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# METHOD EFFECTIVENESS FOR SEAWEED CULTIVATION IN ARCHIPELAGIC COMMUNITES

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**ABSTRAK**

Tulisan ini ditujukan untuk memberi gambaran mengenai kehidupan masyarakat di daerah kepulauan yang dapat meningkatkan kesejahteraannya melalui kegiatan budidaya rumput laut. Bisnis budidaya rumput laut di Indonesia dimulai sejak tahun 1980-an. Sejak itu hanya satu tipe kegiatan budidaya *in situ* yang dipakai, yaitu metode rawai datar (*long-line*). Metode merupakan bagian terpenting yang mempengaruhi keberhasilan produksi rumput laut hasil budidaya. Hasil penelitian menunjukkan bahwa laju pertumbuhan rumput laut *Kappaphycus alvarezii* dengan berat bibit 50 g lebih efektip daripada berat bibit 75 g dan 100 g. Terlihat bahwa lebih banyak hasil panen yang dapat dihasilkan di perairan-dalam dibandingkan di perairan-dangkal dengan luas lahan yang sama. Namun, masyarakat lebih suka menggunakan bibit dengan berat 100 g karena yakin memperoleh pertumbuhan yang lebih baik dengan produksi biomassa yang lebih tinggi. Temuan ini penting untuk pembudidaya yang ingin menggunakan bibit rumput laut dengan volume yang lebih sedikit, terutama jika mereka terlibat dengan budidaya skala besar yang membutuhkan bibit dalam jumlah yang besar. Beberapa pembudidaya telah biasa menggunakan metode rawai datar dan atau tanpa rakit apung di perairan dangkal. Pemanfaatan perairan-dalam jarang dilakukan sekalipun tersedia dalam jumlah besar dan telah siap untuk dimanfaatkan. Masyarakat sering ragu menggunakan perairan-dalam sebagai akibat kurang trampil dan tidak mudah membelanjakan uang. Untuk mengatasi masalah tersebut, dibutuhkan metode budidaya yang lebih efektif sebagai faktor penting supaya masyarakat mau memanfaatkan lingkungan sekitarnya.

**Kata kunci:** Efektifitas metode, Budidaya rumput laut, *Kappaphycus alvarezii*.

**ABSTRACT**

This paper aims to give examples for the survival of communities in archipelagic region concerning with the explanation of seaweed aquaculture. Commercially cultivation of seaweed in Indonesia began in 1980-iest. Since that period only one type of *in situ* activity is used that is long-line method. Method is essential part which affects seaweed production for the successful of cultivation. The result of one experiment shows that the growth rate of *Kappaphycus alvarezii* based on 50 g seedling is more effective than those on 75 g and 100 g seedlings. It was also shown that more yields were produced in deep seawater than those in shallow one from the same area. However, people are pleased to use 100 g seedling since it is believed to give better growth and higher biomass of production. These finding is important for the cultivar who wants to afford less volume of seaweed seedlings, especially when they are dealing with large scale farm. Some cultivars are used to employ long-line method with or without floating raft in shallow water. The use of deep seawater is rare even though it is vast in existence and is still waiting to be exploited. People are often hesitant to utilize deep seawater as the consequence of lacking skills and uneasy to spend money. In order to overcome this problem, method effectiveness is the most important factor to encourage people to use the nature of the surrounding area.

**Key words:** Method effectiveness, Seaweed aquaculture, *Kappaphycus alvarezii*.

## INTRODUCTION

Since Indonesia is known as the biggest producer cottonii in the world (www.malaya.com), efforts have been made to disseminate seaweed cultivations all the way through this country. Thanks to Philippines, especially when cultivars are dealing with *Kappaphycus alvarezii* (Doty). This is true since country like Indonesia located within $10^o$ latitude ($10^o$ N – $10^o$ S) where it is the best geographically position for eucheumatoid (*Eucheuma* and *Kappaphycus*) growth (Hayashi *et al.*, 2010). Several countries located in this area other than Indonesia such as Philippines, Malaysia, Tanzania, Kampuchea, Vietnam, Brazil, China and

India are in the same situation. These countries collectively offer more than 160 thousand ton dry weight (DW) cottonii for global markets (Hurtado, 2007; FAO, 2006).

