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Model of Ice-Ice Control on Seaweed Farming Through Polyculture System with Introduction of Resistant Cultivar in Hundihuk Village

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ABSTRACT

Seaweed farming has developed in Rote-Ndao Regency since 1999, and in Hundihuk Village seaweed farming is currently a mainstay commodity for coastal communities. The main problem faced in seaweed farming there is the phenomenon of the ice-ice disease that attacks seaweed, especially before the change of seasons. The existence of the disease has an impact on a decrease in production which results in a decrease in the income of farmers. The existence of the ice-ice disease, it is suspected that bio-ecologically and bio-physically conditions of the waters that are farmed are experiencing disturbances due to pollutants and/or decreased water quality, farming methods that are not suitable due to the dependence of the community on monoculture farming, However, the disease can also be caused by the use of low quality seeds. Therefore, a solution is needed to overcome the problem of ice-ice disease. One of them is the ice-ice disease control model through the application of appropriate and effective farming techniques or methods, so as to increase the productivity of the seaweed farming business, the method in question is farming with a polyculture system and the introduction of resistant cultivars. Farming with a polyculture system that utilizes other macroalgae/seaweeds as companion plants is very effective in controlling the ice-ice disease. The total intensity of infection of the ice-ice disease every week is very small, ranging from 0.2 - 2.5 for the polyculture system compared to the monoculture system with a large range of 0.1-17.1%.

Key words : *Seaweed, Ice-ice disease, Polyculture, Resistant cultivars, Hundihuk Village*

Introduction

One of the marine aquaculture commodities which is currently a mainstay commodity in Rote Ndao Regency, East Nusa Tenggara Province, and has market prospects is Seaweed. One of the strategic objectives of developing seaweed farming in Indonesia is to seek quality and highly competitive seaweed products through improving farming technology and processing.

Seaweed farming has developed in Rote Ndao Regency since 1999. The coastal area used for seaweed farming in this district in 2014 reached 1,718 Ha (57.21%) of the potential land area for seaweed farming in Rote Ndao Regency of 3.003 Ha. The volume of seaweed production in Rote Ndao Regency from year to year tends to increase, whereas at the district level in 2020 it is 15.746 dry tons (Rote Ndao dalam Angka 2020). In the last decade, seaweed farming is an economic activity that is in great demand by coastal communities in Rote Ndao Regency

Ice-ice disease in seaweed is a phenomenon of the condition of seaweed experiencing physiological and morphological disorders. The decline in seaweed production due to ice-ice disease has hit seaweed production centers. Seaweed farmers in Rote Ndao generally use seeds from part of their harvest, which is then propagated by fragmentation. This repeated propagation causes genetic decline which results in decreased growth speed, carrageenan yield, and decreased gel strength. besides, a decrease in genetic diversity also causes an increase in susceptibility to disease (Sulistiani *et al.,* 2014).

The results of the study by Bessie *et. al.* (2020), showed that most of the waters used for seaweed farming in Northwest Rote Sub-District (including Hundihuk Village) experienced biological disturbances, namely *ice-ice* disease in seaweed. *Ice-ice* disease, with the characteristics of the main thallus is white, the thallus becomes soft and easily broken/falls off. Several variables were found as triggers for ice-ice disease, including: the use low quality of seeds (the seeds used were cuttings from previous farming and the age of the seedlings was no longer known), the attack of pathogenic bacteria (*Vibrio alginolitycus*, *Aeromonas faecalis*, and *Pseudomonas* sp.), extreme seasonal changes (especially the second transition/west season), primary infection of herbivorous biota, and attachment of epiphytes.

A simple solution by farmers is to cut the white part and clean it. The presence of ice-ice disease is suspected to be bio-ecologically and biophysically part of the waters that become farmed areas experiencing disturbances due to pollutants and/or a decrease in water quality, as well as inappropriate farming methods due to the dependence of the community on monoculture farming. The presence of the ice-ice disease has a negative impact on the decline in seaweed production which results in a decrease in the income of farmers. This disease attacks throughout the year with a peak in March and October.

To overcome the above problems, it is necessary to apply appropriate and effective farming techniques or methods, so as to increase the productivity of seaweed farming. The method in question is farming with a polyculture system and the introduction of resistant cultivars. This method is expected to reduce the invasion of ice-ice disease, especially at the change of seasons.

