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Original Research

Effect of organic waste variations as materials for making MOL on the growth of pakcoy (*Brassica rapa*) plants

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Abstract
Organic waste is still a problem in the community because it can cause health, environmental and life problems. MOL (*local microorganisms*) is one of the alternatives to the use of organic waste that acts as plant fertilizer. The purpose of this study is to determine the influence of variations of organic waste as a material for making MOL on the growth of pakcoy plants (*Brassica rapa*). This study used a Group Random Design (RAK) consisting of 5 types of MOL, namely fruit waste (M1), vegetable waste (M2), banana hump (M3), mixed fruit waste, vegetables and banana hump (M4), and control (M5). Various types of MOL are analyzed for nutrient content at the end of fermentation and then applied to pakcoy plants. The observed growth parameters included plant height, number of leaves and plant root length, which was followed by statistical analysis of Anova. The observed nutrient test parameters are total nitrogen content, organic carbon, phosphorus, C/N ratio and pH level. Based on research, the nutrient content of various types of MOL has not met the test standards for organic fertilizers according to the Decree of the Minister of Agriculture of the Republic of Indonesia Number 261/KPTS/SR.310/M/4/2019. Only the M2 treatment has been in accordance with the C/N ratio of the organic fertilizer standard. For its effect on plant growth, MOL fruit waste (M1) is able to increase plant height and the number of leaves of pakcoy plants at 35 days after planting. However, the treatment of various MOL variations has not been able to affect the root length parameters. Thus, the application of MOL can be used as a liquid organic fertilizer to increase plant growth.

Keywords: banana hump; fruit waste; local microorganisms; vegetable waste

1. Introduction

Human activities can never be separated from waste, ranging from household waste to industrial and market waste. Nationally, the volume of waste generation in 2023 is 23,076,803.26 tons/year. Organic waste is still the largest type of waste produced with a percentage of 52.98% (Kementerian Lingkungan Hidup, 2024). Waste generation in Yogyakarta Province itself is 1,231.55 tons/year in 2023, with the volume of waste handled only at 61.39% (Badan Perencanaan Pembangunan Daerah, 2024). The amount of garbage or waste that accumulates can result in health, environmental and life problems.

The 3R movement (reduce, reuse, recycle) is an alternative solution that can be applied in society. One of them is the use of vegetable and fruit waste that is widely wasted in traditional markets and household waste as materials for making organic fertilizer. Vegetable waste usually consists of ingredients that have a lot of water content, so they decompose quickly. Liquid organic fertilizer products that can be made include Local Microorganisms (MOL). MOL solution contains macro and micro nutrients for plants (Suhastyo et al., 2013). In addition, Handayani et al., (2015) stated that MOL contains microorganisms that have the potential to be a refiner of organic matter, a growth stimulator, and a pest and disease control agent for plants, so that it is good for decomposers, biofertilizers, and organic pesticides.

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Organic waste contains various elements that are beneficial for soil fertility, so it has the potential to become a raw material for MOL. The content in organic waste includes nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), iron (Fe), sodium (Na) and vitamins (Syamsiah et al., 2021). Banana hump MOL is reported to contain various phosphate solvent microorganisms such as *Bacillus sp., Aeromonas sp and Aspergillus sp.* (Suningsih et al., 2019). The application of rice seed soaking in banana hump MOL is able to affect the growth and productivity of Ciherang rice plants, including the parameters of plant height, panicle length, panicle weight and seed weight (Sigit et al., 2023). The MOL of banana humps also affects the growth of caisim plants (*Brassica juncea L.*) with a wick system (Fahmi et al., 2020).

In addition to banana humps, MOL of vegetable and fruit waste was proven to affect plant height, number of leaves, pod weight in mung bean plants (*Vigna radiata L.*) at 14 HST (Anwar et al., 2023). Abadi et al. (2022) researched the growth and productivity response of tomato plants to various doses of MOL of fruit waste. The administration of a dose of 30 mL/plant was able to increase plant height, number of leaves, number of fruits, and fruit weight. Research by Marantika and Suharti (2019) also showed the effect of mixing MOL of fruit waste with MOL of vegetable waste on the growth of radish plants. The application of a mixture of the two types of MOL affects the height parameters of the plant significantly.

The effectiveness of MOL still depends on the main ingredient of its manufacture. In this study, the main ingredients derived from various organic wastes were used, including vegetable waste, fruit waste and banana bumps. One of the fruit wastes used is salak fruit (*Salaca zalaca*) which is the main fruit commodity from Sleman Regency, DI Yogyakarta Province. Therefore, this study aims to determine the effect of MOL variations of organic waste on the growth of pakcoy plants (*Brassica rapa*).