The ability of Philippines to achieve successful depends on hard working along the years. It was before 1973 that the majority of seaweed production was dominated by natural collection. Intensive experiments on eucheumatoid have put this country into first leading carrageenan resources (James, 1990). That is why cultivation history has changed since then from natural collection to production by cultivation which caused the increase in seaweed farming (Doty, 1973; Parker, 1974; Doty and Alvarez, 1975). Accordingly, the livelihood of most seaweed farmers becomes even better than before although they run small scale or family scale cultivation activities (Smith and Pestano-Smith, 1980; Smith, 1987). Not only Philippines but also around 20 tropical countries including Indonesia are practicing cottonii cultivation with various methods (Glenn and Dotty, 1981; Russell, 1983; Doty, 1986; Glenn and Doty, 1990).

On the other hand, seaweed production in Indonesia began several decades ago since it comes from natural collection at different places (Winarno, 1990). Aside from Philippines, seaweed production in Indonesia was uncertain before 1980-iest because it depends on environmental changes or good will of local people to collect stuff at the proper season. However, times has changed when people shift from natural collection to cultivation according to the development of technologies and increasing demand. Cultivation technique is a successful key to carry out this activity. A number of countries have adopted the technique since the invention of cottonii farming method by Vicente Alvarez (Neish, 2005). Japan is the first to run the technique for cultivation of eucheumatoid group, followed by application of methods such as on and off bottom system at several farming sites (Beleau *et al*., 1975).

Cultivars from many tropical countries may have a chance to benefit from the Philippines technologies (i.e., seedling preparation, disease prevalence and infestation of epiphytes, utilization of shallow water till deep seawater, growth rate and quality of product, and genetic engineering for obtaining phycocoloid, seaweed extract and new strains) (Dawes *et al*., 1993, 1994; Largo *et al*., 1995, 1999; Hurtado-Ponce, 1995; Hurtado *et al*, 2006; 2008). The progress of these experiments depends on aquaculture technologies since it has interrelatedness to method effectiveness for increasing growth rate as well as biomass production.

Accordingly, the first commercial cultivation of *K. alvarezii* in Indonesia began in Bali since 1986 (Adnan and Porce, 1987). Formerly, it was provided for *Eucheuma denticulatum* (Burman) in 1984. From that time cultivation of seaweed has been carrying out almost in every coastal region. The reason why people want to perform the culture is correlated to increasing demand of carrageenan sources. However, not all places are suitable for seaweed cultivation. People are pleased to do the culture with such conventional long-line technique, with or without the raft in shallow water. The utilization of this area may arouse conflict among people in long run: first, conflicts are related to the quantity of cultivars who want to share the same limited area; and secondly, the arouse of conflict is related to cultivation pressure that may exceed the threshold value of carrying capacity. Some experts believe that the cultivation of single commodity species such as *Kappaphycus* spp in the long period is a type of unsustainable aquaculture that may cause negative impact to the future (Neori *et al*., 2004, 2007; Neish, 2009).

*Kappaphycus alvarezii* is an economic seaweed commodity that needs an enormous area for cultivating activities. This happens in accordance with the increasing demand of carrageenan sources each year. People from different places are interested to do the culture that drives the government to accept the idea of producing 1 million ton DW by the year of 2014 (Nurdjana, 2010). This is also a good challenge from the government to fulfill global demand. The offer is very attractive to drag some regions to establish the fantastic target according to how big the area they have for running cultivation activities. Substitution of shallow water by deep seawater is an important strategy to overcome the scarcity of the area for cultivation. In addition, intensification of shallow water through method effectiveness is an appropriate direction to increase cultivation activity in various seawater profile (Figure 1).