Materials and Methods

In principle, polyculture cultivation is the farming of seaweed by combining it with other seaweeds. The main consideration of this farming technique is the protection of seaweed from the invasion of microorganisms that cause ice-ice disease by utilizing antimicrobial/antibacterial compounds released by selected macroalgae. Antimicrobial/antibacterial compounds released into the environment will inhibit the growth of microorganisms so that seaweed is expected to grow well.

In this research, several stages were carried out, namely:

- Seaweed screening was carried out at several locations, especially on resistant cultivars, and had been farmed in several water areas (seeds from the selection of the Sakol Sulamu variety, tissue culture seedlings, and *Eucheuma denticulatum* Oeseli seedlings which were known to be disease-resistant).
- The facts in the field showed that seaweed farmers only grow one species of seaweed, namely *Kappaphycus striatum*/local Sakol, therefore in this study, three types of seaweed are needed as companion plants (*Kappaphycus striatum*/Sakol Sulamu from a variety selection, *Kappaphycus alvarezii*/Kotoni from tissue culture, and *Eucheuma denticulatum* Oeseli).
- Design of polyculture farming models for the introduction of new cultivars using the longline method. Placed at four different locations according to the wind directions (West, East, North, and South locations) with Dengka Island as the midpoint. Each location has 5 ris ropes with a length of 10 meters. The distance between the seeds of seaweed is 30 cm with a weight of 100 g/seed. The position of the seaweed ris rope is arranged as follows: the first ris rope for *Kappaphycus striatum*/Sakol Sulamu seedlings, the second ris rope for the main plant seeds (*Kappaphycus striatum*/Sakol Rote), the third ris rope for *Kappaphycus alvarezii*/Kotoni seedlings from tissue culture, the fourth ris rope for plant seeds main plant (*Kappaphycus striatum*/Sakol Rote), and the fifth row of seedlings of *Eucheuma denticulatum*/

Spinosum Oeseli, the same pattern for the other three locations. Harvesting is planned after the seaweed is 45 days old.

From the stages of the research activities above, data were collected and analyzed as follows:

1. The appearance of the seaweed thallus (morphological symptoms of ice-ice disease, the thallus is white and easily broken), the percentage of infected clumps. These data were tabulated and described quantitatively to see the difference between monoculture and polyculture
2. Thallus wet weight was measured weekly. Wet weight data were analyzed to determine the specific growth with the following equation :

$$SGR = [(\ln Wt - \ln Wo) / t] \times 100\%$$

Where:

SGR = Specific Growth Rate (%)

Wt = Final Weight (gram)

W0 = Initial Weight (gram)

t = Time (day)

3. To calculate the intensity of ice-ice disease, the formula according to Tisera (2009) was used as follows:

$$\text{Intensity} = \frac{\text{no of Infected Branches}}{\text{Total number of branches}} \times 100$$