2. Research Methods

2.1. Preparation of Ingredients

The vegetable waste used is lettuce, mustard greens, cabbage, and green broccoli waste. Banana bulbs are taken from banana trees that have already borne fruit, about 8-10 months old. Vegetable waste and banana lumps were obtained around Nogotirto Village, Gamping, Sleman, DI Yogyakarta Province. The fruit waste used is papaya, banana and salak fruits. Fruit waste is obtained from traders in the Godean area, Sleman, DI Yogyakarta Province.

2.2. MOL Manufacturing

There are five variations of organic waste as ingredients for making MOL, namely M1 (fruit waste compared to 33% banana, 33% papaya and 33% salak), M2 (vegetable waste compared to 25% lettuce, 25% mustard, 25% cabbage, 25% green broccoli), M3 (banana lump waste), M4 (mixed waste with a ratio of 33.3% banana lumps, 33.3%, vegetable waste and 33.3% fruit waste), and M5 (control treatment using water). As much as 1 kg of ingredients are crushed or thinly sliced, then put into a plastic bucket. The ingredients are mixed with 2 L of rice washing water, 200 mL of molasses is added and stirred until evenly distributed. Then it is put into a plastic jar and tightly closed, then fermented for 15 days (Pujiastuti et al, 2021).

2.3. MOL Nutrient Testing

After 15 days of fermentation, the aroma and color produced are observed. The nutrient test for MOL was carried out at the Laboratory of the Agricultural Technology Assessment Center (BPTP) Yogyakarta. Nutrient testing includes testing nitrogen, phosphorus and organic carbon. Nitrogen testing

uses the Kjledah method, phosphorus with wet oxidation method while organic carbon testing uses the Walkey and Black method.

2.4. Sowing Pakcoy Seeds

Seeding is carried out in containers measuring 30 cm long, 20 cm wide, and 10 cm high. The medium used is a planting medium containing soil composition, compost and husk charcoal. The planting medium is put into a container, then moistened and the seeds are sown on the medium. Watering is carried out daily using a sprayer. After 2 weeks of age, the seedlings of pakcoy plants are ready to be transplanted on the prepared medium (Mursalim et al., 2018).

2.5. Application

MOL is applied as a liquid organic fertilizer to mustard plants by watering the top of the soil and then on the leaves and stems using a concentration of 100ml/L and a dose of 10 mL per plant. MOL is first applied to plants after 7 HST, then applied every 7 days (Mursalim et al., 2018).

2.6. Maintenance

The plants are placed in a green house at a temperature of 30^{o}C with a humidity of 60%. Irrigation at the beginning of growth is very necessary and is done regularly once a day. Weeding is carried out by looking at the condition of the plant and looking at the growth conditions of weeds. The application of biopesticides can be done if there is an attack of plant pests and diseases (Sasmita et al, 2019).

2.7. Measurement

Observation and measurement variables include plant height, number of leaves, wet weight, and root length. Measurements of plant height and number of leaves were carried out at 7, 14, 21, 28 and 35 HST, while the length of the plant was at 35 HST (Sasmita et al, 2019).

2.8. Data processing and analysis

Data processing and analysis included plant height, number of leaves, wet weight and root length of pakcoy plants using variant analysis (Anova). If it turns out that the results of Anova show that there is a real difference between the treatments, then continue using the Duncan test. The data from this study was also processed with the help of SPSS software version 16.

3. Results and Discussion

3.1. MOL Nutrient Content Test

The organic waste MOL is harvested on the 14th day of fermentation. A sour aroma resembling tapai appears on all variations of organic waste. This is in accordance with the opinion of Yunilas et al (2022) which states that MOL that is ready to use and is ripe is characterized by producing a sour aroma like tapai. This aroma is formed from the activity of microorganisms that hydrolyze carbon and produce various organic acids such as lactic acid and alcohol. In addition, fermentation also helps to breed the presence of microorganisms in organic waste that is beneficial for soil fertility and plant growth (Mawarni et al., 2024).

The change in the color of MOL that occurs during the fermentation process indicates that the manufacture of MOL has been successful. The color change occurs on 7 days of fermentation. After 15 days of fermentation, the MOL changes color to brownish. This is in accordance with the opinion of Ramli (2022), who stated that the indicator of the success of liquid organic fertilizer is dark brown liquid organic fertilizer.

The results of the nutrient content test analysis at the end of the fermentation process are presented in table 1. The nutrient content tested includes total nitrogen, organic carbon, phosphorus, pH and C/N ratio. The test value is compared with the Decree of the Minister of Agriculture of the Republic of Indonesia number 261/KPTS/SR.310/M/4/2019 concerning the minimum technical requirements for organic fertilizers, biological fertilizers and soil amendments.