As in Figure 1, all cultivation activities occur in site $A_1$ by using long-line technique. People may also use cultivation technology such as on or off bottom methods. Unlike floating method, cultivars are not accustomed to apply these methods although it is possible to be treated in shallow water. The ultimate constrain comes from grazers that always occurs around farming sites in shallow

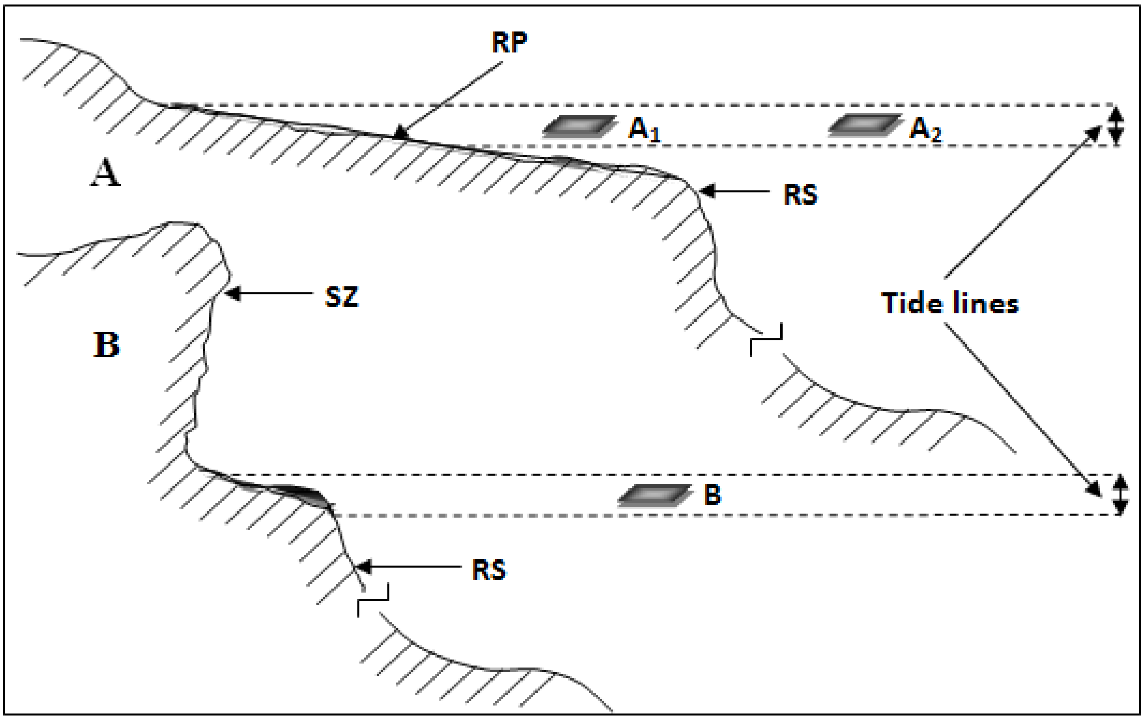


Figure 1. Typical profile of waters: type A, coastal area from shallow to deep ($A_1$ the site in shallow water, $A_2$ the site in deep seawater); type B, coastal area from steep to deep (B, the site in deep seawater; RP, reef platform; RS, reef slope; SZ, spray zone. (Source: Wenno and Soumokil, 2007).

water. Water pollution and the most important problem come from anthropogenic intervention. However, the use of deep seawater is nearly not happened because most cultivars are lacking skills and anxious to spend more money.

As in this case, it is possible to utilize deep seawater to accomplish the government target which requires more public involvement. This is depended on method effectiveness that one may apply to seaweed cultivation in such area. For example, majority of seaweed production in Indonesia during 1980-iest came from Maluku (Winarno, 1990; Anggadireja *et al.*, 2006). This can be achieved by cultivars that come from this province in the future. However, people may apply cultivation techniques on the basis of three standard methods (Dawes, 1980).

