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Productivity Improvement of Milkfish and Seaweed Polyculture using Vermicomposting Fertilizer from Sources of Waste

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Abstract: ***Polyculture cultivation depends on the balance of several factors. Seaweed functions as a supplier of oxygen, protection for milkfish from predators, and an absorber of the dissolved CO_2 from the respiration of the milkfish. In turn, the milkfish waste was used as nutrients by the seaweed. This research was carried out in Ujungpangkah Pond, Gresik District, East Java. The objective of the study was to increase pond productivity using vermicompost fertilizer from various wastes in a seaweed and milkfish polyculture system. The treatment was using food waste, Alang-Alang (Imperata) waste, banana stems, and a combination of all wastes were used to produce the vermicompost. The polyculture system used milkfish and the seaweed Gracilaria verrucosa and was cultivated for 42 days. It was found that the highest carbon uptake (717.77 ppm/day) by G. Verrucosa was with no added organic waste; the highest nitrogen uptake (16.47 ppm/day) was with combined organic waste, and the highest phosphorus uptake (19.17 ppm/day) was with feed waste. The highest daily specific growth rate (6.21%/day) of the milkfish was with banana stem waste. The feed conversion ratio (FCR) was 1.04–1.26. This small FCR showed that seaweed could be used as an alternative feed source for milkfish within a polyculture system.***

Keywords: ***polyculture, vermicompost, milkfish, seaweed, growth, nutrient uptake***

I. INTRODUCTION

Aquaculture can improve both the macro- and micro-economy. In the vast scope, aquaculture has the potential to contribute to the largest foreign exchange in the world export process. On a small scale, the aquaculture sector has an economic influence by providing experts, increasing the purchasing power of the local community, and increasing the income for the community by acting as fisheries entrepreneurs (Nugroho, 2013). Rahim et al. (2016) seaweed is a water plant that requires a balance of several physical and chemical factors, such as water movement, temperature, salinity, carbon, the nutrients nitrogen and phosphorus, and sunlight. During the growth process, nutrients diffuse into the thallus, while the photosynthetic process takes place with the sunlight that penetrates the waters. The milkfish (*Chanos chanos*) is the only species in the Canidae family. They live around the coast and islands in areas that have many coral reefs. After hatching they live in marine waters for three weeks and then move into the mangrove, brackish or estuary waters or lakes. In adulthood, they return to the sea to reproduce (Sumawidjaja, 2002).

The polyculture cultivation system involves land use with more than one aquaculture organism in a cultivation medium. This kind of system can be used to increase pond efficiency and increase the farmers' income. The cultivation process of more than one aquaculture organism depends on a balance of factors in the cultivation system. Seaweed produces oxygen during photosynthesis, protects fish from predatory attacks, and absorbs the CO_2 from the respiration of the milkfish. In return, the milkfish release feces, which contain nutrients for the seaweed (Mangampa & Burhanuddin, 2014).

Addition of nutrients to a polyculture medium of the seaweed *Gracilaria verrucose* and milkfish, in the form of macro elements such as carbon, nitrogen, and phosphorus, can maintain the fertility level of aquaculture ponds. Using waste such as residual feed waste or fertilizer, Alang-Alang waste, and banana stems to make vermicompost is a way of producing natural fertilizers that could increase production, in terms of the quality and quantity of milkfish and seaweed. This would reduce the use of synthetic or chemical fertilizers, which are relatively expensive and can cause a decrease in long-term productivity. This study was carried out in Gresik District, East Java Province, Indonesia. It investigated the daily specific growth rate and the feed conversion ratio (FCR) of milkfish in a polyculture system with the seaweed *G. verrucosa* and vermicompost fertilizer. Different fertilizers were prepared from different organic wastes to increase pond productivity. The carbon, nitrogen, and phosphorus uptake by the seaweed were also measured.

II. METHODOLOGY

A. Time and Location

The research was conducted from January to February 2019 for 42 days in the brackish ponds of Banyu Urip Village,Ujungpangkah Sub-district, Gresik District, East Java Province, Indonesia; at the Fisheries Laboratory of Universitas Muhammadiyah Gresik; and the Soil Laboratory of Universitas Brawijaya Malang.

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B. *Fertilizer Production*

Vermicompost fertilizers were made with different organic waste materials at the Aquaculture Laboratory of Universitas Muhammadiyah Gresik. Five plastic boxes (35 × 35 × 15 cm), with nine 3 mm holes in the bottom and covered with plastic, were used to make the vermicompost. The media used were cow dung (1.6 kg), as a starter, and soil (600 g). The cow dung and soil were mixed and placed in the base of each container. Alang-Alang (*Imperata)* and banana stems were roughly chopped to a thickness of 2–3 cm and then put into each container (300 g). The feed waste was aerated for seven days until the waste became moist. Adult earthworms (26 g/kg of vermicompost medium), were added and the resulting vermicompost medium stirred and sprayed with water every day. The fertilizer was harvested after two months, and the earthworms separated manually from the vermicompost (Rahim, 2018).