Table 1. Nutrient Content of Various Variations of Organic Waste as Materials for Making MOL at the end of the Fermentation Process

Treatment	N-total (%)	C-organic (%)	Phosphorus (%)	C/N ratio	pH (%)
M1	0.05	2.00	0.03	40	3.10
M2	0.07	1.20	0.03	17.14	3.62
M3	0.03	1.45	0.02	48.33	2.80
M4	0.04	1.34	0.01	33.5	3.56
Minimum technical requirements for organic fertilizers	≥ 0.5	≥ 10	2-6	≤ 25	4-9

Information:
M1: fruit waste, M2: vegetable waste, M3: banana waste waste, M4: mixed fruit, vegetable and banana waste

All MOL treatments have total nitrogen values below the standards of the Decree of the Minister of Agriculture (table 1). The highest total nitrogen content in M2 is MOL of vegetable waste while the lowest total nitrogen content is produced in M3 treatment, the result of MOL of banana humps. This result is in line with the research of Gani et al. (2021), which stated that the organic nitrogen content in MOL was 0.22% after 31 days of fermentation. The low nitrogen content can be caused because the nitrogen content in MOL raw materials is still low. The low nutrient content in MOL is likely due to the lack of time in the fermentation process of organic waste (Walida et al., 2019).

Based on Table 1, the results of carbon analysis were the highest in the M1 treatment and the lowest in the M2 treatment, with values of 2.00% and 1.20%, respectively. The organic carbon content produced in organic fertilizers has not met the standards of the Decree of the Minister of Agriculture. The element carbon is a source of energy in the process of metabolism and cell multiplication by bacteria. The use of carbon for bacterial energy sources will produce organic acids, alcohols, and others (Yuwono, 2005).

For phosphorus content, the M1 and M2 treatments had the highest content, while the lowest results in the M4 treatment (table 1). However, the results of MOL phosphorus levels have not met the standards of the Decree of the Minister of Agriculture. The standard of the Decree of the Minister of Agriculture for phosphorus content ranges from 2-6% while the MOL variation only has a value of around 0.01-0.03%.

In the C/N ratio parameter, the M2 treatment has a result that has been in accordance with the Decree of the Minister of Agriculture of 17.14 (table 1). Other MOL variations still have a C/N ratio above the standard of the Decree of the Minister of Agriculture. The C/N ratio is an indicator of the maturity of organic fertilizers. The C/N ratio is obtained from the comparison between the organic carbon and nitrogen content, so that if there is a decrease in the organic carbon and nitrogen content.

Based on the pH results, all variations of MOL at the end of fermentation still have low pH levels (table 1). The highest pH result was in the M2 treatment with a result of 3.62. The lowest result of pH was found in the M3 treatment, which was 2.80. The pH in accordance with the standards of the Decree of the Minister of Agriculture ranges from 4-9. During the fermentation process, there tends to be a

decrease in temperature due to the activity of bacteria producing enzymes and organic acids (Viantini et al., 2022).

3.2. Effect of MOL on the growth of mustard plants

The growth observation paremeter in this application test includes plant length, number of leaves, and root length. The results obtained were then analyzed using the oneway annova average test with a duncan follow-up test.

Table 2. Growth parameters of pakcoy plants to the application of various MOL variations at 35 HST

Treatment	Plant Height (cm)	Number of leaves (strands)	Root length (cm)
M1	5.65^{a}	5.70^{a}	9.00^{b}
M2	4.40^{b}	3.85^{ab}	8.40^{bc}
M3	3.23^{cd}	3.85^{ab}	7.60^{bc}
M4	3.85^{bc}	4.15^{ab}	8.20^{bc}
M5	1.45^{e}	1.75^{c}	8.50^{bc}

Information: Numbers marked by different letters indicate statistically significant

The plant height parameter was obtained that the M1 treatment provided the largest value compared to other treatments (table 2). At the age of 35 HST, the average increase in the height of pakcoy plants applied by M1 was 5.65 cm. These results were significantly different from the control treatment (M5) which had a height of 1.45 cm at 35 HST. The M1 treatment also gave significantly different results from the M2, M3, and M4 treatments.

In the leaf count parameter, the M1 treatment still gave the largest value compared to other treatments (table 2). The average number of leaves treated with M1 was 5.70 at 35 HST. This value is significantly different from the control treatment (M5). However, the M1 treatment did not make any significant difference from other MOL treatments. This shows that the application of various variations of MOL is able to affect the number of leaves.

On the root length parameter, the MOL variation treatment did not have a significant effect between treatments including the control treatment (M5). The average root length was lowest in M3 treatment. However, the M1 treatment had the largest root length compared to the others, which was 9.00 cm (table 2).