## MATERIALS AND METHODS

Some weight kg of *K. alvarezii* (green and brown strains) were transferred from Wael village in Kotania bay West Seram island to Baguala bay in Ambon Island for acclimation purpose. Acclimation was designed to accomplish water depths for three or four weeks before treatment. A cultivation method that fits environmental condition of deep seawater is a hanging long-line technique with a raft. In this system, each raft can accommodate 90 hanging long-lines, descending down from raft to 10 m depth arranged in three rows of 30 lines, each line can accommodate 20 seedlings, generates a total of 1800 seedlings at different initial weights (50, 75 and 100 g seedling). Ideally, a hectare of space can accommodate 400 rafts or a total of 720.000 seedlings. The harvest is done after a month, and material can be used for next cultivation. During this research, nylon line serves as mono line while plastic twine is used to secure plants as so-called 'tie-tie' system. This system is the only one that developed from field and laboratory experiments (Doty and Alvarez, 1975) exhibited in three forms: fixed off-bottom, floating long line and rafts (Trono, 1989). Furthermore, the system primarily pre-dominated because it was simple, farm materials were readily available and inexpensive, and plants grew well (Trono, 1989; Ask, 1999). Comparing to tie-tie system, the use of bags and tube nets is rare, especially on a small scale cultivation. However, these methods can be used in case that water condition is too rough to carry out seaweed cultivation.

Three different weights of seedlings were used in this experiment i.e., 50 g, 75 g, and 100 g. The equal rafts 4 by 5 m dimension were used in this experiment for each stock density. The collection of samples was done every two weeks until the end of the seasonal period. Growth can be measured through fresh and dry weight data to perform that so called Daily Growth Rate, DGR (%) (Dawes *et al.*, 1993) with the formula:

$$\mathbf{DGR\ (\%) = ln\ (W_f / W_o) / t \times 100}$$

Where: $W_f$, fresh weight (g) at day t; $W_o$, initial fresh weight (g); t the number of cultivation days.

## RESULTS AND DISCUSSION

Cultivation of *K. alverezii* in several tropical countries involves many strains (Hayashi *et al.*, 2010). However, Indonesia cultivars use green, brown and red strains. Each strain performs different growth rate and biomass production. Short seasonal periodic is used to produce high biomass, on the contrary long seasonal periodic is used to produce low biomass. Cultivars are usually applying 45 days of cultured period (Hurtado *et al*., 2008). The successful of seaweed cultivation is influenced by the exact method as a combination of basic standard methods (Dawes, 1981) and seedling treatments (Lirasan and Twide, 1993; Goes and Reis, 2010).

Supposed that seedlings were not available in location, they should be brought in from other places at transition period. There is no cultivation period in succession along the year following seasonal changes. Acclimation phase which involves cutting, planting and harvesting of seaweeds in one place should be treated according to hanging long-line method (Ricohermoso and Deveau, 1979). New plants as a result of the acclimation phase are the seedling resources which can be used for next cultivation activities on the given plot. The plot is arranged according to cultivars desire. The cultures can be carried out on 50 $m^2$ plot of fixed bottom method with 10 long lines of 10 m length each between two stakes. The distance between two lines can be certain at 0.5 m. Stock densities are measured according to the initial weights and the distance of lines. One may arrange stock density of 500 g $m^{-2}$ from 50 g seedlings by 10 tie-tie systems. Growth rates can be found out from weekly plant weight of each long line until reaching around 1.5 kg for each plant.

According to Luxton and colleagues (1987), each family or a group of people may handle 0.4 ha seaweed bed for obtaining optimal biomass production. Ten seaweed beds of 40 by 10 m lines may provide accommodation for as many as 11 – 12 weekly cultured cycles. Supposed that good season were available for cultivation, the yield can be dried on 5 by 25 m drying platform to lodge as much as 500 kg DW each week. Cultured activities can be achieved according to the illustration of method and seedlings treatments (Table 1). Furthermore, orientation of cultured method can be executed as vertical or horizontal systems. A vertical orientation involves seawater column, and a horizontal one employs seawater layers. Commonly, the entirely cultured activities are presented in horizontal systems. However, more yields can be produced by vertical system as a result of making use of seawater column instead of the use of horizontal systems (Hurtado-Ponce *et al*., 1996; Hurtado and Agbayani, 2002) (Figure 2).