C. *Seedstock Preparation*

The seed stock was fresh, free from foreign material, had many branches with a slightly dark brown end, a young hard thallus, no white spots and exfoliated, and was least two weeks old when collected. The mass of seaweed seed stock used was 50 g for each treatment. The milkfish (5–7 cm) came from Tuban, North Coast of Java Island. The milkfish had passed the larval phase and were susceptible to disease. The milkfish were not fed for the three days of the acclimatization process.

D. *Containstock Preparation*

Fifteen styrofoam boxes (45 × 30 × 30 cm) were washed and dried. To make miniature ponds, each styrofoam box was filled to a thickness of 5 cm with mud taken from the bottom of the pond. Later, the cultivation container was filled with seawater.

E. *Seedstock Spread*

Seaweed seed stock from tissue culture (50g/container) (Rahim, 2018), and milkfish (30 heads/container) (Sumawidjaja, 2002) were added to each container. The containers were placed on top of the ponds and maintained for 42 days as a polyculture system.

F. *Adding Fertilizer*

Rahim et al. (2015) fertilizer was dissolved in seawater (450 ppm or 0.45 g/l of seawater) before.

G. *Parameters*

.The parameters measured were the dissolved carbon, nitrogen, and phosphorus concentrations in the polyculture water, using UV-VIS spectroscopy methods the Soil Laboratory of Universitas Brawijaya, Indonesia. The decline rates for carbon, nitrogen, and phosphorus (ppm/day) nutrients were calculated using the formula: final CNP nutrient concentration minus initial CNP nutrient concentration divided by the final observation time minus the initial observation time (Kurniawan, 2006). The milkfish daily growth rate was determined by weighing all the fish in each treatment once a week; the daily growth rate was calculated by the formula: (average weight of end cultivation) minus (average weight of initial cultivation) divided by the time of cultivation (Handajani & Widodo, 2010). The feed conversion ratio (FCR) of the milkfish was calculated using the formula from Directorate General of Fisheries Cultivation (2004): the feed given divided by final weight minus the initial weight of milkfish.

H. *Research Design.*

This study used a Completely Randomized Design (RAL) with five treatments and three replications so that there were 15 experimental units. The treatments were:

1. Treatment A: Vermicompost Fertilizer (without organic waste)
2. Treatment B: Vermicompost fertilizer (with feed waste)
3. Treatment C: Vermicompost Fertilizer (with *alang-alang* (*Imperata*) waste)
4. Treatment D: Vermicompost Fertilizer (with banana stem waste)
5. Treatment E: Vermicompost Fertilizer (with combined waste)

G. Data Analysis

The data obtained were analyzed using Analysis of Variance (ANOVA). If any vermicompost fertilizer was found to have a significant effect on the increasing growth of the milkfish and the milkfish FCR ($P < 0.05$), a Tukey test was used to identify any significant differences between each treatment. The decline rates in nitrogen, carbon, and phosphorus concentrations were analyzed descriptively based on the seaweed's life needs.

III. RESULTS AND DISCUSSION

The rate of uptake of carbon by the seaweed *G.verrucosa* was in the range 626.13–717.77 ppm/day. Treatment A had the highest rate of uptake(717.77 ppm/day), then treatment C (656.34 ppm/day), treatment D (647.3 ppm/day), treatment B (645.51ppm/day), and treatment E (626.13 ppm/day) had the lowest rate of uptake. Akmal et al. (2009) found that the rate of uptake of carbon that produced the best growth and quality of seaweed was in the range 100.89–202.79 ppm/day. Rahim (2016) found that the uptake rate of carbon by *G. Verrucosa*was in the range 112.38–114.17 ppm/day. According to Erlania et al., (2013), the massive amounts of carbon taken up by *Gracilaria sp.*was because carbon was used in large quantities as the fundamental element in the formation of carbohydrates and sulfates.

