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Improving the quality of organic fertilizer by utilizing local microorganisms (LMO) of cassava tapai

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ABSTRACT

Local Micro Organism Solution (LMO Solution) is a fermentation solution made from various locally available resources, both plants and animals. The LMO solution contains micro and macronutrients and bacteria that have the potential to decompose organic matter in the soil, stimulate plant growth, and act as a pest and plant disease control agent. It is easy to obtain and makes it possible to increase farmers' desire to process agricultural waste. This research aims to determine the quality of organic fertilizer from livestock manure by utilizing local microorganisms (LMO) in cassava. This research was carried out from March 2023 to December 2023. The research was carried out at the Soil Laboratory of Hasanuddin University and the Greenhouse of the Faculty of Agriculture and Forestry, West Sulawesi University. The experimental design used in this planting test was a Completely Randomized Design (CRD), consisting of four LMO dose treatments, with each treatment carried out three times. The results of the research showed that the planting media provided by LMO tapai cassava had a significant effect on increasing the availability of the nutrients Nitrogen (N) and Phosphorus (P). The treatment regimen involving a dose of 240 ml (M3) showed the highest average values for nutrient content, specifically 0.25% for Nitrogen (N) and 13.75 ppm for Phosphorus (P2O5). Providing cassava tapai LMO in the planting medium had a significant effect on the average height of spinach plants at the observation time of 10 day after planting (DAT) and the average leaf weight. The M3 treatment showed the highest average value of plant height at 10 DAT of 7.17 cm and leaf weight of 0.73 g.

Keywords:
Bioactivator, Decomposer, Spinach

1. Introduction

Improper application of land management and continuously decreasing soil fertility can cause plant productivity to decrease [1]. According to Noegraha [2], efforts can be made to increase crop production and reduce farmers' dependence on inorganic fertilizers, it is necessary to encourage the development of technology that is more environmentally friendly, cheap, and sustainable, one of which is increasing organic fertilizer which utilizes organic waste such as manure cattle.

Utilizing livestock manure as organic fertilizer is a very appropriate alternative to overcome the problem of rising fertilizer prices [3]. However, until now, farmers have not used livestock manure as organic fertilizer optimally. Farmers' lack of knowledge about the use of livestock waste in organic fertilizer is one of the factors causing the low use of organic fertilizer by farmers. Therefore, a simple method is sought to utilize materials found in the environment so that it is easier for farmers to process their waste [4].

Organic fertilizer is fertilizer that comes from plant remains, animal or human waste such as manure, green manure, and compost in either liquid or solid form [5]. Apart from being a source of nutrients for plants, organic fertilizer can also play a role in increasing the biological, chemical, and physical activity of the soil so that the soil becomes fertile and good for plant growth [6]. One of the factors causing the low availability of organic fertilizer is the length of the composting process, so it is necessary to develop bioactivators that can shorten composting time and improve quality [7].

Local Micro Organism Solution (LMO Solution) is a fermented solution made from various locally available resources, both plants and animals. The LMO solution contains micro and macro nutrients and also bacteria that have the potential to break down organic matter in the soil, stimulate plant growth in plants, and act as pest and plant disease control agents [8]. LMO is often used as a bioactivator that can be made independently and is currently being widely discussed among farmers. Tapai LMO contains microorganisms such as tapai yeast, namely *Pediococuss, Bacillus*, *Amylomyces, Mucor, Rhizopus* sp., *Endomycopsis fibular, Saccharomyces cereviceae*, and *Hanseula* sp. [9]. The ease of obtaining and making it can increase farmers' desire to process agricultural waste.

Spinach is one of the vegetable plants consumed by people and comes from topical America. Spinach was initially known as an ornamental plant, but in its development, spinach was promoted as a food source of protein, vitamins, and contains mineral salts such as calcium, phosphorus, and iron [10]. Spinach plants have many types and varieties, both cultivated and wild, each of which is different. Indonesia grows two types of spinach plants, *Amaranthus tricolor* L., and *Amaranthus hybridus* L. *Amaranthus tricolor* L. is a non-kale plant and consists of two varieties, namely green spinach (white spinach, sekul spinach, or Chinese spinach) and amaranth [11].