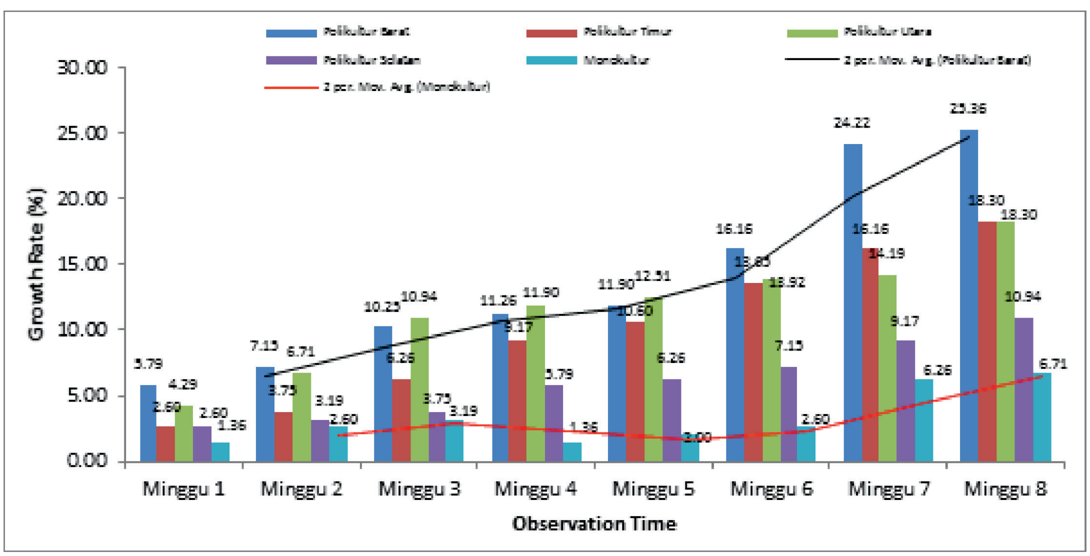
Results and Discussion

Growth of Seaweed

An important aspect studied in seaweed farming is growth. Growth in an individual is defined as a change in length or weight over a certain period of time. In seaweed, growth expression is indicated by the increase in weight or weight over a certain period of time compared to the initial weight. Growth is one indicator of evaluating the quality of the seeds used, especially in polyculture farming models to minimize ice-ice disease attacks on seaweed. The results of the growth analysis were shown in Figure 1.

In Figure 1, it could be seen that the average growth of seaweed in polyculture systems from the first week to the eighth week ranged from 6.11-14.01%, while the growth of monoculture seaweeds averaged was 3.26%. Seaweed growth for the West, East, and North Locations with a good growth model/pattern, where in the first week to the eighth week experienced an average growth increase of 11.89% compared to the South Location of only 6.11%.

Seaweed growth in the Southern Location was not very good, both the main seeds (*Kappaphycus striatum*/local Sakol) and companion seeds (*Kappaphycus striatum*/Sakol Sulamu, *Kappaphycus alvarezii*/Kotoni from tissue culture, and *Eucheuma denticulatum* Oeseli). This condition is thought to be due to adjustment to a new environment that is less supportive of growth in the early weeks (especially *Kappaphycus striatum*/Sakol Sulamu taken from Kupang Regency). The southern location is close to the mangrove ecosystem in the dense category with high water turbidity with a water transparency value of 0.6 meters, and the water conditions are



Gambar 1. Growth of seaweed in Hundihuk Waters

slightly covered by Dengka Island in front of it and mangroves on the left and right of Dengka Island so that the water circulation is not good. The current speed parameter measurement in the South Location was 4 cm/sec.

This was supported by the explanation of *Kadi et. al*. (1998), that in the first week the growth of seaweed is not so normal because it is in the adaptation stage to the environment, and usually takes place in the first to third week. Maximum growth will usually occur above the fourth and fifth weeks.

The growth of seaweed with a polyculture system with the introduction of new cultivars turned out to be better growth compared to monoculture farming, where the results of this study obtained that the average growth of seaweed with a monoculture system was only 3.26% for 8 weeks of observation. There was a decrease in growth in the fourth to eighth week of monoculture farming due to ice-ice disease that attacks the plant thallus.

Based on the results of the analysis above, besides supporting water conditions, it can also be concluded that the quality of seaweed seeds, both main and companion plants, was categorized as good. According to DKP (2004), the growth rate of seaweed weight which is considered quite good is above 5% weight gain per day.

The weight gain of seaweed in the polyculture system during the study showed a graph that is quite normal for plant growth (Figure 1), wherein one of its life cycles found a slow growth phase, a fast-growth phase, and a growth peak.

Ice- Ice Disease and growth of Seaweed

Diseases of a plant including seaweed will only occur if it involves 3 factors, namely pathogens, a weak of the host defense system, and changes in environmental quality. Seaweed with weak resistance will be easily infected by pathogenic microorganisms. On the other hand, seaweed with good resistance will be difficult to be infected by pathogenic microorganisms. The role of the environment in disease infection can be seen from two sides, triggering physical and physiological damage to seaweed. Strong shock waves caused cuts or fractures in the thallus propel infectious pathogens into the thallus.

In particular, observations in four demonstration locations/ plot zones (West, East, North, and South) on the main plant (*Kappaphycus striatum*/Sakol local) with a polyculture system, showed that in the first to third week no ice-ice disease was found, but only found in the fourth week and so on. Disease intensity ranged from 0.2% at the fifth week to a high of 2.5% at the seventh week and tended to decrease in the eighth week. While in monoculture the intensity of infection ranged from 0.1% in the second week and the highest 17.1% in the seventh week. The results of observations for eight weeks are presented in Figure 2.