2. Uptake of Nitrogen by Seaweed

Nitrogen uptake by the seaweed *G.verrucosa*ranged from 12.35–16.47 ppm/day. The rates of nitrogen uptake measured were: treatment E (16.47 ppm/day), treatment D (14.74 ppm/day), treatment C (14.18 ppm/day), treatment A (12.65 ppm/day), and treatment B (12.35 ppm/day). In a previous study, the highest nitrogen uptake for the *G. verucossa* was in the range 0.14–2.47 ppm/day (Kurniawan, 2006). According to Rahim (2016), the range of nitrogen uptake of *G. verrucose*, with a different ratio of vermicompost fertilizer to the one in this study, was 2.12–2.40 ppm/day. Syah et al. (2017) found that nitrogen (as nitrate and ammonia) was diffused by phytoplankton into a much simpler form. The formation of nitrate and ammonia depends on the oxygen content of the water. If the oxygen concentration is low, nitrogen will be a dangerous element as ammonia is formed.

If the oxygen concentration is high, the nitrogen will be in the form of nitrate, which can then be used by the seaweed as a source of nutrition. As well as being necessary for photosynthesis, nitrogen assists in the formation of chlorophyll, protein, fat, and other organic compounds. Nitrogen is an essential element for increasing the size of seaweed.

This is because nitrogen is a limiting factor for macroalgal growth. It can also fertilize water plants leading to growth increases (Salundik & Simamora, 2006).

3. **Uptake of Phosphorus by Seaweed**

Phosphorus uptake of *G. verrucosa* seaweed in this study ranged from 17.91 to 19.17 ppm/day. The highest absorption of phosphorus was in treatment B (19.17 ppm/day), then treatment C (18.41 ppm/day), treatment D (18.25 ppm/day), treatment A (17.99 ppm/day) and treatment E (17.91 ppm/day). According to Kurniawan (2006), the range for *G. verrucosa* growth was 0.11–0.45 ppm/day. Whereas according to Rahim (2016), the range of phosphorus absorption, using vermicompost fertilizers with a different ratio to the one in this study, was 0.28–0.52 ppm/day. Lingga and Marsono (2007) stated that phosphate was a critical component for seaweed. Phosphate is easily decomposed and absorbed by plants and is an excellent nutrient source. Phosphorus stimulates growth and accelerates the formation of seaweed spores (Anam, 2007).

4. Daily Growth Rate of Milkfish

The daily growth rate of the milkfish *Chanos chanos* was 4.02–6.21%/day. The highest daily growth rate was for treatment D (6.21%/day) while the lowest was for treatment A (control) (4.02%/day). According to Triyanto et al. (2014), the daily growth rate of cultivated milkfish in a reservoir was 0.26–1.1%/day. Mangampa and Burhanuddin (2014), found that milkfish cultivated together with *G. Verrucosa* had a daily growth rate of 4.8%/day. An important factor determining growth is the type and composition of feed according to the needs of the fish. Spikadhara et al. (2012) the substances in the feed must be by the availability of endoenzymes in the digestive tract so that they can be appropriately processed and the remainder that is energy leads to weight gain. According to Rahim (2018), the carbon content of *G. Verrucosa* was 23.53–29.47%, and the nutrient content made it a good source of fish food for promoting development.

5. **Milkfish Feed Conversion Ratio**

Handajani (2011) stated that more efficient feeding could increase the weight of the fish. The efficiency of the feed can be determined by the feed conversion ratio (FCR). Serdiati et al. (2011) proposed that the lower the FCR, the less feed needed to produce each kilogram of fish.

The FCRs determined for milkfish (*Chanos chanos*) were 1.04–1.26. The lowest FCR was for treatment C (1.04), and the highest was for treatment E (1.26).

IV. CONCLUSION

From the results of the study, the conclusions are as follows:

1. The highest carbon uptake of the seaweed *Gracilaria verrucosa* was 717.77 ppm/day, using vermicompost with no additional organic waste. The highest nitrogen uptake was 16.47. ppm/day, using vermicompost from mixed waste, and the highest phosphorus uptake was 19.17 ppm/day, using vermicompost from feed waste.
2. The highest daily growth rate of milkfish *Chanos chanos* was 6.21%/day, using vermicompost from banana stem waste. The Feed Conversion Ratios (FCR) measured for milkfish were 1.04–1.26.
3. The FCR value was smaller than in previous studies. This showed that combined seaweed and milkfish production, using polyculture technology and vermicomposting fertilizers from various wastes, was able to reduce the use of artificial feed, which is relatively expensive for milkfish.

V. ACKNOWLEDGMENTS

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VI. APPENDIX

Figure 1. Layout of Cultivation Media for Seaweed *(Gracilaria verrucosa)* and Milkfish *(Chanos chanos)* Polyculture.