Spinach is a vegetable that contains many nutrients, so spinach is called the King of Vegetables. 20 percent of the spinach content is a substance needed in the Nutritional Requirements Number (AKG). 100 grams of spinach contain 21 kcal of energy, 92.9 grams of water, 0.2 grams of fat, 2.7 grams of carbohydrates, 2.1 grams of protein, 1.4 grams of ash, 0.7 grams of fiber, 29 grams of phosphorus, 90 mg of calcium, 3.8 mg of iron, 131 mg of sodium, 385 mg of potassium, 76.7 mg of vitamin C, folic acid, and oxalic acid. [12]. Based on the description above, this research aims to determine the quality of organic fertilizer from livestock manure by utilizing local microorganisms (LMO) of cassava tapai.

2. Methods

2.1. Research Materials

This research used bioactivators in the form of cassava tapai LMO. The method of making tapai cassava LMO was to mix organic waste containing carbohydrates with a brown sugar solution with a volume ratio of 1:1 as a food source for microorganisms. After that, the bacterial source (tapai cassava) was added, then stirred evenly and closed tightly. It was then stored for approximately 5–7 days while still checking until it gave off an aroma like the results of fermentation. If it had released an aroma, it indicated that the LMO was ready to use. Other additional materials include polybags; compost fertilizer obtained from Cahaya Buana, Bulukumba, Indonesia; and red spinach seeds obtained from Bintang Asia, Jember, Indonesia.

2.2. Experimental Design

The experimental design used in this planting test was a Completely Randomized Design (CRD), consisting of four LMO dose treatments, with each treatment carried out four times. Thus, the experimental units involved were 4 × 4 = 16 experimental units. The four doses of LMO used are as follows:

M0 = no LMO (Control)
M1 = LMO dose 80 ml/polybag
M2 = LMO dose 160 ml/polybag
M3 = LMO dose 240 ml/polybag

2.3. Data Collection

In this research, researchers obtained observation data through laboratory observations and field observations carried out in each experimental treatment. Laboratory observations for quality testing of chemical properties include macronutrient composition, namely C, N, K, and the C/N ratio. Meanwhile, field observations were to see the effect of organic fertilizer on plants directly with the parameters observed, namely plant height (cm), number of leaves per plant (strands), shoot dry weight (g), and root dry weight (g).

2.4. Data Analysis

Data were analyzed using analysis of variance (ANOVA) and if differences occurred, they was continued with the BNT Test [13]. If the treatment does not show a real effect, it will be displayed in graphic form in Microsoft Excel.

3. Results and Discussion

3.1. Nutrient Content of N, P, K and C/N Ratio in Planting Medium Added with LMO of Cassava Tapai

3.2.1. Nitrogen (N) Content

Table 1. Nitrogen (N) nutrient content in the planting medium added cassava tapai LMO

Treatment	N content (%)	Comparative Level	Criteria
M0 (Control)	0.10 a	0.10–0.20	Low
M1 (LMO 80 ml)	0.19 b	0.10–0.20	Low
M2 (LMO 160 ml)	0.22 b	0.21–0.50	Medium
M3 (LMO 240 ml)	0.25 b	0.21–0.50	Medium
Standard deviation	0.06		

Note: Numbers followed by the same lowercase letter are not significantly different at the 5% level in the BNT Test. The criteria listed in the Table 1 are based on the standard quality criteria for liquid fertilizer [14].

Based on the results of the analysis of variance (Table 1), shows that increasing the dose of cassava tapai LMO in the planting medium has a significant effect on increasing the nitrogen element. The results of the 5% BNT test showed that there was a difference in N levels in the planting medium that was not added with cassava tapai LMO (M0) and the planting medium that was added with cassava tapai LMO at different doses of M1, M2, and M3. Meanwhile, there was no difference between the planting medium added with LMO at a dose of 80 ml (M1), 160 ml (M2), and 240 ml (M3) in increasing N levels in the planting medium.

The highest value of N content in the planting medium was shown in the M3 dose treatment, namely 0.25% with medium criteria, while the lowest value of N content in the planting medium was shown in the treatment without LMO (M0), namely 0.10% with low criteria. This shows that giving cassava tapai LMO can increase the N content in the planting medium, which will then help in the plant growth process, especially in the process of photosynthesis. This is in line with the opinion expressed by Hartini et al. [15]. That the nitrogen element is needed for plant growth because it helps the photosynthesis process. The increase in photosynthesis results corresponds to an increase in the quantity of chlorophyll within the leaves, where chlorophyll is obtained from the nitrogen element.