**a. Cultured Alternatives**

One may utilize cultured location of around 50 m depth for deep seawater cultivation (Figure 1). Substrate is not the case that as physically it gives no direct impacts on growing seaweeds. Topographic profiles of deep seawater are similar, such as shallow along the beach lines till the edge

Table 1. Illustration of cultured methods

| Method of cultivation | Tie-tie technique (TT) | Net-tubular technique (NT) |
|---|---|---|
| **A.** On bottom | A-TT | A-NT |
| **B.** Off bottom | B-TT | B-NT |
| **C.** Floating | C-TT | C-NT |

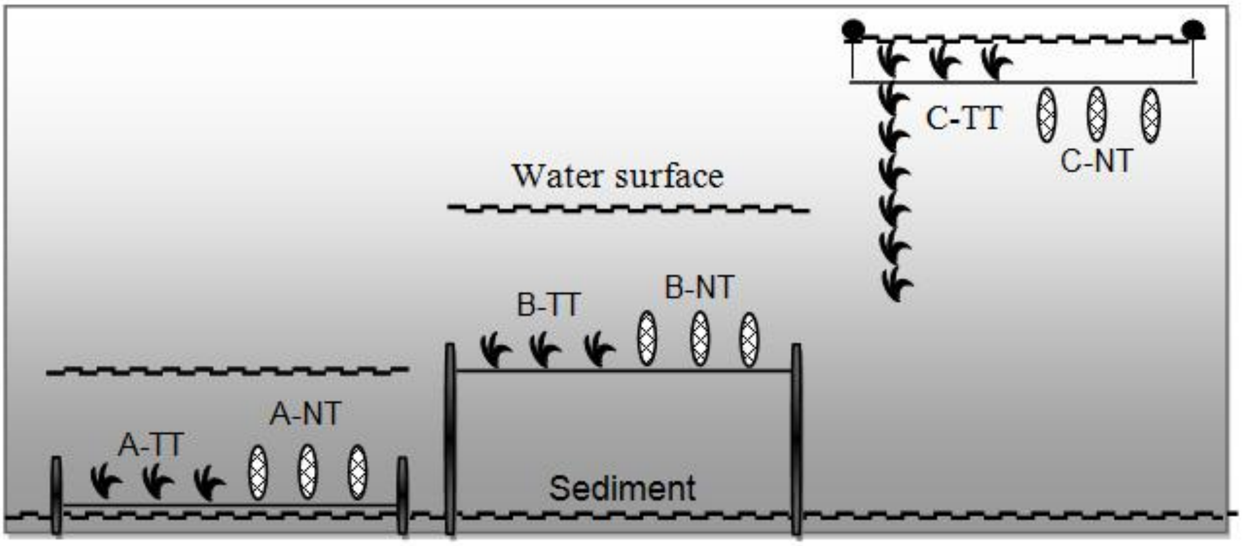


Figure 2. The Illustration scheme of cultured method demonstrates plant without and within net at different seawater depths based on three basic standard of cultivation.

of reef platform, and steepness to the bottom. There are not so much shallow coastal areas for cultivation reason compared to deep areas of seawater.

There are some differences between both profile types as they are illustrated for seaweed cultivation. The cultured activities for type A profile is carried out on shallow water areas ($A_1$). More deep seawater areas situated at $A_2$ and B has almost never been utilized so far although they are huge in existences and dominates the Maluku water. These areas are abundant and can be utilized to accommodate many cultivars, especially where shallow water areas are limited. Growing seaweeds in deep seawater are very attractive as the plant color is more contrast visually. Location around type $A_2$ and B (*off shore*) is clean and clear, relatively unpolluted, and out of grazers and human intervention.

Deep seawater is exaggerated comparing to the shallow water. Foster and colleagues (1997) suggested that rhodolith beds which dominating substrate of California bay have a number of good characteristics for cultivating activities. According to them, wave-bed at shallow water (0-12m) is governed by wave movement, meanwhile current bed at deep seawater (10 >30 m) is controlled by current movement. The second is dominated by biological materials, therefore light and current movement is necessary for nutrients absorption as well as preventing them from attached and submerged within substrates (Marrack, 1999).