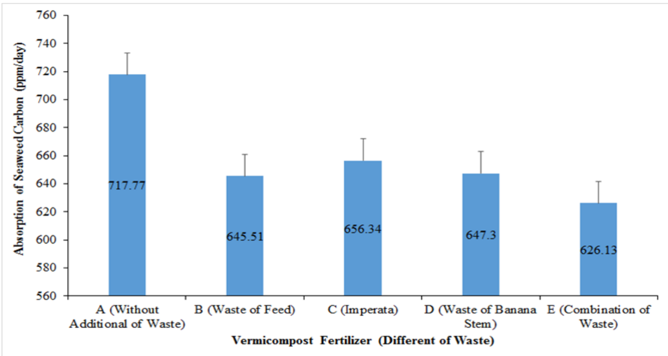

Figure 2. Uptake of Carbon by Seaweed

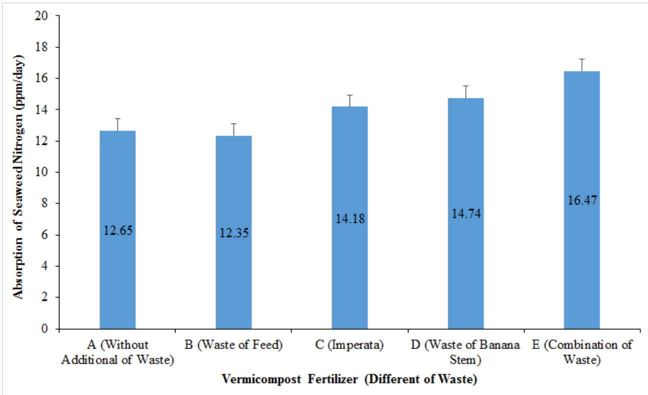

Figure 3. Uptake of Nitrogen by Seaweed

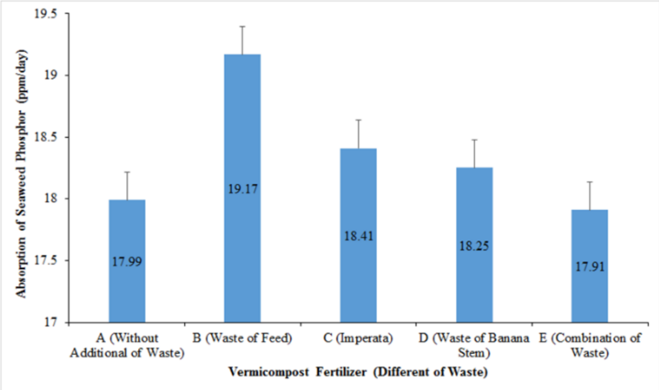

Figure 4. Uptake of Phosphorus by Seaweed (ppm/day)

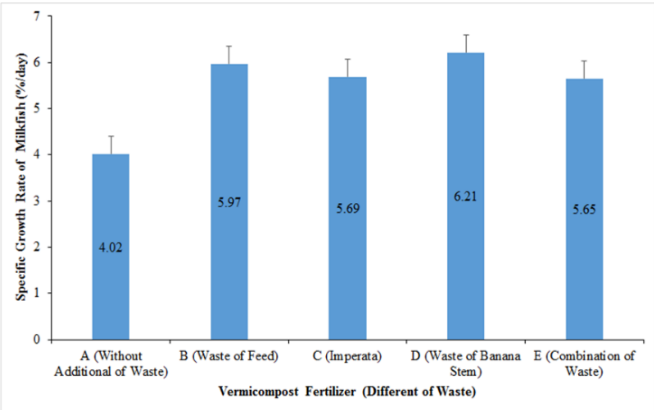

Figure 5. Daily Growth Rate of Milkfish

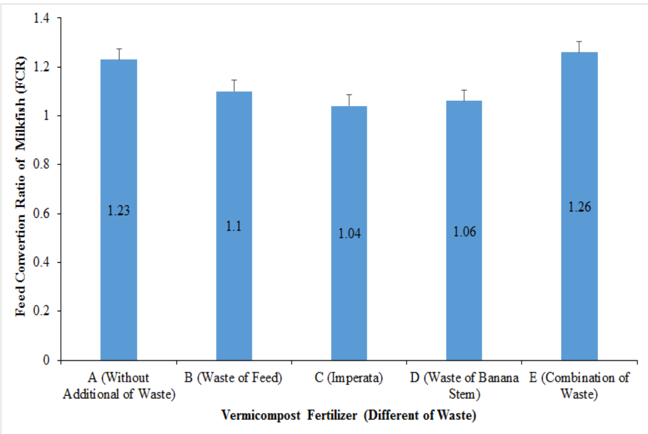

Figure 6. Milkfish Feed Conversion Ratio

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