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The Effect of Bioactivator and Biochar Types on The Organic Waste Composing Process

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Abstract

Background: Combining the right bioactivator and biochar dosage can speed up the process and increase the compost quality. Using compost in agriculture can reduce the excessive use of chemical fertilizers, improve soil health and crop yields, and contribute to overall agricultural sustainability. **Methods:** The research was conducted in March-August 2021 in Kemantren Village, Tulangan District, Sidoarjo Regency. Analysis activities were conducted at the Land Resources Laboratory, Faculty of Agriculture, UPN "Veteran" East Java. This research uses a factorial experimental design based on CRD (Completely Randomized Design) and consists of two factors. Factor 1 is the type of bioactivator, namely: A0: Control; A1: Cattle Farmer; A2: Tapai; and A3: Banana Beetle. Factor 2 provides biochar: B0: Control; B1: 200 grams; and B2: 300 grams. Observation data were analyzed using Analysis Of Variance (ANOVA). Then, if there is a real difference between treatments, the Honest Significant Difference (BNJ) test is carried out with an error rate of 5%. **Results:** The research results showed that the best compost was the use of a banana hump cultivator, while the best biochar was 200 g. The best results from the combination of bioactivator and biochar were the application of 200 g of cow manure and banana hump bioactivator. **Conclusions:** The combination of banana stem bioactivators and cow dung with 0 gr biochar (control) improved the quality of the chemical properties of the compost. In contrast, adding biochar at both 200 g and 300 g concentrations showed improvements in the physical quality of the compost texture.

Keywords: bioactivator; biochar; compost; soil properties

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Introduction

Waste is one of the factors that causes environmental damage and is still a big problem today. Based on the chemical content, waste is divided into inorganic waste and organic waste. Most inorganic waste like plastic and metal does not experience heat. In contrast, organic waste generally experiences heat, such as leaves, food, and vegetable waste, which is very easy to find in traditional markets. Widarti et al. (2015) stated that vegetable waste from the market is generally not processed by throwing it directly into the final place. This is very disappointing, considering the potential for waste to become organic compost fertilizer. According to Cahaya & Adi (2009), one way to manage organic waste is to use it in organic compost. Compost contains nutrients for plants. Using compost in agriculture can reduce the excessive use of chemical fertilizers. Managing organic waste into compost is also a solution to agricultural problems and environmental problems, such as increasing land fertility and contributing to reducing the effects of greenhouse gases.

Compost results from the fermentation of organic materials from plants, animals, or organic waste. The use of compost in agriculture can provide good results in soil structure, drainage, and porosity, absorb and activate nutrient elements, strengthen the binding capacity of aggregates in sandy soil and increase air absorption; composting is the decomposition process of organic material due to the activity of microorganisms in a specific environment. Composting produces a product (compost) that has the function of increasing soil fertility. Good compost raw materials from organic waste are organic materials with high carbon and nitrogen content, such as fruit or vegetable waste and dry leaf litter. These materials are easily decomposed and nutrient-rich (Purwendro, 2006).

Making compost requires bioactivators to speed up the composting process. Bioactivators are liquid substances rich in local microorganisms and can generally be made from kitchen waste. The main composition of the bioactivator is a medium for the growth of microorganisms and living microbial cells. Apart from speeding up composting, the advantages of using bioactivators are that they reduce the smell of waste, provide fertility to the soil, and can be used as a starter for making liquid fertilizer. Hermawan (2014) stated that compost requires bioactivators to speed up composting. Bioactivators can be made from household waste, and the resulting solution is rich in local microorganisms. The material forming the bioactivator functions as a growth medium for microorganisms and living microbial cells. Other advantages of using bioactivators, apart from speeding up the compost-making process, are minimizing unpleasant odors in waste, increasing soil fertility, and being a starter for making liquid organic fertilizer. Materials for making bioactivators can come from stale rice, banana stems, bamboo shoots, golden snails, maja fruit, vegetable scraps or market waste, household waste, and so on. The characteristics of a bioactivator liquid that is finished or has gone through a fermentation process is that it will smell like tape. The types of microbes found in banana weevil bioactivators include *Bacillus* sp., *Aeromonas* sp., and *Aspergillus nigger*; these microbes can break down organic materials (Tanmenu, 2024).

Biochar is added to the composting process. Biochar is black charcoal, which burns organic material without or with limited oxygen. Biochar is used as another option for fresh organic materials in soil management. Researchers aim to develop this technology to overcome critical or degraded land conditions and improve soil quality. One of the functions of biochar as a bulking agent in the composting process is to strengthen the humification process and the final quality of the compost. Rice husk biochar can be used as a fertilizer companion to bind nutrients contributed by fertilizer and increase fertilization efficiency. The combined application of 8 tons of rice husk biochar ha-1 and 30 tons of compost ha-1 affects increasing pH, organic C, and P-available Ultisol in incubation soil and soil with corn plants (Herhandini, 2021).