The intensity of ice-ice disease infection has started in the second week for the monoculture system and only started in the fourth week for the polyculture system, specifically for the West, East, and North locations, it is suspected that in the early

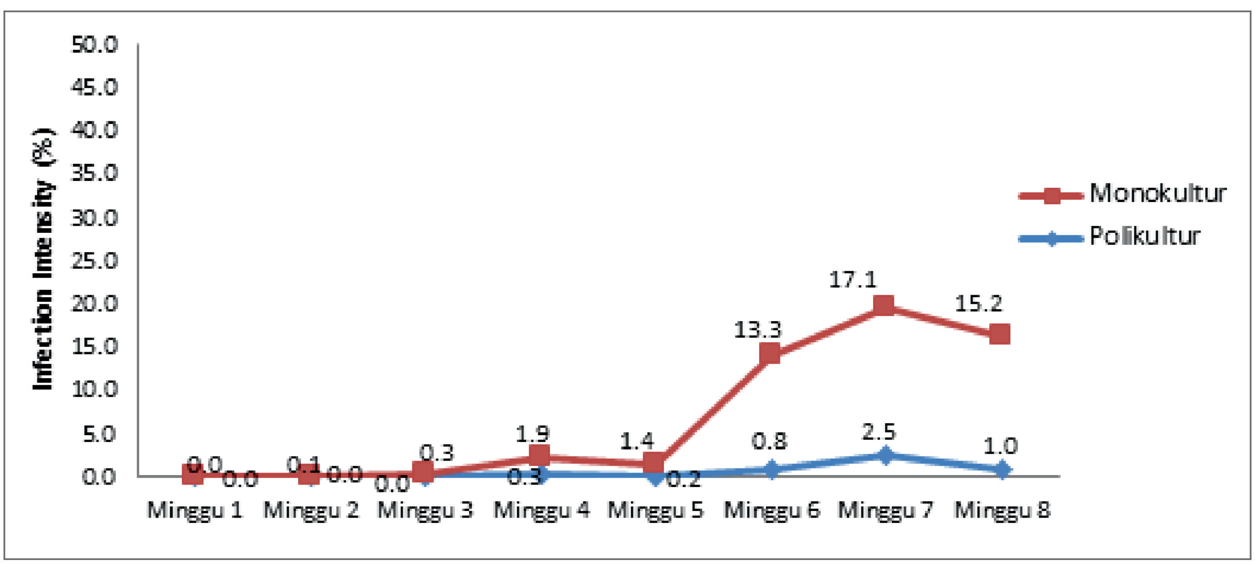


Fig. 2. Infection Intensity of *ice-ice* disease

weeks of the acclimatization process to the new environment it can run well and seaweed still able to defend themselves against disease attack, especially pathogenic bacteria because of the use of good and resistant seeds (the results of tissue culture and variety selection). Seaweed was not experiencing stress, which makes it difficult for pathogenic bacterial infections, because when under stress conditions, seaweed releases organic substances that cause the thallus to become slimy and stimulate bacteria to grow abundantly.

In relation to growth, the measurement results showed that the growth of the main plant (*Kappaphycus striatum*/Sakol local) in the polyculture system infected with the disease was significantly different from the monoculture culture. The growth range for the main *Kappaphycus striatum*/Sakol local plant in the polyculture system with the lowest value of 120 g (first week of East and South Locations) and the highest 590 g in the eighth week of West Location. The growth rate in the polyculture system is faster than in the monoculture system, presumably because the antimicrobial contribution of companion plants suppresses the spread of ice-ice disease so that the growth of the main plant is less disturbed and grows well and normally. While in the monoculture system the lowest growth was 110 g in the first and fourth weeks, and the highest was 160 g in the eighth week. The weight gain was not significant in the second week and tended to decrease from the fourth week to the sixth week, due to the attack of ice-ice disease in those weeks which was very high where the infection intensity averaged 5.5% during that week and reached its peak in seventh by 17.1%.

Model of *Ice-Ice* Disease Control Through Polyculture

Disease in seaweed is a functional disorder or abnormal anatomical changes. These changes will ultimately result in a decrease in seaweed production. The disease that often appears in seaweed is an ice-ice disease, with signs of spots on some of the thallus turning pale and white, then disconnected and marked by slowing seaweed growth (Partosuwiryo and Hermawan, 2008). This disease is mostly caused by extreme water conditions such as low salinity due to frequent rains, water temperatures that are too hot (more than 31 °C) or too cold (less than 26 °C) (Largo *et al.*, 1995 and Largo, 2006).

