by tying plant seeds to rocks or cement blocks and then arranging them in rows like a vegetable garden on land [3].

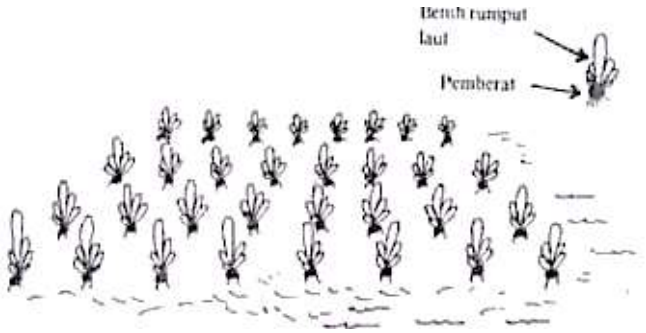

Figure 5. Bottom farm seaweed cultivation method
Source: [4]

2.3 Floating Method

The floating method is an modification form of the off-base method where in this method no longer uses wooden stakes but uses floats [1].

a. Floating-monoline method

The floating single rope method is carried out by tying the seeds on a nylon monofilament rope as in the off-bottom-monoline method. However, in this method a raft is made with a size of about 2.5 x 2.5 m^2. Several rafts are then combined into one module for high unit area production. The number of these rafts depends on the movement of the water. If the influence of water movement cannot reach the raft in the middle of the raft collection, then the seeds on the raft in the middle cannot grow properly [3].

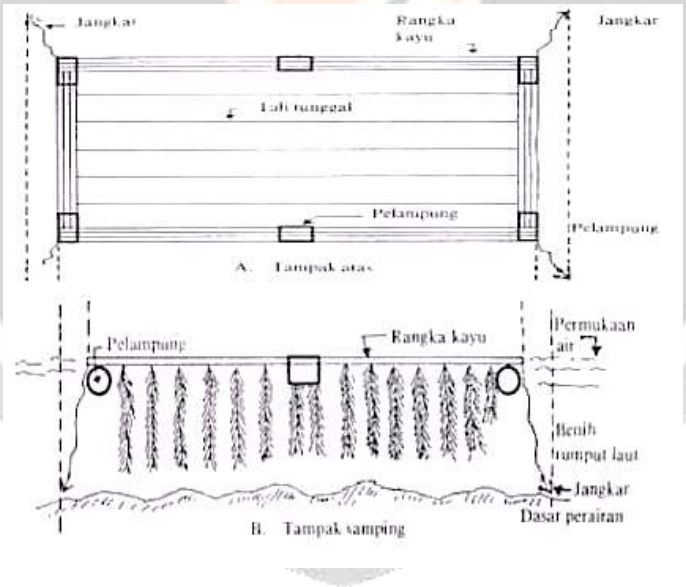

Figure 6. Floating-monoline seaweed cultivation method
Source: [4]

b. Floating-net method

The floating net method is carried out on nets with a standard size of 2.5 x 5 m^2 as in the off-bottom-net method. The buoy used can be a plastic or bamboo buoy. When using a plastic float, the frame of the raft is made entirely of wood. Meanwhile, when using bamboo, the raft frame consists of two pieces of bamboo measuring 5 m and two pieces of wood measuring 2.5 m [3].

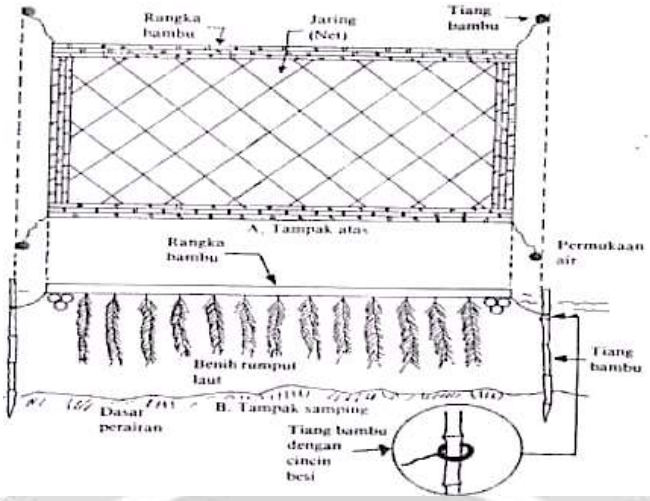

Figure 7. Floating-net seaweed cultivation method
Source: [4]

3. SEAWEED PRODUCTIVITY IN VARIOUS CULTIVATION SYSTEMS

Many studies have been carried out related to seaweed productivity based on the type of cultivation system carried out. Some of them can be seen in Table 1.