This research shows the effect of adding types of bioactivator and biochar on the process and quality of compost. Furthermore, it is hoped that the combination of the right bioactivator and biochar dosage can be found to speed up the process and increase the compost quality. The potential to increase compost production has a more significant impact on sustainable agricultural practices. This will improve soil health and crop yields and contribute to rural sustainability. It is important to continue researching and promoting the use of compost to create a more sustainable and environmentally friendly food system for future generations.

Methods

This research was carried out from March to August 2021 in Kemantren Village, Tulangan District, Sidoarjo Regency. This analysis was conducted at the Land Resources Laboratory, Faculty of Agriculture, National Development University "Veteran" East Java. The tools used include plastic buckets, stirrers, measuring cups, scales, scissors, sieves, sprayers, drums, thermometers, pH meters, and tools for analyzing compost content in the laboratory. The materials used in this research include cow manure bioactivator, banana weevil bioactivator, tapai bioactivator, biochar, vegetable waste, lamtoro leaves, sugar cane molasses, sawdust, dry leaves, water, trash bags, and chemicals used during laboratory analysis.

Experimental design

This research is a factorial design experiment prepared based on CRD (Completely Randomized Design), which consists of two factors and is repeated three times. Factor 1st is the provision of bioactivators consisting of 4 levels. Factor 2nd is the provision of biochar, which consists of 3 levels. Factor 1st consists of 4 levels: A0: No bioactivators (control); A1: Cow Manure Bioactivator; A2: Tapai Bioactivator; and A3: Banana Weevil Bioactivator. Factor 2nd consists of 3 levels, namely: B0: No Biochar (control); B1: Biochar 200 g; and B2: Biochar 300 g.

Research procedure

There are three bioactivators used to compare compost quality: cow manure, banana weevil, and tapai. The cow manure bioactivator prepares 500 g of lamtoro leaves, 500 g of cow manure, 100 ml of molasses, and 4 l of clean water. All ingredients are stirred until evenly mixed and stored in a closed container for 14 days to ferment. The banana weevil bioactivator is made by mixing 1 kg of clean and cut banana weevil, 500 g of lamtoro leaves, and 100 ml of molasses. All ingredients are stirred until evenly mixed and stored in a closed container for 14 days to ferment. Making tapai bioactivation, namely preparing 1 ounce of tapai, 100 ml of sugar cane molasses, and 500 grams of tapai. Lamtoro leaves. All ingredients are stirred until evenly mixed and stored in a closed container for 14 days to ferment.

Making biochar in this research follows the research method of Djaenudin (2007), namely the open system method using ram wire. Biochar is made by preparing materials derived from agricultural waste in dry rice husks, which are placed in a circle around a wire ram. Then, burn charcoal and dry banana leaves into the wire ram. This method takes approximately 4-6 hours until the husk is charcoal black.

Parameter determination

The sampling technique used is random sampling. Namely, samples are taken randomly from mature compost fertilizer in each sample. The samples are labeled and put into plastic clips. They are prepared and analyzed at the Land Resources Laboratory of the Faculty of Agriculture, National Development University "Veteran" East Java.

pH measurement

pH by preparing 5 grams of air-dried samples weighed, put into a 50 mL beaker, 12.5 mL of distilled water is added to the beaker, the mixture of samples and water in the beaker is stirred for 30 minutes, then the pH is measured with a pH meter.

N-Total

The soil's N content analysis is determined using the Kjeldahl method: shaking the extract by pipetting 2 ml of extract and 5 ml of distilled water into a test tube using a shaker. The extract is pipetted as much as 2 ml, and tartrate and na-phenate buffer solutions are added, each given 5 ml, and then shaken for 10 minutes. The addition of hypochlorous acid (NaOCl) is then shaken using forex until homogeneous. Measurement of N levels is carried out using a spectrophotometer at a wavelength of 636 nm (Soil Research Institute, 2005).

P2O5 concentration

Measurement of phosphorus concentration using the Spectrophotometry method reference (Horwitz, 2000). P2O5 testing is carried out using concentrated HNO3 and concentrated HClO heated at high temperatures. The clear extract was taken and added with distilled water, 2N HNO3, and Vanadate solution, then left for 30 minutes and observed on a spectrophotometer at a wavelength of 650 nm and compared with the standard solution (0, 2.5, 5.0; 7.5; 10; 12, 5;

K2O content

The measurement of potassium concentration was carried out based on the Flamephotometry method (Horwitz, 2000). K2O measurements were carried out using concentrated HNO3 and concentrated HClO heated at high temperatures. Then, the clear extract was taken and added with distilled water, 2N HNO3, and Vanadate solution, then observed on a Flame photometer and compared with the standard solution (0; 5; 10, 15, 20 ppm).