Indriani *et al.* (1992), explained that plant disease management efforts are divided into 5 groups, namely: (1) controlling plant diseases by regulations, (2) farming disease-resistant cultivars, (3) controlling by farming that can prevent disease. plants from disease or cause plants to be resistant to disease, (4) biological control, and (5) physical and chemical control.

Biological control in phytopathology includes every effort to reduce the intensity of plant disease by using the help of one or more living bodies, other than the host plant itself and humans (Indriani *et. al.*, 1992). Furthermore, it was explained that there are several mechanisms in biological control, namely: antagonism, plant growth-promoting rhizobacteria, inducing resistance (immunization), cross-protection, mixed crops, and post-harvest disease control.

Mixed planting or polyculture is a technique of planting more than 1 type of plant on a certain land area. Polyculture techniques are generally applied on land.

In this study, 3 species of macroalgae/seaweed were used as companion plants, namely *Kappaphycus striatum*/Sakol Sulamu from variety selection, *Kappaphycus alvarezii*/Kotoni from tissue culture, and *Eucheuma denticulatum* Oeseli. The determination of these three species of macroalgae/seaweed was based on the consideration that these three species are available in the cultivation area and are capable of producing anti-microbials and are quite resistant to disease.

The results showed that the farming of seaweed with a polyculture system was able to prevent the invasion of ice-ice disease, while the monoculture farming was relatively susceptible to the invasion of ice-ice disease. As shown in Figure 2, the invasion of ice-ice disease attacks seaweed with a monoculture system compared to the test plants with a polyculture system, and the polyculture test plants were only attacked in the fourth week, with a very small percentage of infection, was 0.3%-2, 5%. These results illustrate that when seaweed is grown with a monoculture approach, it becomes more susceptible to the invasion of pathogenic microorganisms. Local *Kappaphycus striatum*/Sakol also produces antimicrobials to protect itself from the invasion of ice-ice disease. However, the number and species of antimicrobials that are less diverse will not provide full protection against disease. The more macroalgae, the more diverse the anti-microbial and the more the possibility of releasing anti-microbials with high inhibitory power into the surrounding environment.

When seaweed is attacked by pathogenic microorganisms, the seaweed or macroalgae immediately responds by producing anti-microbials as soon as possible to protect themselves. Anti-microbial products will inhibit and or kill microorganisms that have attached themselves to the surface of the thallus, or that have colonized in the thallus. In this study, the binding positions of the companion macroalgae were arranged as follows: the first rope of *Kappaphycus striatum*/Sakol Sulamu seedlings, the second rope of the main plant (*Kappaphycus striatum*/Sakol Rote), the third rope of *Kappaphycus alvarezii*/Kotoni from tissue culture, and the rope of the third row of *Kappaphycus alvarezii*/Kotoni. the four main plant seeds (*Kappaphycus striatum*/Sakol Rote), and the fifth seedling of *Eucheuma denticulatum* Oeseli, the same pattern for the other three locations. This kind of position benefits the seaweed in the middle (*Kappaphycus striatum*/Sakol Rote).

In this study, the spacing between the seaweed clumps and the companion macroalgae clumps and the distance between each rope was the same, was 30 cm. This distance was still ideal to support the growth of seaweed. The distance was closely related to competition for nutrients and sunlight. The results of observations and analysis show that in the West, East, and North locations the growth was faster than in the South locations. The average wet weight gain of polyculture seaweed was relatively higher than the monoculture system. This difference is also due to the presence of grazers, Siganid fish that eat seaweed, especially in monoculture systems.

The prospect of ice-ice disease management with polyculture farming can be economically profitable because the macroalgae/seaweed companion used is also of high economic value. At first glance, it seems that planting with a polyculture system was not profitable because the planting of seaweed was interspersed with other macroalgae/seaweeds, but if it was associated with the frequency of planting, planting with a polyculture system was almost all year round (except for storms). In a monoculture system, when an ice-ice disease occurs, the farmers usually stop planting, in other words, the frequency of planting in a year is smaller. Besides the frequency of planting more on polyculture techniques, the macroalgae/company seaweed that was planted was also of economic value so that it brings profit.

Conclusion

The conclusions of this study were: (1) Farming with a polyculture system that utilizes other macroalgae/seaweeds as companion plants were very effective in controlling the ice-ice disease; (2) The ice-ice disease control model was a polyculture system with the introduction of new resistant cultivars.

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