3.2.2. Phosphorus (P) Content

Table 2. The P_2O_5 (ppm) nutrient level in the planting medium added cassava tapai LMO

Treatment	Olsen P_2O_5 levels (ppm)	Comparative Level	Criteria
M0 (Control)	9.97 a	<10	Very low
M1 (LMO 80 ml)	12.09 ab	10–25	Low
M2 (LMO 160 ml)	12.72 b	10–25	Low
M3 (LMO 240 ml)	13.75 b	10–25	Low
Standard deviation	1.57		

Note: Numbers followed by the same lowercase letter are not significantly different at the 5% level in the BNT Test. The criteria listed in the Table 2 are based on the standard quality criteria for liquid fertilizer [14].

Based on the results of the analysis of variance (Table 2), it shows that increasing the dose of cassava tapai LMO in the planting medium has a significant effect on increasing the Phosphor (P) element. The results of the 5% BNT test showed that there was a difference in P levels in the planting medium that was not added with cassava tapai LMO (M0) and the planting medium that was added with cassava tapai LMO at a dose of 160 ml (M2) and a dose of 240 ml (M3), but it was not significantly different with an additional dose of 80 ml (M1). Meanwhile, there was no difference between the planting medium added with LMO at a dose of 80 ml (M1), 160 ml (M2), and 240 ml (M3) on the increasing P levels in the planting medium.

The highest value of P level in the ppm has very low criteria. This shows that giving cassava tapai LMO can increase the element P content in the planting medium. The P nutrient is one of the essential nutrients that plants need in large or macro quantities. The P nutrient has a considerable and important role in plant growth after the N element. According to Kurniawati et al. [16], the P element is the most important nutrient for plants after N. This element is an essential part of various phosphate sugars, which play a role in reactions in the dark phase of photosynthesis, respiration, and various other metabolic processes. P is also part of nucleotides (in RNA and DNA) and phospholipids, which make up membranes. Planting medium was shown in the M3 dose treatment, namely 13.75 ppm with low criteria, while the lowest value of P content in the planting medium was shown in the treatment without LMO (M0), namely 9.97.

3.2.3. *Potassium (K) Content*

Table 3. The Potassium (K) nutrient level in the planting medium added cassava tapai LMO

Treatment	K-dd (CLMO.kg^{-1})	Comparative Level	Criteria
M0 (Control)	0.14 a	0.1–0.2	Low
M1 (LMO 80 ml)	0.21 a	0.1–0.2	Low
M2 (LMO 160 ml)	0.27 a	0.1–0.2	Medium
M3 (LMO 240 ml)	0.29 a	0.1–0.2	Medium
Standard deviation	0.06		

Note: Numbers followed by the same lowercase letter are not significantly different at the 5% level in the BNT Test. The criteria listed in Table 3 are based on the standard quality criteria for liquid fertilizer [14].

Based on the results of the analysis of variance (Table 3), it shows that increasing the dose of cassava tapai LMO in the planting medium has no significant effect on increasing the Potassium (K) element. Although there is no real effect between giving cassava tapai LMO and the addition of K elements to the planting medium, (Table 3) indicates a proportional increase in the average potassium levels within the planting medium with the escalating dosage of LMO. The highest value of K level in the planting medium was shown in the M3 dose treatment, namely 0.29 CLMO.kg^{-1} with low criteria, while the lowest value of K level in the planting medium was shown in the treatment without LMO (M0), namely 0.14 CLMO.kg^{-1} with low criteria. For plant growth, element K has an essential function. The function of potassium (K) for plants is to form starch, activate enzymes, open stomata (regulate respiration and evaporation), regulate the physiological processes of plants and metabolic processes of cells, influence the absorption of other elements, increase resistance to drought and disease, and support root development. Apart from that, the function of K is to strengthen plant structures, because this element can strengthen tissue cells in plants [17].

3.2.4. *The C/N Ratio*

Based on the results of the analysis of variance (Table 4), it shows that increasing the dose of cassava tapai LMO in the planting media has a significant effect on decreasing the C/N ratio. The results of the 5% BNT test showed that there was a difference in C/N ration in the planting media that was not added with cassava tapai LMO (M0) and the planting media that was added with cassava tapai LMO at different doses of M1, M2, and M3. Meanwhile, there was no difference between the planting media added with LMO at a dose of 80 ml (M1), 160 ml (M2), and 240 ml (M3) in decreasing the C/N ratio in the planting media.

