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The Effect of Liquid Organic Fertilizer of Rabbit Urine and Concentration of Plant Growth Promoting Rhizobacteria of Bamboo Root on the Growth and Yield of Mustard Green Plants

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Abstract

Mustard greens (Brassica juncea L.) are one type of favorable vegetable. However, mustard greens production and productivity still fluctuate. Also, society expects quality, healthy and safe vegetable products for consumption. So, it is necessary to increase the use of organic fertilizers to produce high productivity and good products. LOF of rabbit urine contains high nutrients, and PGPR contains microorganisms that act as bioactivators that decompose organic matter. This study aimed to determine the effect of giving LOF of rabbit urine and concentration of PGPR of bamboo roots on the growth and yield of mustard greens. The experiment was carried out factorially using Random Design Complete with three replications. The first factor was the LOF dose of rabbit urine, and the second was the PGPR concentration which consisted of 4 levels. The results showed that (1) the interaction of LOF of rabbit urine and concentrations of PGPR of bamboo root had no significantly different effect on all variables; (2) LOF of rabbit urine had no significantly different effect on all variables and (3) PGPR concentration of bamboo roots had a significant different effect on all variables except root volume and number of leaves, where treatment of 15 ml/L (B3) gave the best results on the yield of mustard greens.

Introduction

Mustard greens (Brassica juncea L.) are a type of vegetable that is very popular among people because of its nutritional and vitamin content which can overcome various diseases (Hanum et al., 2021). Nowadays its consumption is increasing. It is reported that the average consumption of mustard greens in Jember Regency tends to increase, respectively, in 2018-2021 was 0.053, 0.039, 0.040, and 0.042 kg/capita/week (BPS, 2021). In addition, according to BPS data (2021) in the last four years, the production of mustard greens in Jember Regency has fluctuated. Several factors, such as reduced land, use of inaccurate attack fertilizers and pests/diseases, or inadequate land drainage/irrigation, may influence the fluctuations in the productivity of mustard plants (Dixon, 2015; Popescu et al., 2022). Due tue this challenge, farmers strive to increase the productivity of mustard greens in Jember Regency by chemical fertilization treatment. However today's society becoming more aware on the quality, healthiness, and safe vegetable products for consumption (Golnaz Rezai, 2012). Therefore the use of organic fertilizers becoming the best solution that is environmentally friendly and able to produce high productivity and good products (Wei et al., 2019). Organic fertilizer made from livestock waste is one of the organic fertilizers that are easy to process and contains many nutrients (Hazra, 2016).

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Liquid Organic Fertilizer (LOF) from Rabbit urine is very helpful in increasing the vegetative development and production of caisim plants (Kurnianta et al., 2021). LOF with a concentration of 40 ml/L of water will produce optimal growth (Leksono et al., 2017). In order to accelerate the absorption of nutrients in LOF after being given to plants, additional microorganisms are needed (Olle & Williams, 2013). PGPR is a group of beneficial bacteria in the root zone that colonize the rhizosphere and positively affect plant growth. PGPR contains many microorganisms which can become bioactivators to decompose organic matter which will be converted into food ingredients with nutrients that plants will later absorb (Lehar et al., 2018). Based on those backgrounds, it is necessary to determine the ability of rabbit urine LOF and PGPR of bamboo roots to increase the yield and growth of mustard green plants.

Methods

This research was conducted from January to February 2023 at the Greenhouse Agrotechnopark, University of Jember, East Krajan, Sumbersari District, Jember Regency, East Java. The tools used in this study included hoses, stoves, scales, pots, measuring cups, shovels, knives, watering can, tape measure, hoes, cameras, and ovens. While the materials used include rabbit urine, bamboo roots, EM4, seedling trays, mustard greens of the Tosakan variety, polybags, shrimp paste, rice bran, bottles, plasticine, jerry cans, sugar, lime, water, molasses, planting medium (topsoil, charcoal husk & manure).