K (%) = ppm curve × ml extract 1000 mL × 100mg sample-1 fp × fk

Note:
Ppm curve: sample concentration obtained from the regression curve of the relationship between the concentration of the standard series and its reading minus the blank.
Fp : dilution factor
Fk : correction factor air concentration: 100/(100 - % air content)
100 : conversion factor to %

Water content

The air content in compost can be measured gravimetrically by determining the weight loss of the sample after being placed in the oven for a specific time. In the gravimetric method, it is assumed that some air is lost during the drying process. According to (Murbandono, 2008), the principle of the gravimetric method states that the air contained in the compost will evaporate if the compost material is heated at a temperature of 105^{o}C for a specific time until it reaches a constant weight. The difference between the weight of the compost before and after being heated is the air content contained in the compost.

Physical Parameters of Mature Compost (temperature, color, odor, and texture)

The physical quality of mature compost includes color, odor, and texture. Color and odor are references in determining mature compost and unmatured compost. Compost that is suitable or mature has a blackish-brown color. Mature compost has an odor that resembles the smell of soil, is crumbly in texture, and experiences a decrease in temperature (SNI 19-7030-2004). Observations of compost maturation are carried out once a week and assessed through respondent assessments. The temperature and humidity variables of the compost pile are observed twice a week using a digital temperature and humidity device. Measurements are made by inserting the end of the tool's sensor rod right in the middle of the compost pile. Temperature and humidity measurements are carried out to maintain the condition of the media when the waste becomes compost.

Data Analysis

The observational data from the experiment is then explained to determine the effect of the treatment applied using Analysis Of Variance (ANOVA) with the F test at an error rate of 5%. If there is a fundamental difference between the treatments, it is continued with a further test of Honest Significant Difference (HSD) at an error rate of 5%.

Result

The results of the analysis of variance showed that the bioactivator and biochar treatments each showed a single significant effect on the parameters of soil C-organic, soil organic matter, soil N-total, C/N Ratio, P-total, and K-total, but soil pH did not influence each treatment (Table 1; Table 2).

Table 1. Effect of bioactivator application on soil pH, soil C-organic, soil organic matter, soil N-total, C/N Ratio, P-total, and K-total.

Bioactivator Treatment	pH	C-organic	N-total	C/N ratio	P-total	K-total	Organic Matter
A0 (control)	6.89	25.63a	2.03ab	13.54bc	0.21ab	2.12a	44.19ab
A1 (cow manure)	7.00	24.63a	2.43b	9.87a	0.22b	2.82b	42.46a
A2 (tapai)	6.82	27.08b	2.03ab	13,14b	0.20ab	2.75b	46.68b
A3 (banana weevil)	6.74	27.19b	1.70a	16.02c	0.19a	2.99b	46.88b
BNJ 5%		2.21	0.42	2.83	0.03	0.47	3.81

Description: The average number followed by the same letter in the same column and treatment shows no significant difference in the 5% BNJ test;

Table 2. Effect of bioactivator application on soil pH, soil C-organic, soil organic matter, soil N-total, C/N Ratio, P-total, and K -K-total.

Biochar Treatment	pH	C-organic	N-total	C/N ratio	P-total	K-total	Organic Matter
B0 (control)	7.14	35.63c	2.71b	13.47ab	0.26b	3.17b	61.43c
B1 (200 grams)	6.74	24.31b	1.76a	14.53b	0.18a	2.43a	41.91b
B2 (300 grams)	6.71	18.45a	1.66a	11.42a	0.19a	2.34a	31.82a
		1.73	0.33	2.21	0.025	0.36	2.99

Description: The average number followed by the same letter in the same column and treatment shows no significant difference in the 5% BNJ test;

This was conveyed in treatments A1 (Table 1), B0 (Table 2), and A1B0 (Table 3). The soil pH obtained was 7, 7.14, respectively, and 7.58.

Table 1. Effect of applying a combination of bioactivator and biochar on soil pH.

Bioactivator Biochar	A0 (control)	A1 (cow manure)	A2 (tapai)	A3 (banana weevil)
B0 (control)	6.86	7.58	6.89	7.25
B1 (200 grams)	6.91	6.69	6.94	6.39
B2 (300 grams)	6.90	6.73	6.64	6.59

Table 4. Effect of combined application of bioactivator and biochar on soil C- organic.

Bioactivator biochar	A0 (control)	A1 (cow manure)	A2 (tapai)	A3 (banana weevil)
B0 (control)	24,24ab	36.94c	38.69c	42.66d
B1 (200 grams)	34.5c	20.87ab	21.62ab	20,23ab
B2 (300 grams)	18.15a	16.08a	20.92ab	18.67a
BNJ 5%		5.01		

Description: The average number followed by the same letter in the same column and treatment shows no significant difference in the 5% BNJ test;

Table 5. Effect of applying a combination of bioactivator and biochar on soil organic matter.

Bioactivator biochar	A0 (control)	A1 (cow manure)	A2 (tapai)	A3 (banana weevil)
B0 (control)	41.79ab	63.68c	66.70cd	73.55d
B1 (200 grams)	59.47c	35.99ab	37.27ab	34.88ab
B2 (300 grams)	31.28a	27.72a	36.07ab	32.20a
BNJ 5%		8.63		

Description: The average number followed by the same letter in the same column and treatment shows no significant difference in the 5% BNJ test;

Table 6. Effect of applying a combination of bioactivator and biochar on soil N-total.

