Productivity Improvement of Seaweed (Gracilaria verrucosa) Fertilized With Vermicompost Made From Different Organic Wastes

By Andi Rahmad Rahim

PRODUCTIVITY IMPROVEMENT OF SEAWEED (*GRACILARIA VERRUCOSA*) FERTILIZED WITH VERMICOMPOST MADE FROM DIFFERENT ORGANIC WASTES

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ABSTRACT

The development of profitable *Gracilaria verrucosa* seaweed cultivation is possible because of the high market demand for gelatine (agarose). *Gracilaria* has a low seedstock price, a short harvest time of just 42 days, and can be processed into agarose, which sells at a high price. These advantages make *Gracilaria verrucosa* cultivation attractive, but problems of decreasing productivity are encountered, due to the use of chemical/inorganic fertilizers. In this study we investigated the use of vermicompost fertilizer, from different organic wastes (feed waste, reed waste (*Imperata*), and banana stem waste), and its effect on the productivity of *Gracilaria verrucosa* seaweed. This research used a Completely Randomized Design with three replications. The data were analysed using ANOVA and the Tukey Test. The results showed that the lengths of the short and long axes of the seaweed cells were 165.0–227.3 µm and 170.3–253.7 µm, respectively. The daily growth rate was 0.95–1.61% per day. The agar yield quality on Day 0 was 12.4–16.0% and on Day 42 it was 24.6–30.6%. The nitrogen content of *Gracilaria verrucosa* seaweed on Day 0 was 1.50–1.86% and 2.93–3.60% on Day 42 while the phosphorus content on Day 0 was 0.13–0.22% and 0.41–0.61% on Day 42. The water used for cultivating *Gracilaria verrucosa* seaweed had a temperature of 27.30–34°C, pH of 8.2–10.2, and a salinity of 15–21 ppt. Treated banana stem waste is the best waste to increase the growth and quality of *Gracilaria verrucosa* seaweed.

Keyword: *G. verrucosa,* Mineral Content, Growth, Cell Size, Vermicompost.

I. INTRODUCTION

Gracilaria verrucosa seaweed can be cultivated by marine aquaculture and has a high selling price. The development of profitable *Gracilaria verrucosa* businesses in Indonesia could considerably increase people's income due to the high market demand for this seaweed, as it can be processed into agarose (İlknur *et al.,* 2011). *Gracilaria* is a highly favored-seaweed species for development by aquaculturists, because it has a low seedstock price and can be processed into agarose, which sells at a price three times higher than the seedstock price. Another advantage is that it can be cultivated in ponds with a harvest time of just 42 days.

In seaweed cultivation, there is often a decrease in productivity caused by a lack of nutrients. This problem can be overcome by fertilization. Organic fertilizers are found in natural and artificial waters and can be used by aquatic flora, directly or indirectly, to obtain the macro elements needed to increase the weight of the plants (Manuhara et al., 2016). The use of organic fertilizers is expected to reduce the use of inorganic fertilizers that can negatively affect the environment.

Vermicompost fertilizer is an environmentally benign fertilizer that uses natural ingredients (waste from earthworm cultivation) and contains nutrients needed by *Gracilaria verrucosa* seaweed to increase its weight. In vermicompost fertilizer, earthworms change the activity of microorganisms (Morales, Sanchez, Rodrigo, 2014) so that the mineralization rate of organic materials increases rapidly (Mohee and Soobhany, 2014). The use of wastes such as feed waste, reed waste (*Imperata*), and banana stem waste, to produce organic fertilizer by vermicomposting, is expected to improve the productivity of *Gracilaria verrucosa* seaweed. The aim of this research was to investigate the effect of vermicompost fertilizer, made from different organic wastes, on the cell size, daily growth rate, agar yield quality, nitrogen and phosphorus contents, and water quality for *Gracilaria verrucosa*.