The experiment started by making LOF of rabbit urine and PGPR of bamboo roots. The process of making PGPR root consists of three stages. First was making the starter by preparing 100 grams of bamboo plant roots soaked in 1 liter of boiled water for three days. The second was making the growing media by mixing all the ingredients, such as 100 grams of original shrimp paste (protein), bran (vitamins) 1 kg, sugar (carbohydrates) 500 grams, and lime (pH neutralizer) 1 teaspoon into clean water (boiling) 20 liters (Fani Patading & Song Ai, 2021; Rachmat et al., 2021), then cooked, stir well and cool to room temperature then filtered and ready to be used as a growing medium. The third was mixing the PGPR starter and growing media, then fermenting for seven days. PGPR, which ready to use is, smells sour, and the solution turns more turbid and can be used as fertilizer (Amanda, 2020). The process of making LOF of rabbits urine by mixing 5 liters of rabbit urine, 50 mL of EM4 bioactivator, and 50 mL of molasses into a jerry can then fermented for 14 days. The jerry can was provided with a hole to drain the hose. Close it in a bottle filled with water so that the gas in the jerry can escape, place it in a shady place and avoid rainwater. Mature LOF and PGPR were then subjected to laboratory analysis to determine nutrient content and bacteria.

Green mustard seeds were sown for 14 days and then transplanted into 30 cm x 35 cm polybags. The plants were then carried out routine maintenance and given weekly LOF and PGPR fertilization treatments. Harvesting was carried out after 35 days by uprooting the roots and making final observations.

The experiment was carried out in a factorial manner using a Completely Randomized Design with three replications. The first factor was the LOF dose of rabbit urine which consisted of 4 levels, namely A0 = 0 ml/plant, A1 = 20 ml/plant, A2 = 40 ml/plant, and A3 = 60 ml/plant. The second factor was the PGPR concentration consisting of 4 levels, namely B0 = 0 ml/L water, B1 = 5 ml/L water, B2 = 10 ml/L water, and B3 = 15 ml/L water. The observation variables used in this study were plant height, number of leaves, leaf area, root length, root volume, plant wet weight, and plant dry weight. The data analysis used was analysis of variance. If there were significant differences between the treatments, a further test was carried out using Duncan's Multiple Range Test at the 5% level.

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Results and Discussion

The results showed that the interaction treatment of LOF of rabbit urine concentration (A) and PGPR of bamboo root (B) had no significant effect on all variables. The main factor effect of rabbit urine LOF concentration showed no significant effect on all variables. In contrast, the main factor effect of bamboo root PGPR concentration showed significantly different results on all variables except the number of leaves and plant root volume.

Table 1 LOF of rabbit urine analysis result

Sample	Analysis result				
	C-Organik	N Total	P_2O_5	K_2O	pH
LOF of Rabbit Urine	0.46%	0.07%	0.003%	0.04%	5.8

Source: Soil Laboratory, Faculty of Agriculture University of Jember

Table 2 PGPR bamboo root concentration analysis result

No	Bacteria type	TPC (CFU/ml)
1	Nitrogen-fixing Bacteria	3.87×10^5
2	Phosphate-solubilizing Bacteria	1.46×10^6

Source: Soil Laboratory, Faculty of Agriculture University of Jember

The LOF (Table 1) and PGPR (Table 2) analysis results showed that the content of NPK, C-Organic, and bacterial populations was relatively low compared to the Ministry of Agriculture regulations (PERMENTAN regulations) No.261/KPTS/SR.310/M/4/2019 (Ministry of Agriculture of the Republic of Indonesia, 2019). The minimum requirements set by PERMENTAN for LOF are that the N, P, and K content in liquid organic fertilizer is 2%, C-Organic minimum of 10%, and pH of 4-9, while the bacterial population in biological fertilizers is 1 x 108 CFU/ml.