**b. Growth and Biomass Production**

Classically, growth is defined as the increase of organism biomass arranging in phases. Growth rates is known through biomass production and seasonal periodic of seaweed during cultivation. Again, the yields or biomass production is known through thalli weights at the end of seasonal periodic. Growth rates are known by the differences between the last and the initial weight during certain period. Experiment was carried out at five meters depth under the seawater surfaces. Analysis of growth was performed at different depth till five meters (A) and different initial weight (B).

Analysis of growth was performed based on initial weight and the distance of tie-tie system that shows stock densities. Rapid growth occurs at lowest initial weight where 50 g is more productive than 75 g and 100 g seedlings. Growth rates at initial weight 50 g, 75 g, and 100 g in successive are 5,13-5,67%; 4,30-4,98%; and 3,50-4,79%. The initial weight 100 g is used to apply for all cultivation activities.

Growth rate at the distance 75 cm is more effective than those at 50 cm, and 25 cm. Growth rates at the distance 75 cm, 50 cm, and 25 cm in successive are 5,15-7,67; 4,71-6,45; and 4,31-5,73%. The more distance between two consecutive tie-tie gives the more chance for plant to grow better by carrying out its photosynthetic processes. This is occurred because plants may tap the light effectively comparing to those at 50 cm, and 25 cm. The less distance which normally used is 25 cm. Plant grows at the water surface is easy to get light for photosynthesis. Therefore, the distance 25 cm between plants at the water surface of the horizontal lines is better than those growing in the water column of the vertical lines.

**c. Environmental Factors**

The results shows that the average of physical and chemical parameters of seawater are: temperature 30.3 $^{o}$C; salinity 30.08 ‰, pH 8.4, transparancy 7.74 m, and water movement 34 cm/second is optimal for plant growth (Poncomulyo *et al*., 2006). Plants may have as much as light effectively for photosynthetic process during the day in together with current movement for absorption of nutrients for the formation of thalli biomass.

It is important to consider sunlight and the existence of grazers as environmental factors which controlled growth and distribution of seaweeds (Rowan, 1989; Fryxell, 1983). Cultivation of seaweeds in deep seawater should be based on both factors. The distance among vertically and horizontally tie-tie systems should be arranged to receive sunlight effectively. Biomass production of seaweeds at the combination of vertical tie-tie 50 cm and horizontal tie-tie 75 cm was bigger than those at the same tie-tie 50 cm and 25 cm systems. This finding suggested that the growth of seaweeds needs to be considered as spatial dependent. On the other hand, the existence of grazers affects seaweed biomass production. Growing thalli that located next to the substrates is very susceptible to the existence of grazers, especially for cultivation in shallow water at small scales. However, this is not the problems for deep seawater cultivation.

**d. Method Effectiveness**

It is important to consider shallow water or deep seawater as different type of physical characteristics. Culturing seaweed in shallow water is necessary as long as space is practically available. Aslan (2006) and Poncomulyo *et al*. (2006) suggested that the condition of still and quiet water is saved from harmful wind and wave except for current movement that necessary for nutrients absorption. Seawater movement is necessary to defend seaweed thalli away from water debris and domestic wastes. On the contrary, turbidity may block photosynthesis process. Negative impact of wave has been noticed during cultivation with floating method, such as thalli detached and released from main colony is often seen, this is not happened in deep seawater cultivation. However, the positive effect of water current is also occurred during thalli growth in deep seawater. It is suggested that people may cultivate seaweed *K. alvarezii* in either shallow or deep seawater effectively as long as they put their attention to the method effectiveness on surrounding environment.

**CONCLUSION**

The utilization of shallow water as well as deep seawater is very important in the future. The successful of seaweed farming in Indonesia is depending on good seasonal periodic when the market is available with good prices. It is also gave hard currency to the Government, opened up self employment opportunities to many archipelagic communities who before do this venture wasted their time to none of any cash income. In terms of reef area suitable for seaweed farming that probably deteriorated the environment, Maluku water is huge enough to run the projects in the coming time.

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