II. METHOD

Time and Place. This studies become carried out over forty two days in November and December 2018 at the embankments of brackish water ponds in BanyuUrip Village (Ujungpangkah, Gresik Regency, East Java Province, Indonesia), withinside the Fisheries Laboratory of Muhammadiyah University of Gresik, and withinside the Soil Laboratory of Brawijaya University, Malang. Fertilizer Production. Experimental packing containers for making vermicompost fertilizer had been withinside the shape of 5 plastic boxes (35 × 35 × 15 cm), with 9 holes (diameter three mm) withinside the backside and included with plastic. The starter medium contained cow dung (1.6 kg) and soil (six hundred g). The cow dung and soil had been combined and positioned withinside the base of every container. Organic wastes, withinside the shape of reeds (Imperata) and banana stems, had been chopped kind of to a thickness of 2–three cm after which placed into every container (three hundred g for every natural waste). Meanwhile, the feed waste become aerated till the waste have been wet for seven days after which additionally weighed as a whole lot as three hundred g. Adult earthworms (26 g/kg of vermicompost medium) had been introduced and the ensuing vermicompost medium stirred and sprayed with water each day. The fertilizer manufacturing method become whole after months and the earthworms had been then eliminated manually. Seedstock Preparation. The G. verrucosa seedstock become produced through tissue culture. The seedstock used become fresh, loose from impurities and had many branches, a barely darkish brownish color, a younger tough thallus, no white spots, peeled off, and become as a minimum weeks antique while collected. The weight of seaweed seeds for every remedy become 50 grams. Container Preparation. Fifteen cultivation packing containers fabricated from Styrofoam (forty five cm × 30 cm × 30 cm) had been used. The packing containers had been washed and dried earlier than use after which full of mud (five cm depth) taken from the lowest of the pond. The packing containers had been then stuffed to the brim with water. Seedstock Distribution. G. verrucosa seedstock (50 g) become unfold in every of the packing containers (Fadilah et al., 2016), which had been positioned at the embankment of brackish water ponds for forty two days. Fertilization. Fertilization worried dissolving vermicompost fertilizer withinside the water (zero.forty five g / L of seawater) (Rahim et al., 2015; Rahim et al., 2016). Parameters. The wide variety and size (length) of Gracilaria verrucosa seaweed cells (mobileular boom) had been found horizontally and vertically the use of a zero.zero mm ruler and an ocular microscope (80× magnification). The day by day boom rate (% / day) and the agar yield quality (%) had been measured on the Fisheries Laboratory of Muhammadiyah University of Gresik. The nitrogen and phosphorus contents and the water quality (temperature, pH, and salinity) of the Gracilaria verrucosa seaweed had been decided the use of a UV-VIS technique withinside the Soil Laboratory of Brawijaya University, Malang. Research Design. This studies used a totally randomized layout with 5 remedies and 3 repetitions. The 5 remedies had been: 1. Treatment A: Vermicompost Fertilizer (no waste) 2. Treatment B: Vermicompost Fertilizer (feed waste) three. Treatment C: Vermicompost Fertilizer (reed waste or imperata) 4. Treatment D: Vermicompost Fertilizer (banana stem waste) five. Treatment E: Vermicompost Fertilizer (mixed waste) Data Analysis. The records had been analyzed the use of ANOVA to decide the impact of the use of vermicompost fertilizer crafted from special natural wastes at the productiveness of Gracilaria verrucosa seaweed. Significance become decided with Tukey's (HSD) Test with a 95% self belief level (p<zero.05).

III. RESULTS AND DISCUSSION

Morphology and Cells of *Gracilaria verrucosa* Seaweed

The color of seaweed can be an indicator of the amount of chlorophyll contained in its cells. A thallus with a more concentrated color indicates a higher chlorophyll content. The difference in the color of the seaweed thallus is one of its morphological characteristics because seaweeds are able to synthesize color pigments. Shaharudin et al. (2011) stated that red seaweeds, such as *Gracilaria* sp., contain the dominant pigments phycoerythrin and ficocyanine, which are responsible for the red color.

Cell Size (μm)

With the use of vermicompost made from different organic wastes, the length of the short axis of *Gracilaria verrucosa* seaweed cells ranged from 165–227.3 μm and the length of the long axis ranged from 170.3–253.7 μm.

Analysis of Variance (ANOVA) for the cell sizes of *G. verrucossa* seaweed showed that the administration of vermicompost fertilizer made from different organic wastes had a significant effect on the increase in the length of the short axis ($p<0.05$). In contrast, vermicompost fertilization had no significant effect on the increase in the length of the long axis ($p>0.05$). Furthermore, the results of the Tukey (HSD) Test suggested that the short axis length on Day 21 in Treatment D (Banana Stem Waste) was significantly different from that in Treatment A (without addition of waste), Treatment B (feed waste), and Treatment E (combination of waste) ($p<0.05$). However, Treatment A (without addition of waste), Treatment B (feed waste), Treatment C (reed waste or *Imperata*), and Treatment E (combined waste) did not show any difference from each other on Days 0, 21 and 42 ($p>0.05$) (Figure 3). The long axis length of *G. verrucosa* seaweed cells were not further analyzed using the Tukey (HSD) Test because the ANOVA results showed no significant effect ($p>0.05$).