The lowest value of C/N ratio in the planting media was shown in the M3 dose treatment, namely 11.50 with medium criteria, while the highest value of C/N ratio in the planting media was shown in the treatment without LMO (M0), namely 20.00

Table 4. The C/N ratio in planting media added to cassava tapai LMO

Treatment	C/N Ratio	Comparative level	Criteria
M0 (Control)	20.00 a	18–25	High
M1 (LMO 80 ml)	12.50 b	11–18	Medium
M2 (LMO 160 ml)	14.00 b	11–18	Medium
M3 (LMO 240 ml)	11.50 b	11–18	Medium
Standard deviation	3.80		

Note: Numbers followed by the same lower-case letter are not significantly different at the 5% level in the BNT test. The criteria listed in Table 4 are based on the standard quality criteria for liquid fertilizer [14].

with high criteria. This shows that increasing the dose of cassava tapai LMO has an effect on reducing the C/N ratio of the compost used as one of the components in planting media. The C/N ratio value lower than 20 indicates that the fermentation process of organic material is almost perfect or nearly similar to soil. Organic material that has a C/N ratio of less than 20 can increase the availability of nutrients in the soil, especially Nitrogen content. According to Ramadan et al. [18], the C/N ratio is an indicator of the quality and maturity level of the compost material. The degradation process that occurs in composting requires organic carbon (C) to provide energy and growth, and nitrogen (N) to fulfill protein as a building block for metabolic cells. The effective C/N ratio for the composting process ranges from 30 to 40. Microorganisms break down C compounds as an energy source and use N for protein synthesis. At C/N values between 30 to 40, microbes get enough C for energy and N for protein synthesis. If the C/N value is too high, microbes will lack N for protein synthesis, so decomposition is slow. Compost with a low C/N ratio will contain a lot of ammonia (NH_3) produced by ammonia bacteria. This compound can be further oxidized to become nitrites and nitrates, which are easily absorbed by plants.

3.2. *Plant Height, Number of Leaves, Leaf Weight, and Root Weight of Spinach Plants*

3.2.1. *Plant Height*

Table 5. Average height of spinach plants after being given cassava tapai treatment

Treatment	Average Plant Height (cm)		
	10 DAP	20 DAP	30 DAP
M0 (Control)	3.80 a	17.67 a	32.00 a
M1 (LMO 80 ml)	4.83 ab	21.83 a	35.47 a
M2 (LMO 160 ml)	5.70 ac	22.80 a	36.53 a
M3 (LMO 240 ml)	7.17 c	25.83 a	39.83 a
Standard deviation	1.42	3.37	3.22

Note: Numbers followed by the same lowercase letter are not significantly different at the 5% level in the BNT Test. DAP = Days After Planting

The results of the analysis of variance showed that the application of LMO to the planting media had a significant effect on the height of the spinach plants at the age of 10 DAP (Table 5). The results of the 5% BNT test showed that at the age of 10 DAP, plant height was significantly different between treatments without LMO (M0) and 240 ml LMO (M3). Meanwhile, treatment without LMO (M0) and treatment with LMO giving doses of 80 ml (M1) and 160 ml (M2) showed results that were not significantly different a plant age of 10 DAP on spinach plant height.

Providing LMO to the planting medium at a dose of 240 ml (M3) showed the highest values at plant ages of 10, 20, and 30 DAP, namely 7.17 cm, 25.93 cm, and 39.83 cm. Giving the highest dose of cassava tapai can increase the height of spinach plants and have a significant effect on the initial growth of plants at 10 DAP because the planting medium in treatment M3 has a higher nutrient content than treatments M0, M1, and M2, so that spinach plants in treatment M3 had greater plant height than the other 3 treatments. According to Feriyatna et al. [19], plants need compounds derived from nutrients for their growth, so the availability of nutrients is very important for plants.

3.2.2. Number of Leaves

Table 6. Average number of leaves of spinach plants after being given cassava tapai treatment

Treatment	Average Number of Leaves		
	10 DAP	20 DAP	30 DAP
M0 (Control)	5.67 a	12.00 a	25.00 a
M1 (LMO 80 ml)	6.00 a	15.67 a	29.67 a
M2 (LMO 160 ml)	6.00 a	16.00 a	33.67 a
M3 (LMO 240 ml)	6.33 a	19.33 a	35.33 a
Standard deviation	0.26	2.99	4.60

Note: Numbers followed by the same lowercase letter are not significantly different at the 5% level in the BNT Test. DAP = Days After Planting