Bioactivator biochar	A0 (control)	A1 (cow manure)	A2 (tapai)	A3 (banana weevil)
B0 (control)	2.82	3.05	2.38	2.59
B1 (200 grams)	1.63	2.26	1.84	1.33
B2 (300 grams)	1.97	1.97	1.86	1.15

Table 7. Effect of applying a combination of bioactivator and biochar on the C/N ratio land.

Bioactivator biochar	A0 (control)	A1 (cow manure)	A2 (tapai)	A3 (banana weevil)
B0 (control)	8.93a	12,19ab	16.34 BC	16.42 BC
B1 (200 grams)	21.66c	9.27a	11.77ab	15.45 BC
B2 (300 grams)	10.03ab	8.14a	11.31ab	14.05ab
BNJ 5%		6.41		

Description: The average number followed by the same letter in the same column and treatment shows no significant difference in the 5% BNJ test;

Table 8. Effect of combined application of bioactivator and biochar on P-total soil.

Bioactivator biochar	A0 (control)	A1 (cow manure)	A2 (tapai)	A3 (banana weevil)
B0 (control)	0.28b	0.27b	0.24b	0.25b
B1 (200 grams)	0.17a	0.20a	0.19a	0.15a
B2 (300 grams)	0.20a	0.19a	0.18a	0.17a
BNJ 5%		0.07		

Description: The average number followed by the same letter in the same column and treatment shows no significant difference in the 5% BNJ test;

Table 9. Effect of combined application of bioactivator and biochar on K -total land.

Bioactivator biochar	A0 (control)	A1 (cow manure)	A2 (tapai)	A3 (banana weevil)
B0 (control)	2.52	3.32	3.04	3.79
B1 (200 grams)	1.85	2.69	2.79	2.37
B2 (300 grams)	1.97	2.43	2.41	2.54

Table 10. Effect of combined application of bioactivator and biochar on temperature.

Treatment Combination	Week						
	I	II	III	IV	V	VI	VII
A0B0	32.0	36.0	38.0	32.0	29.3	28.0	27.5
A0B1	32.7	36.0	37.0	31.0	30.0	30.0	28.3
A0B2	33.0	35.0	37.0	32.7	30.0	29.9	28.3
A1B0	33.9	33.0	31.7	30.7	30.1	29.3	28.5
A1B1	34.4	33.3	31.7	30.2	30.0	29.8	28.7
A1B2	37.4	34.0	33.0	32.0	31.0	30.0	29.0
A2B0	34.3	32.3	31.8	31.0	30.8	29.7	28.5
A2B1	34.9	33.0	31.3	30.8	30.0	29.3	28.6
A2B2	33.6	32.0	31.1	29.7	29.3	29.3	29.0
A3B0	36.7	32.0	32.1	31.2	30.7	29.3	28.8
A3B1	36.9	32.3	31.5	30.7	30.7	29.7	28.7
A3B2	37.8	32.7	31.3	30.9	30.3	29.0	27.7

Table 11. Effect of combined application of bioactivator and biochar on physical odor parameters.

Treatment Combination	Week						
	I	II	III	IV	V	VI	VII
A0B0	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Slight Earthy Smell	Earthy Smell	Earthy Smell
A0B1	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Slight Earthy Smell	Earthy Smell	Earthy Smell
A0B2	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Slight Earthy Smell	Earthy Smell	Earthy Smell
A1B0	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Earthy Smell	Earthy Smell	Earthy Smell
A1B1	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Earthy Smell	Earthy Smell	Earthy Smell
A1B2	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Earthy Smell	Earthy Smell	Earthy Smell
A2B0	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Slight Earthy Smell	Earthy Smell	Earthy Smell
A2B1	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Slight Earthy Smell	Earthy Smell	Earthy Smell
A2B2	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Slight Earthy Smell	Earthy Smell	Earthy Smell
A3B0	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Earthy Smell	Earthy Smell	Earthy Smell
A3B1	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Earthy Smell	Earthy Smell	Earthy Smell
A3B2	Smell	A bit smelly	A bit smelly	Slight Earthy Smell	Earthy Smell	Earthy Smell	Earthy Smell

Table 12. Effect of combined application of bioactivator and biochar on physical color parameters.