The effect of the different LOF and PGPR interactions was not significant because the simple effect of each factor was almost the same. Apart from being influenced by the two main factors, it can be influenced by environmental factors such as the presence of pest attacks on the leaves, which affect the photosynthesis process of plants. Bio urine and PGPR will interact with each other if the combination can provide the nutrients needed by plants, and the microbes contained can fix nitrogen in the air so that plants can absorb these nutrients. However, the performance of bacteria on PGPR is strongly influenced by many factors, one of which is the organic matter content (Nursayuti, 2021). A high organic matter content would increase C-organic levels and pH. The organic matter in LOF of rabbits urine which the PGPR of bamboo roots bacteria should use to work, is hampered due to its low content (Rosniawaty, 2021).

Treatment of LOF of rabbit urine had no significant effect on all observed variables because the nutrient content in LOF of rabbit urine was very low and did not meet the minimum standard of organic fertilizer that had been set. The low nutrient content in LOF of rabbit urine is caused by several factors, such as the length of the fermentation process, the fermentation process's pH level, the fermentation type, and the decomposer microbes' content. Based on the research of Sulfianti et al. (2021), anaerobic fermentation will increase the NPK content in LOF where the increase in N elements is affected by the activity of EM4 bacteria anaerobically, the P content is affected by the acidity of the solution and the K content is affected by the speed of the fermentation process. Asriyani et al. (2022) also stated that the longer the fermentation process, the NPK content in organic fertilizers will increase. However, it is also possible that the source of rabbit urine used will also affect the size of the nutrient content in the resulting

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LOF. According to Lussy et al. (2017), the nutrient content in livestock manure can be influenced by the type of food, drinking water provided, age, and physical form of livestock. In addition, the addition of other sources of materials besides urine will also impact the high levels of LOF nutrients produced.

PGPR of bamboo roots treatment significantly affected all observation variables except root volume and the number of leaves on mustard green plants. Although the bacterial population in the PGPR of bamboo roots based on not fulfilling the requirements of PERMENTAN No.261/KPTS/SR.310/M/4/2019, the provision of PGPR concentrations of bamboo roots had a significant effect on the observational variables of plant height, leaf area, root length, weight plant wet and plant dry weight.

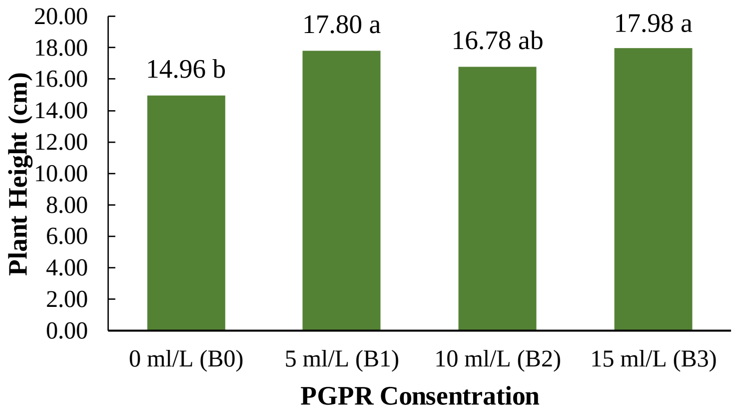

Figure 1 Effect of PGPR Concentration on Plant Height

Plant height (showed by Figure 1) is one of the observed variables that is often used to measure plant growth. The results of the analysis of variance showed that the PGPR of bamboo root concentration had a significant effect on the height of mustard greens. Based on Figure 1, the highest average plant height was in the 15 ml/L (B3) treatment of 17.98 cm, but not significantly different from the 5 ml/L (B1) treatment of 17.80 cm. So the recommended PGPR of bamboo root concentration is 5 ml/L (B1) treatment. This is in accordance with the research of Kie et al. (2020) that giving PGPR affects the height of mustard plants compared to not being given PGPR. This is presumably due to the presence of N-fixing microbes and P solvents in the PGPR of bamboo roots. According to Kurniasih & Soedrajat (2019), the administration of N-fixing microbes and P solvents, as well as biocontrol agents, will actively colonize plant roots so that they affect plant height which can increase crop yields.