The results of the analysis of variance (Table 6) show that the application of LMO to the planting medium had no significant effect on the number of spinach plant leaves in all observations. Even though it did not have a real effect, the application of cassava tapai LMO to the planting medium was recorded to increase the average number of leaves of spinach plants. Giving LMO with the highest dose of 240 ml (M3) gave the highest average number of leaves at all observation times of 10 DAP, 20 DAP, and 30 DAP, with an average number of leaves of 6.33, 19.33, and 35.33 sheets. The high number of leaves in the M3 treatment is because in this treatment the nutrients produced, especially Nitrogen nutrients, have the highest nutrient content value compared to other treatments. If the nitrogen nutrient content in the soil or other growing media is sufficient for plants, the photosynthesis process will run actively, which will then cause cell division and elongation to take place properly. According to Kogoya et al. [20], Nitrogen is a nutrient needed for plant vegetative growth. The availability of macronutrients (Nitrogen) in sufficient quantities during vegetative growth causes the photosynthesis process to run actively, so that cell division, elongation, and differentiation will run well. Plant growth is the process of increasing the number of cells, cell size, and cell differentiation. Plant growth is influenced by the activities of the plant meristem, namely the tip meristem, which is a network of plant cells that produces new cells at the tips of the roots and shoots, thus making the plant grow taller and longer. The fresh weight of the canopy includes stems and leaves, which means the accumulation of photosynthesis results and is influenced by the availability of nutrients. Nitrogen nutrients are nutrients needed for the vegetative growth of plants such as roots, stems, and leaves.

3.2.3.Root Weight and Leaf Weight

Table 7. Average weight of roots and leaves of spinach plants after being given cassava tapai treatment

Treatment	Root Weight (g)	Leaf weight (g)
M0 (Control)	0.27 a	0.33 ab
M1 (LMO 80 ml)	0.33 a	0.47 b
M2 (LMO 160 ml)	0.60 a	0.57 bc
M3 (LMO 240 ml)	0.77 a	0.73 c
Standard deviation	0.23	0.16

Note: Numbers followed by the same lowercase letter are not significantly different at the 5% level in the BNT Test.

The results of the analysis of variance showed that the application of LMO to the planting medium had a significant effect on the leaf weight of the spinach plants and had no significant effect on the weight of the roots of the spinach plants (Table 7). The results of the 5% BNT test showed that there was a difference in the leaf weight of spinach plants between the treatment without giving LMO to the planting medium (M0) it was not significantly different from giving LMO at a dose of 80 ml (M1) and a dose of 180 ml (M2). Meanwhile, the leaf weight treated with LMO at a dose of 240 ml (M3) was significantly different from that given LMO at a dose of 80 ml (M1) and without LMO (M0), but was not significantly different from that given LMO at a dose of 160 ml (M2). The highest value of spinach leaf weight was shown in the M3 dose treatment, namely 0.73 g. This indicates that administering 240 ml of cassava tapai LMO can provide the best performance in increasing the leaf weight of spinach plants compared to the lower doses. The observed phenomenon is attributed to a low C/N content, which is below 20% in M3 treatment. If the C/N ratio of the compost is below 20%, then the compost has reached a mature condition so that it can provide adequate nutrients for plant growth. According to Haruna et al. [21], the faster the organic material decomposes, the faster the essential nutrients will be available to plants. According to Ramadan et al. [22], the importance of the C/N ratio of an organic material (OM) is related to the effect of OM on the availability of N for plants and the rate of OM decomposition in the soil. A low C/N ratio means OM contains a lot of N and is easily decomposed, so it quickly supplies N for plants. On the other hand, OM with a high C/N ratio will be difficult to decompose and can cause low N availability for plants. According to Siswanto et al. [23], if plants get enough N, their leaves will grow big and expand their surface. The broad leaf surface allows it to absorb more sunlight so that the photosynthesis process takes place more quickly. As a result, the photosynthesis formed will accumulate in plant weight, which is the economic result of spinach plants.

4. Conclusion

Based on the results of the research that has been carried out, it can be concluded that overall, the administration or mixing of cassava tapai LMO in compost and soil planting medium can significantly increase the availability of the macronutrients of Nitrogen and Phosphorus. The highest increase in nutrients in the planting media occurred in the treatment with the highest LMO dose, namely 240 ml. The increased availability of nutrients in the planting medium then affects plant height and leaf weight of spinach plants. The treatment of cassava tapai LMO with a dose of 240 ml significantly increased the plant height and leaf weight in spinach plants during the observation period.

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