Treatment Combination	Week						
	I	II	I, I, I	IV	V	VI	VII
A0B0	Chocolate	Chocolate	Dark brown	Black Brown	Black Brown	Black	Black
A0B1	Chocolate	Light brown	Dark brown	Black Brown	Black Brown	Black	Black
A0B2	Chocolate	Chocolate	Dark brown	Black Brown	Black	Black	Black
A1B0	Chocolate	Dark brown	Black Brown	Black	Black	Deep Black	Deep Black
A1B1	Dark brown	Black Brown	Black	Black	Deep Black	Deep Black	Deep Black
A1B2	Dark brown	Black Brown	Black	Deep Black	Deep Black	Deep Black	Deep Black
A2B0	Chocolate	Dark brown	Dark brown	Black Brown	Black	Black	Black
A2B1	Dark brown	Black Brown	Black	Black	Black	Deep Black	Deep Black
A2B2	Chocolate	Chocolate	Dark brown	Black Brown	Deep Black	Deep Black	Deep Black
A3B0	Dark brown	Black Brown	Black	Black	Black	Deep Black	Deep Black
A3B1	Dark brown	Black Brown	Black	Black	Deep Black	Deep Black	Deep Black
A3B2	Dark brown	Black Brown	Black	Deep Black	Deep Black	Deep Black	Deep Black

Table 13. Effect of combined application of bioactivator and biochar on physical color parameters.

Treatment Combination	Week						
	I	II	III	IV	V	VI	VII
A0B0	Not Unsolved	Not Unsolved	Coarse Decomposition	Coarse Decomposition	Coarse Decomposition	Coarse Decomposition	Coarse Decomposition

A0B1	Not Unsolved	Not Unsolved	Coarse Decomposition	Starting to Unravel	Decomposed	Unraveled	Fine
A0B2	Not Unsolved	Not Unsolved	Coarse Decomposition	Starting to Unravel	Decomposed	Unraveled	Fine
A1B0	Not Unsolved	Start Unraveled	Decomposed	Unraveled	Unraveled	Fine	Smooth (Like Soil Granules)
A1B1	Not Unsolved	Already Unraveled	Unraveled	Unraveled	Unraveled	Fine	Smooth (Like Soil Granules)
A1B2	Not Unsolved	Decomposed	Unraveled	Unraveled	Unraveled	Fine	Smooth (Like Soil Granules)
A2B0	Not Unsolved	Starting to Unravel	Starting to Unravel	Decomposed	Unraveled	Unraveled	Fine
A2B1	Not Unsolved	Starting to Unravel	Starting to Unravel	Decomposed	Unraveled	Fine	Smooth (Like Soil Granules)
A2B2	Not Unsolved	Starting to Unravel	Starting to Unravel	Decomposed	Unraveled	Fine	Fine
A3B0	Not Unsolved	Starting to Unravel	Decomposed	Unraveled	Unraveled	Fine	Smooth (Like Soil Granules)
A3B1	Not Unsolved	Already Unraveled	Unraveled	Unraveled	Unraveled	Fine	Smooth (Like Soil Granules)
A3B2	Not Unsolved	Already Unraveled	Unraveled	Unraveled	Unraveled	Fine	Smooth (Like Soil Granules)

Discussion

Degree of acidity (pH)

Analysis results show that the degree of soil acidity due to bioactivator and biochar treatment is still classified as neutral pH, in the range of 6.5 to 7.00. Hartatik & Setyorini (2012) reported that the degree of soil acidity for decomposer microbial activity was 6.5-7.5, so all treatments showed good decomposition activity by soil organisms. However, soil acidity tends to be alkaline when treating cow manure bioactivators without adding biochar. This was conveyed in treatments A1 (Table 1), B0 (Table 2), and A1B0 (Table 3). The soil pH obtained was 7, 7.14, respectively, and 7.58.

The degree of soil acidity plays a role in nutrient availability, soil formation, the activity of soil organisms, and so on. The results of the research stated that all types of bioactivator treatment and the addition of biochar were each able to increase soil pH. This was confirmed by Yuniarti et al. (2020) that the application of manure to soil can undergo a faster decomposition or mineralization process to release minerals in the form of basic cations (Ca, Mg, Na, K). The release of these minerals can cause an increase in the concentration of OH.- ions, increasing soil pH.

This is different from bioactivators from plant tissue, such as treatments A2 and A3, which come from tapai and banana tubers, respectively. The second treatment showed a lower increase in soil pH values compared to the application of cow manure. This is because compost from plant tissue generally decomposes more slowly. After all, there are cell walls characteristic of plant tissue. Kaya (2014) reported that the application of straw bioactivator experienced a relatively longer decomposition process than the application of other organic fertilizers, so the increase in pH was not too significant.

C-organic Soil

The addition of banana weevil and tapai bioactivator differed significantly from the control (A0), while the cow manure treatment was not significantly different. However, overall, soil C-organics resulting from applying various types of bioactivators are classified in the very high category (>5). According to Wulandari et al. (2009), the carbohydrate content in banana weevil reaches 66.2%. High carbohydrate levels can increase the development of microorganisms.