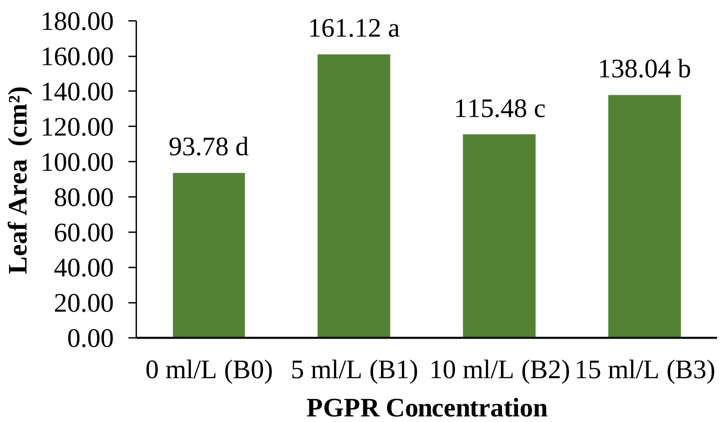

Figure 2 Effect of PGPR Concentration on Leaf Area

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The analysis of variance showed that the PGPR of bamboo roots concentration had a significant effect on leaf area but had no significant effect on the number of leaves. Green mustard plants treated with PGPR had a wider leaf area than plants not treated with PGPR of bamboo root. Figure 2 shows that the average widest leaf area with 5 ml/L (B1) treatment was 161.12 cm2. According to research by Kie et al. (2020), the administration of PGPR was proven to significantly increase the leaf area of mustard plants. The 10 ml/L (B2) and 15 ml/L (B3) treatments showed lower leaf area due to attacks by caterpillars and aphids, so the leaves shriveled and perforated (Figure 3).

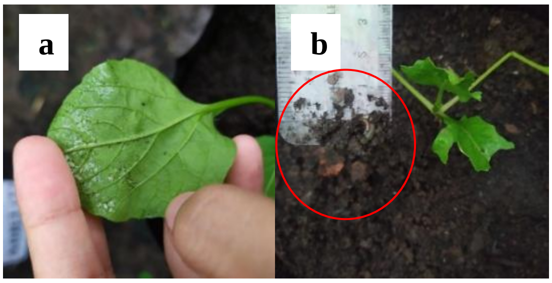

Figure 3 Pests of Green Mustard; a) Thrips & b) Krop Larvae

Thrips (Thrips sp) and Krop Larvae (Crocidolomia binotalis) are pests that are often found in horticultural crops. Thrips can damage plant leaves by sucking leaf fluids, especially on young leaves and flowers (Idrus dkk, 2018). Meanwhile, the Krop larvae actively eats the leaves of mustard plants by eating the tops of the leaves and then moving to older leaves and leaving the veins (Gazali, 2011). The existence of these pest attacks causes inhibition of the growth of new shoots and leaf growth so that the process of photosynthesis becomes hampered. This is different from the research by Naihati et al. (2018), where the administration of PGPR affects the number of leaves, which continues to increase the growth and yield of lettuce plants. However, it is also possible that the low microbial content in the PGPR of bamboo roots causes the leaf growth process in mustard greens to be disrupted. According to Shofiah & Tyasmoro (2018), plants with sufficient N elements will form wide leaf blades to produce photosynthates to support vegetative growth.