Table 1. Studies on seaweed productivity in various cultivation systems

Methods	Treatments	Results	References
Off-bottom method	Four treatments with different planting depths, namely the planting depth of 20 cm from the water surface (Treatment A), 40 cm from the water surface (Treatment B), 60 cm from the water surface (Treatment C) and 0 cm from the water surface (Treatment D).	Treatment with a planting depth of 40 cm from the water surface (Treatment B) was the best treatment for the growth of *Gracilaria gigas* seaweed with an absolute weight growth value of 0.64 g and a daily growth rate of 0.14%/day. While the highest quality agar yield was in the treatment with a planting depth of 20 cm from the water surface (Treatment A) and the lowest was in the treatment with a planting depth of 60 cm from the water surface (Treatment C).	[5]
Off-bottom-net method	Three treatments with different number of net layers, namely one layer of netting (Treatment A), two layers of netting (Treatment B) and three layers of netting (Treatment C).	The results showed that the use of the off-bottom method with net bags in the cultivation of *Kappaphycus alvarezii* had an effect on the specific growth rate. The treatment with the best growth rate value was in the treatment with one layer of netting (Treatment A) which was 4.95±0.70% g/day	[6]
Off-bottom-tubular-net method	The treatments used are bag container factor (K) and depth factor (D).	The use of pouches in the cultivation of *Sargassum* sp. considered less effective in spurring the growth of	[7]

	The bag holder factor (K) consists of no bag (K0), 1.5-inch mesh (K1), 0.75-inch (K2) and 0.25-inch (K3) mesh size. While the depth factor consists of 0 cm (D0), 50 cm depth (D1), 100 cm depth (D2), 150 cm depth (D3) and 200 cm depth (D4).	*Sargassum* sp. because its growth is influenced by light intensity, so in the cultivation of this type of seaweed it is necessary to pay attention to the water depth factor which is correlated with light intensity.	
Broadcast method	Two treatments and three replications with treatment A (tissue culture seeds) and treatment B (local seeds) weighing 10 kg each per container were spread in *hapa*.	The results showed that the cultivation of seaweed *Gracilaria verrucosa* from tissue culture (Treatment A) had a growth rate, agar content and gel strength of 4.97%, 22.19±2.45% and 204.20±0.45 g/cm3 higher than that of local seedling seaweed (Treatment B).	[8]
Floating method	Four treatments with different types of immersion detergent, namely, powder detergent (Treatment A), cream detergent (Treatment B), bar detergent (Treatment C) and control treatment.	The results showed that there was no significant difference between treatment A, treatment B and treatment C. These three treatments had an effect that could slow down the growth rate of seaweed. Of the three treatments, treatment C gave the highest specific growth rate of 7.34%.	[9]
Floating and off-bottom method	The treatments used in this study were the floating method and the off-bottom method with the weight of each seedling of 20 grams per bond.	The results of statistical analysis showed that there was a significant difference in the growth of *Gracilaria* sp. using the floating method and the bottom off method. The growth rate of seaweed for 45 days with the floating method showed better results when compared to the treatment with the off-bottom method, namely 5.9%/day and 5.1%/day.	[10]

4. CONCLUSIONS

Based on the literature study, it can be seen that the appropriate seaweed cultivation system will greatly affect the productivity it produces. In addition to the cultivation system, the productivity of seaweed cultivation is also influenced by climate and geography, such as sunlight, currents, pressure and water quality and salt content, which are in accordance with the biological needs and growth of seaweed.

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