Biochar application showed no better results than the control (B0) (Table 2). Lu et al. (2014) reported that the decrease in soil C-organic content was influenced by several factors, such as soil character and microbial activity as one of the soil organisms. Dwina & Sembiring (2013) added that C-organic levels in soil can be caused by decreased activity of microorganisms. Soil microorganisms, whether they live singly or in groups, maintain their lives by using carbon or other substances as a substrate. Next, metabolic processes occur and end with mineralization. The final results of the mineralization process are generally CO_2 and H_2O. A continuous mineralization activity with a substrate in the form of C-organic can cause an increase in CO_2 due to soil microbial respiration, thereby reducing the availability of soil C-organic. Applying biochar to the soil is thought to increase the mineralization activity, resulting in decreased C-organic in the soil.

The exciting thing in this research found on the combination of banana weil bio activator treatment with no biochar (A3B0), namely that only a single application of banana weevil bio activator gave the best effect in increasing soil C- organic acid, with a value of 42.66% (Table 5). by Tanmenu's (2024) research, the nutrient content in the treatment using banana stump bio activator has benefits as a decomposer of organic matter and provides bacteria. So, the results show that the banana stump bioactivator treatment is the best treatment for farmers who compost with the banana stump bioactivator. Biochar manufactured from feedstock containing high amounts of heavy metals can transfer pollutants into the soil, resulting in long-term harmful effects on agricultural and human health. Furthermore, using biochar at high rates can overburden the soil with carbon, reducing nutrient availability for plants and potentially slowing development.

Soil organic matter

The addition of tapai and banana weevil bioactivator was significantly different from the control, while the cow manure treatment was not significantly different from the control. Respectively. The role of banana weevil or tapai as the best treatment in increasing soil organic matter occurs because the organic material is rich in micro and macronutrients. Oktaviani (2020) confirmed that bioactivators, especially banana weevils, contain several commonly found macronutrients, including nitrogen, phosphorus, and potassium. Some carbohydrates can also increase soil microbes because they function as food for soil microbes. This results in the absorption of nutrients in the soil by plant roots that can work optimally. Good nutrient absorption can increase plant growth. Microbes decompose organic matter using carbon, nitrogen, oxygen, and water to produce water, carbon dioxide, heat, and soil-enriching compost. This compost contains biologically stable humic substances and is an excellent soil amendment (Białobrzewski et al., 2015). During the process, a spontaneous rise in temperature helps eliminate pathogens.

Saraiva et al. (2012) stated that the element phosphorus found in the banana extract is 0.2–0.5%, which is known to be able to provide additional nutrition in plant growth and productivity. Maspary (2012) added that apart from containing growth regulators cytokinins and gibberellins, banana weevils also contain many microbes such as *Azospirillium*, *Azotobacter*, *Bacillus*, *Aeromonas, Aspergillus*, phosphate-solvent microbes, and cellulolytic microbes, all of which are very good for plants and are often found in liquid fertilizers.

Biochar application at 200 g and 300 g doses did not have a better effect than the control treatment/no biochar addition (Table 2). It is suspected that soil microbial activity has increased due to biochar treatment at this dose, thereby increasing the mineralization process in the soil and reducing the soil organic matter content. The soil organic matter decreases because organic material acts as a substrate (nutrient source) in mineralization activities.

The best combination of bioactivator and biochar was also shown using banana weevil without adding biochar (A3B0), a single treatment of banana weevil bioactivator (Table 4). This indicates that banana weevils as bioactivators have many roles that can increase soil organic matter, microbial biodiversity, the ability to provide nutrients needed by soil organisms and plants, and PGR, which can increase the availability of nutrients for plants and soil microbes.

N-total soil

The application of bioactivator in cow manure showed the best results on the percentage of N-total soil, namely 2.43%, and it was classified in the very high category because it had >0.75 (Table 1). The addition of cow manure as a bioactivator in increasing soil N-total occurs because cow manure can produce or provide high amounts of nitrogen and phosphorus. This is supported by Dyasmara et al. (2016), who state that cow manure contains large quantities of macronutrients, namely nitrogen and phosphorus. Meanwhile, goat manure is high in potassium elements. Therefore, the application of cow manure bioactivator increased the percentage of N- total soil compared to the control.

Applying 200 g and 300 g of biochar did not show better results than the control (Table 2). This happens because the applied biochar has not been able to increase the percentage of N- total soil during the decomposition process. Even though the soil N-total value is still relatively high, the decrease in this percentage could be due to the low activity of soil microbes in converting N-organic compounds into NH_{4+} and $NO_3{}^-$. It is known that the presence of nitrogen elements in the soil is influenced by the absorption of nitrogen by plants, evaporation of nitrogen elements, or because it is transported during harvest. Rosmarkam & Nasih (2009) explained that soil N-total levels often become lower because the soil is easily lost.

Applying a combination of bioactivator and biochar did not show a significant difference compared to the control treatment on the percentage of N-total soil (Table 5). Applying bioactivator from cow manure improved the increase in N-total soil compared to when combined with biochar at doses of 200 g and 300 g. The effectiveness of cow manure bioactivator in this study tended to decrease when combined with other treatments. This can happen because it is considered less compatible and cannot provide a higher N-total than the control (A0B0).