According to Rahim (2018), the short axis length of *Gracilaria verrucossa* seaweed cells ranged from 28.261–387.725 μm. We found that fertilizing *Gracilaria verrucosa* seaweed with vermicompost accelerated the growth and the formation of new shoots because the vermicompost fertilizer contained nutrients needed by the seaweed in the form of macro and microelements, which accelerate cell division.

Rahim (2018) also reported that the long axis length of *Gracilaria verrucossa* seaweed cells was 30.296–432.426 μm. In general, changes in the cell size are caused by environmental factors, both abiotic (light, salinity, temperature, and nutrient availability) and biotic (marine organism) (Fitria and Fida, 2015).

Daily Growth Rate (%/day)

The daily specific growth rate of *G. verrucosa* ranged from 0.95–1.61% (per day). Analysis of Variance (ANOVA) showed that the administration of vermicompost fertilizer, made from different organic wastes, had a significant effect on the increase in the daily specific growth rates ($p<0.05$). Furthermore, the Tukey (HSD) Test revealed that all the treatments –Treatment A (without addition of waste), Treatment B (waste from feed), Treatment C (reed waste or *Imperata*), Treatment D (waste from banana stems), and Treatment E (combined waste) – were significantly different from one another ($p<0.05$) (Figure 5).

Hasseltrom et al. (2018) argued that a seaweed cultivation activity is categorized as good if the average daily growth rate is at least 3%. It has been suggested that the low daily growth rate of *G. verrucosa* is due to the less favorable environmental conditions in seaweed cultivation, leading to below optimal growth (Rejeki et al., 2018). Another factor was that the rainfall was high during the weeks of this study, so the seaweed did not get enough sunlight. In addition to environmental and weather factors, the increasing weight and length of the seaweed thallus can also affect the daily growth of *Gracilaria* sp.. According to Kasim and Ahmad (2017), the decline in the growth rate of the seaweed was due to different rates of photosynthesis in a clump of seaweed. In addition, Setyowati in Rejeki et al. (2018) explained that stress on seaweed can also lead to tissue damage, resulting in lower growth rates.

The results of this study indicated that the administration of fertilizer from banana stem waste influenced the growth of *Gracilaria verrucosa* seaweed. **Onwu** et al. (2018) found that banana stems contain microorganisms that can store nitrogen and phosphate. Bacteria that can store nitrogen can increase and improve the nitrogen content of water or soil and produce substances that can enhance plant growth. According to Liu et al. (2011), phosphate solubilizing bacteria on banana stems can convert insoluble phosphate 4 into soluble phosphate by secreting organic acids, such as formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids. Phosphate solubilizing bacteria play 5 an important role by increasing the availability of phosphorus for plants by up to 50%.

Agar Yield Quality (%)

Based on the results of this research, the agar yield quality on Day 0 ranged from 12.4–16.0% while on Day 42 this ranged from 24.6–30.6%. Analysis of Variance (ANOVA) found that the administration of vermicompost fertilizer made from different organic wastes had a significant effect on improving the agar yield quality on Day 42 ($p<0.05$). Furthermore, the results of the Tukey (HSD) Test on the agar yield quality on Day 42 indicated that Treatment D (banana stem waste) was significantly different from Treatment C (reed waste or *Imperata*) ($p<0.05$). Treatment A (without addition of waste), Treatment B (feed waste), Treatment C (reed waste or *Imperata*), and E (combination of wastes) were not significantly different from each other ($p>0.05$) (Figure 6).

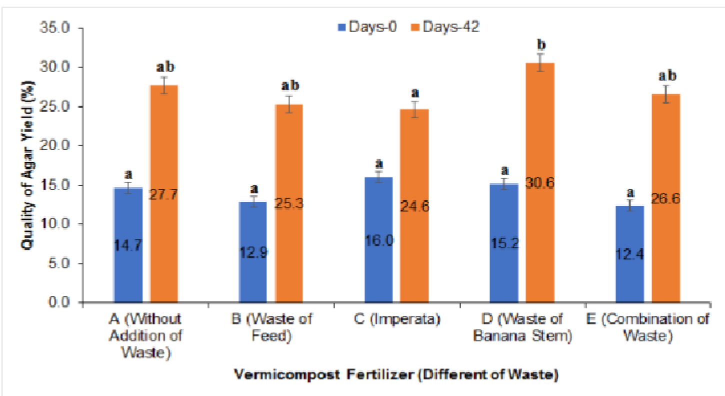

Figure 6. Agar Yield Quality of *Gracilaria verrucosa* Seaweed

According to Beaumont et al. (2010), the best agar yield quality from *G. verrucosa* seaweed, based on the Indonesian National Standards on Agar Quality, was in the range 20–26%. Thus, the agar yield quality in this research was categorized as the best. Venugopal (2011) stated that the amount of seaweed cultivation yield varies according to ecological factors such as light, nutrition, temperature, and water content after being dried.