Based on the results of the application of MOL to plant growth, the treatment of MOL variation had better results compared to the control treatment. These results are in line with the research of Andilau et al. (2019) stating that the application of MOL at a dose of 60-150 cc/plant is able to increase the height and dry weight of plants. This is because MOL not only contains nutrients that play a good role in plant growth, but also rich in microorganisms that play a good role in helping plant growth.

According to Jeksen and Mutiara (2018), microorganisms contained in MOL have various important roles in supporting soil fertility. These microorganisms play a role in breaking down organic matter into inorganic elements that are available to plants and protecting plants from harmful bacteria. Microorganisms contained in MOL include *Lactobacillus*, *Actinomycetes*, *Saccharomyces* and phosphate-solvent microorganisms (Surotin & Purnomo, 2024). Therefore, MOL can also be used as an activator in composting (Dewantari & Sulastri, 2023).

In this study, the manufacture of MOL uses three main ingredients, namely sugar solution, rice washing water, and organic waste including vegetable waste, fruit and banana lumps. According to Hadi & Nastiti (2024), granulated sugar contains a type of sugar disaccharide, namely sucrose. Kusuma et al. (2017) said that the sugar solution is used as an energy source for microorganisms in MOL. Sugar solutions affect the activity of microorganisms because they are the main element of microorganism

cell formation. Sugar solutions are easily digestible substrates and are utilized as growth microorganisms.

Rice washing water has abundant content, including carbohydrates, fats, proteins, and vitamins. The carbohydrate composition of rice washing water is larger than other compositions, which is 85-90%. Rice washing water contains vitamins such as niacin, riboflavin, pyridoxine and thiamin, as well as potassium, magnesium, iron and other nutrients. These nutrients are beneficial for plant growth and the reproduction of microorganisms (Pratiwi, 2024). According to Laily and Palupi (2019), rice washing water has been used as a medium for bacterial growth considering its carbohydrate and vitamin content which can play a role in metabolism and can be converted into energy for its activities.

Vegetable waste, fruits, banana humps act as a source of microorganisms in MOL. In addition to being a source of microorganisms, the organic waste has the function of a source of nutrients for the propagation of MOL. The vegetable waste used is mustard greens, broccoli, lettuce and cabbage. According to several sources, the content of vegetable waste consists of water, protein, fat, carbohydrates, fiber, calcium, phosphorus, iron, sodium, potassium, vitamins (Nisa et al., 2016: Sari et al., 2015). Vegetable waste can be a good medium for the proliferation of decomposing microorganisms, and can be used as a bioactivator in the fermentation process (Suwatanti & Widyaningrum, 2017).

The fruit waste used contains phosphorus, potassium, nitrogen, vitamins and iron. The fruit waste used is bananas, papaya and salak. Salak fruit itself is a local commodity fruit produced in Sleman Regency. The use of fruit waste as a source of microorganisms in the manufacture of MOL is due to a large amount of microorganism contained in rotten fruits, in addition to the content of other elements also as a support for the proliferation of microorganisms in the fermentation process (Wulandari et al., 2019; Handayani et al., 2015)

Banana humps, which have been underutilized, can be used as a source of microorganisms. Banana humps themselves contain proteins, fats, carbohydrates and minerals such as calcium, phosphorus and iron, vitamin B1 and vitamin C. According to Suhastyo (2011), banana humps contain microorganisms that decompose organic matter. Banana hump MOL has a role in increasing plant vegetative growth and is more tolerant of disease. The high level of phenolic acid helps the binding of Al, Fe, and Ca ions so that it helps the availability of soil P which is useful in the flowering process (Setianingsih, 2009).

4. Conclusion

The analysis of the nutrient content of various variations of MOL of organic waste at the end of the fermentation process is not in accordance with the standards of the Decree of the Minister of Agriculture Number 70/Decree of the Minister of Agriculture/SR.140/10/2011. Only the M2 treatment has met the C/N ratio standard of the Decree of the Minister of Agriculture with a value of 17.14. However, based on application data, various variations of MOL of organic waste have been able to affect the growth of pakcoy plants after 35 HST.

This is shown by the parameters of plant height and number of leaves in the treatment of various MOL variations which have real results different from the control treatment. The M1 treatment (fruit waste) had the greatest results among other MOL treatments. While the root length parameter did not provide a significant difference for all MOL treatments. Therefore, MOL treatment was proven to have an effect on plant height growth and the number of leaves of pakcoy plants. Although improving the quality of MOL raw materials is still needed to increase the nutrient content at the end of the fermentation phase. MOL is one of the appropriate technologies that is able to provide an alternative to providing cheap organic fertilizer and reduce the accumulation of organic waste in the community.

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