C/N ratio

The application of bioactivator in the form of banana weevil showed the best soil C/N ratio, namely 16.02, and was classified in the high category because it was in the range 16-25 (Table 1). The lowest C/N ratio percentage indicates the best treatment because this shows the effectiveness of the decomposition process with the addition of bioactivator and biochar or a combination of both. Trivana & Pradhana (2017) explained that the C/N ratio level was relatively high in the initial composting conditions. A decrease in the C/N ratio at the end of composting indicates success. Based on SNI 19-7030-2004, good compost has a C/N ratio of 10 – 20. The results of the banana weevil bioactivator application are still in that range.

The best biochar application was shown by treatment B1, which added 200 g of biochar with a C/N ratio value of 14.53 and was included in the medium category. Meanwhile, the lowest C/N ratio was shown by treatment B2 (biochar 300 g) with a value of 11.42 and was still included in the medium category (Table 2). The best treatment was shown with 300 g biochar because it showed the lowest C/N ratio percentage but was still within the nationally standardized C/N ratio range.

The higher the soil C-organic content, the nitrogen will usually decrease, thereby increasing the C/N ratio, and vice versa. Kesumaningwati (2015) explained that high C-organic levels produce high C/N ratio levels in compost. This occurs because microbes still decompose the material, so the decomposition process of organic material is not yet complete. Wahyudin & Nurhidayatullah (2018) added that the composting process takes quite a long time because it is waiting for the C/N ratio level to decrease.

Combining bioactivator and biochar provides the best overall C/N ratio value for weevil and biochar 200 g (Table 7). The addition of cow manure as a bioactivator in increasing the C/N ratio of soil occurs because banana humps contain various types of microbes which act as decomposers so that they can accelerate the process of soil and biochar decomposition by 200%. This combination is a valuable organic material in the ammonification process, breaking amino acids into ammonium. Next, nitrification occurs when the ammonium turns into nitrate, making the nutrients available to plants.

P-total

The application of bioactivator in cow manure (A1) showed the best P-total soil results, namely 0.22%, and it was classified in the very high category because it was more than 0.13% (Table 1). Based on SNI 19-7030-2004, the phosphorus content in compost is at least 0.10%. Many studies have reported the role of cow manure in helping the decomposition process, one of which is (Yuniarti *et al.*, 2020), that the combination of cow manure + 50% N, P, K or 100% N, P, K can significantly increase the degree of acidity soil, absorption of P by plants, thereby increasing black rice production.

200 g biochar applications and 300 g did not show better results than treatment B0, a treatment without adding biochar (Table 2). This happens because the applied biochar has not been able to increase the percentage of P-total in the soil, both from the dose and type of biochar applied during the decomposition process. Even though the soil P-total value is still relatively high, the decrease in this percentage could be due to the low activity of soil microbes in converting P organic compounds into available P. Not only did biochar application not significantly affect soil P-total, but the combination of bioactivator and biochar gave the same results. The application of bioactivator and biochar in this study showed a decrease in effectiveness compared to their application. This is thought to be due to the lack of compatibility of the type of bioactivator with the biochar dosage used in this treatment.

Studies on the impact of biochar on soil fertility and crop yields - Comparison of different types of biochar and their effectiveness in improving soil quality - Potential drawbacks or limitations of biochar use in agriculture Overall, biochar research suggests that it can be a valuable tool in sustainable agriculture practices. Still, more research is needed to fully understand its long-term effects on soil health and productivity. A detailed example of biochar use in sustainable agriculture is its application in improving soil fertility and crop yields in depleted or degraded soils. Adding biochar to the soil can help improve nutrient retention, water-holding capacity, and microbial activity, resulting in healthier and more productive plants. However, it is essential to carefully consider the type of biochar used and the application rate to avoid it. Improper application of biochar has the potential to result in nutrient leaching or pH imbalances in the soil. Using biochar made from raw materials with high levels of heavy metals can introduce contaminants into the soil, leading to long-term negative impacts on crop quality and human health. Excessive biochar application can saturate the soil with carbon, reducing plant nutrient availability and potentially inhibiting growth.

K-total

The application of all types of bioactivators to potassium levels is classified as very high. Based on SNI 19-7030-2004, the potassium content in compost is at least 0.20%. The results of this study showed that all treatments showed potassium levels that met national standards. There is no potassium, which is very important for plant growth and resilience. It has a role in photosynthesis to produce protein and cellulose (Widarti et al., 2015).

200 g of biochar applications and 300 g did not show better results than treatment B0, a treatment without adding biochar (Table 2). The application of bioactivator and biochar in this study showed a decrease in effectiveness compared to their application. This is thought to be due to the lack of compatibility of the type of bioactivator with the biochar dosage used in this treatment.