Nitrogen and Phosphorus Contents of *G. verrucosa* Seaweed (%)

The nitrogen content of *Gracilaria verrucosa* seaweed on Day 0 ranged from 1.50–1.86% and on Day 42 ranged from 2.93–3.60% (Figure 7). The phosphorus content of *Gracilaria verrucosa* seaweed on Day 0 ranged from 0.13–0.22% and on Day 42 ranged from 0.41–0.61% (Figure 8). Analysis of Variance (ANOVA) showed that the administration of vermicompost fertilizer made from different organic wastes had no significant effect on the increase in the phosphorus contents of *G. verrucosa* seaweed ($p>0.05$), so the Tukey (HSD) Test was not carried out. The application of vermicompost fertilizer from different wastes significantly increased the nitrogen content of *Gracilaria verrucosa* seaweed after 42 days ($p <0.05$). Tukey's tests showed that treatment D (banana stem waste) was significantly different from treatment B (feed waste) ($p <0.05$), but there was no significant difference with treatments A (without addition of waste), C (reed waste or *Imperata*) and E (combination of wastes) ($p> 0.05$) in increasing the nitrogen content of *Gracilaria verrucosa* seaweed.

Based on the results of this research, the nitrogen content of *G. verrucosa* seaweed ranged from 1.50–3.60%. Roleda and Catriona (2019) found that the nitrogen content of seaweed cultivated offshore ranged from 0.44–4.73%. In a study by Boedi *et al*. (2014), the nitrogen content of *G. verrucosa* seaweed cultivated on a laboratory scale was 1.72–2.31%. Nitrogen is fully utilized by *G. verrucosa* seaweed to encourage high growth rates and good seaweed quality. According to Balmori *et al*. (2013), vermicompost fertilizer is an important source of nitrogen, but the nitrogen in fertilizers mostly cannot be mixed and cannot be available immediately for plant use.

In our study, the phosphorus content of *G. verrucosa* was in the range of 0.13–0.61%. Yuniarsih *et. al*. (2014) reported that the phosphorus content of seaweed cultivated offshore was

0.06–1.07%. According to Boedi *et al*. (2014), the phosphorus content of *G. verrucosa* seaweed cultivated on a laboratory scale ranged from 0.03 to 0.10%. The optimal growth of seaweed was obtained with a phosphorus content of 0.3–0.5% (Engelsted, 2007). The role of phosphorus is very important for plants, as it is a constituent component of proteins, cell nuclei, cell walls, the formation of high-energy compounds, and is a component of RNA and DNA (Diacono and Montemurro., 2015). However, the quantity of phosphorus in plants is smaller than the quantities of nitrogen, potassium, and calcium (Costa et al., 2018). In this study, the phosphorus content of *Gracilaria verrucosa* seaweed did not have a significant effect on its growth rate, because phosphorus is not needed in large quantities, but its presence can optimize the growth and quality of the seaweed, especially in *Gracilaria* species (Rahim et al., 2019).

Water Quality

It can be seen in Table 1 that the temperature of the water for all treatments, ranged from 27.30ºC–34ºC. This range is consistent with the findings of Jang et al. (2017), that seaweeds reproduce and grow very well in aqueous media with a temperature range of 26–33ºC. The pH of the water in all treatments ranged from 8.2–10.2. According to Radulovich et al. (2015), seaweed growth requires an optimal pH of seawater that ranges from 6–9. The salinity was found be 15–21 ppt for all treatments. to Radulovich et al. (2015) stated that the salinity levels for a good increase in seaweed weights are in the range of 14–35 ppt.

IV. CONCLUSION

The research results above led us to conclude that:

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1. *Gracilaria verrucosa* seaweed has a red color due to the presence of phycoerythrin and phycocyanin pigments.

2. The use of vermicompost fertilizer made from different organic wastes can increase the productivity of brackish water ponds, in terms of the cell size, daily growth rate, agar yield quality, phosphorus content, and nitrogen content of *Gracilaria verrucosa* seaweed.
3. Water quality in the form of pH, temperature, and salinity, and the use of vermicompost fertilizer made from different organic wastes, provides the best conditions to increase the thallus weight of *Gracilaria verrucosa* seaweed.

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