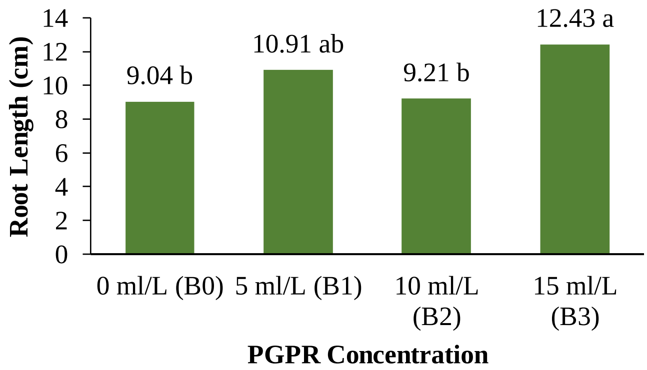

Figure 4 Effect of PGPR Concentration on Root Length

The analysis of variance showed that the PGPR of bamboo root concentration had no significant effect on the root volume of the mustard greens but had a significant effect on the root length of the mustard greens. The highest average root length was in the 15 ml/L (B3) treatment at 12.43 cm, but the 15 ml/L (B3) treatment was not significantly different from the 5 ml/L (B1) treatment. Therefore, the recommended PGPR concentration of bamboo roots was 15 ml/L (B3). According to research by Kasifah (2022), administration of PGPR of bamboo

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root treatment resulted in longer roots of cocoa seedlings and greater root volume than the control treatment. Plant roots are the most essential in plant growth because they absorb nutrients in the soil, which plays a vital role in plant metabolism. Giving PGPR to bamboo root aims to add bacteria to the soil to increase the absorption of nutrients in plants. According to Hamdayanty et al. (2022), PGPR bacteria in the root area positively impact plants because they can synthesize one of the amino acids in the roots to produce the hormone Acetic Acid Indole (IAA). Fathonah & Sugiyarto (2019) added that the IAA hormone in PGPR is one of the endogenous auxins to stimulate plant root growth. Root volume had no significant effect on this study, presumably because mustard greens produce thin but long roots so that the resulting root volume is not too large. This happens because the roots are looking for nutrients deeper so that the roots tend to grow, extending downwards. According to Mahendra et al. (2020), several factors affect the spread of plant roots, namely the availability of nutrients, soil temperature, and water availability.

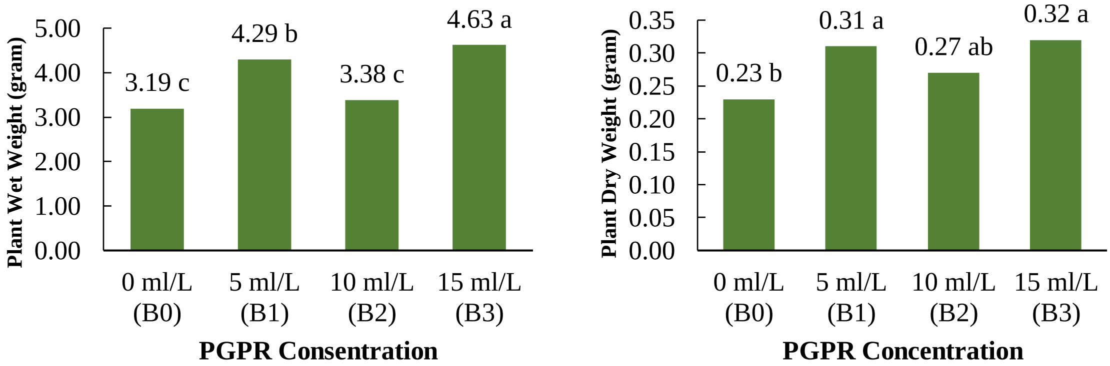

Figure 5 Effect of PGPR Concentration on Plant Wet and Dry Weight

The results of the analysis of variance showed that the PGPR of bamboo root concentration had a significant effect on plant wet weight and plant dry weight. The highest plant wet weight was in the 15 ml/L (B3) treatment of 4.63 grams. Likewise, for the dry weight variable of plants where based on Figure 6, the highest average was in the 15 ml/L (B3) treatment of 0.32 grams. However, the 15 ml/L (B3) treatment was not significantly different from the 5 ml/L (B1) treatment, so the best concentration recommendation for the dry weight variable was the 5 ml/L (B1) treatment. According to research by Kasifah (2022), the application of PGPR of the bamboo root has been shown to significantly affect the wet and dry weight of Arabica coffee seedlings.

Although the bacterial content in the PGPR of bamboo roots in this study did not reach the minimum requirements, it could still support plant growth, especially plant wet weight, and dry weight, because PGPR is known to contain nutrients that can affect the process of photosynthesis and the chlorophyll content of wet plant weight. According to (Khanna et al., 2019) PGPR can streamline the process of photosynthesis to affect the increase in plant photosynthetic pigments. N-fixing bacteria and P-solvents can also increase the number of microorganisms in the planting medium, which are beneficial for plant growth. According to Rachmat et al. (2021), the interaction between beneficial bacteria in the PGPR of bamboo roots affects plant growth because the nutrients for the bacteria will increase and can colonize plant roots properly. Kasifah (2022) also explained that the interaction between N-fixing bacteria and P solvents would increase the availability of N and P nutrients so that they can increase and affect wet plant weight and dry weight.

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Based on the analysis of the resulting data, it was shown that the 15 ml/L (B3) PGPR of bamboo root concentration was the best treatment for increasing the yield of mustard greens. The yield is the wet weight after harvest which can be affected by the growth of mustard-green roots. This can be seen in the variable plant roots treatment of 15 ml/L (B3), which is also higher than the 5 ml/L treatment (B1). In addition to plant photosynthesis, plant wet weight is also affected by the amount of water absorbed. Plant roots affect the absorption of nutrients and water as well as a place for the growth of good bacteria for plants where the more prolonged the roots, the greater the absorption of nutrients. Following the statement of Jayantie et al. (2017) that the longer the volume and the more root hairs, the greater the absorbed nutrients. While the best treatment for mustard plant growth was the 5 ml/L (B1) treatment, the 10 ml/L (B2) treatment was smaller than the 5 ml/L (B1) treatment.

Based on the research of Kasifah (2022) states that the application of high concentrations of PGPR in the bamboo root can increase the number of microorganisms to fix N2 from the air and phosphate bacteria as a provider of phosphate in the soil as well as a biostimulant capable of stimulating and spurring plant growth. The decrease in growth was due to the leaves of the mustard plants in the 10 ml/L (B2) treatment tended to be fewer and smaller (Figure 7) due to pest attacks which affected the photosynthetic process of plants so that it also affected plant growth such as plant height, number of leaves, root length and root volume. Should the provision of high PGPR of bamboo root concentrations contain more PGPR bacteria, it can increase the population of microorganisms in the soil and increase the availability of nutrients in the soil and crop production. According to Lehar et al. (2018), the function of PGPR in plant growth is as biostimulants, biofertilizers, and bioprotectants. Biostimulants will later produce phytohormones to stimulate growth, biofertilizers to increase crop production by making fertilization efficient, and bioprotectants to protect plants from pathogens (Kasifah, 2022).

Figure 6. Yield of green mustard after 35 days

Conclusion

Based on the results of the study, it can be concluded that (1) the combination of Liqquid Organic Fertilizer (LOF) rabbit urine and PGPR bamboo root had no significant effect on all observational variables, (2) administration of LOF of rabbit urine had no significantly different effect on all observational variables and (3) concentration The PGPR of bamboo roots had a

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significantly different effect on all plant variables except root volume and the number of leaves, where the 15 ml/L (B3) treatment gave the best results on mustard greens. The LOF can provide sufficient nutrition for plants without having to use chemicals that are harmful to the environment and health. Apart from that, LOF can also improve soil quality, increase the availability of nutrients for plants, increase plant resistance, and prevent soil erosion. For future research directions, researchers suggest providing additional organic materials when making rabbit urine LOF so that it can increase the nutrient content of N, P and K.

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