Temperature

The activity of microorganisms in breaking down the available C-organic can increase the temperature of the compost raw material. The measurements show that the average temperature at the end of the compost observation ranged between 29-30ºC (Table 10). Based on observation data, all treatments experienced a significant decrease in temperature from the first week of observation to the 6th week. Observation results showed that the highest compost temperature in the first week in the combination of cow manure bioactivator with 200 g biochar was 37ºC, and the lowest temperature in the combination of tapai bioactivator without biochar was 34.3ºC. The last observation in the 8th week showed that the highest temperature of the first compost in the combination of cow manure bioactivator with 200 g biochar was 29ºC, while the lowest temperature in the control treatment was 27.5ºC, the combination treatment of cow manure bioactivator with 200 g biochar showed that the highest temperature occurred because of the C-Organic from cow manure. The control treatment showed a temperature between 30-33ºC, increased in the 2nd and 3rd weeks, then decreased in the 5th week. This occurred because adding simple organic materials meant that the temperature value differed from the combination treatment. Research by Larasati & Puspikawati (2019) shows an increase in compost temperature in the control treatment on the first day, from 300ºC to 390ºC. The total temperature increases from the lowest temperature of 280ºC to the highest temperature of 400ºC. The increase in temperature is caused by bacterial activity that breaks down organic waste into simpler components.

The speed of the composting process is related to the environmental temperature and the activity of microorganisms, which is influenced by the size of the C-organic content in the compost material. According to Muliani (2022), the rapid decomposition process is characterized by an increase in the temperature of the compost material, which indicates the presence of microbial activity, which is related to the consumption of oxygen by the microbes. Observations from weeks 4 to 8 showed a decrease in temperature in the compost. This happens because the composting process has entered a setting period where the compost material has appropriately decomposed. The compost temperature slowly decreases until it reaches average temperature because decomposition of organic material no longer occurs. Lumbranjana (2014) explains that microbes decompose organic compounds by breaking down organic carbon into CO2, water vapor, and heat. Over time, the temperature of the compost decreases, indicating that the organic carbon content has been used by microbes in the decomposition process.

The maximum temperature reached by compost is still mesophilic and has not yet reached the thermophilic temperature of composting. According to Cahaya & Adi (2009). There are three stages in composting: mesophilic, thermophilic, and cooling. The mesophilic stage is characterized by the rapid growth of microorganisms, followed by an increase in the temperature of the compost raw material. At this stage, mesophilic microorganisms carry out changes by reducing the particle size of the raw material and can survive at temperatures of 10-45°C. Next, the thermophilic stage is at a temperature of 60°C. At this stage, thermophilic microorganisms break down the cellulose and hemicellulose of the compost raw material. The final stage of composting is cooling, characterized by a decrease in thermophilic microorganisms as nutrients in the compost raw material decrease.

The highest temperature reached by the compost in this combination of bioactivator and biochar did not reach the thermophilic stage. This is due to the small pile of raw compost materials, so the microbes are not sufficiently successful in isolating heat. Large volumes of raw materials can expand the microbial heat insulation capability. When high temperatures reach the raw material, thermophilic microbes will grow. However, even though it has not reached the thermophilic stage, the composting process is still ongoing by processing it by mesophilic microbes. Supported by Cahaya & Adi (2009), the breakdown of cellulose and hemicellulose in compost raw materials can still be carried out by mesophilic microorganisms even though their abilities are not better than thermophilic microorganisms.

Smell

Observation of the odor in the composting process with a combination of bioactivator and biochar shows no odor and resembles the smell of soil from weeks 6 to 8. The observations show that the combination of treatment of cow bioactivator with biochar and banana weevil bioactivator with biochar shows more changes faster than other combination treatments; in the 5th week, the compost showed an earthy smell. Compost with a combination of tape bioactivator and biochar changes to an earthy smell more slowly than the combination of cow bioactivator and banana weevil with bichar, or cow and banana weevil bioactivator without biochar changes to an earthy smell more quickly.

The decomposition process by microbes produces an unpleasant odor in raw materials. Usually, unpleasant odors are obtained from raw materials that are too wet, so to minimize this, you can turn the compost pile over. The unpleasant aroma is due to the lack of good aeration, resulting in an anaerobic process that produces organic acid compounds, ammonia, and H2S. Compost maturity is indicated by a change in smell, such as an earthy smell. Compost shows physical changes by meeting SNI 2004 standards, namely having a blackish color/resembling soil, no scent, and texture-like soil. Anif et al. (2007) stated that after the composting process is complete, the smell obtained is the smell of soil. According to Subula et al. (2022), composting has reached optimal maturity when the compost no longer smells unpleasant and resembles soil.

Color

Based on Table 12, physical color parameters show that the color changes to black more quickly when combining cow bioactivator and banana weevil with biochar; adding 300 g of biochar shows that the compost color is darker and more concentrated. The color changes to black or darker on average in the 4th week and shows a dark black color in all combinations and controls occurring in the 8th week. Based on SNI Compost NO.19-7030-2004, mature compost is black and has a particle size of around 25 mm. Sagiarti et al. (2020) stated a difference in the primary color of compost and mature compost, where mature compost has a black color.

All treatments display the same color of raw compost material, brown, at the start of composting. At the end of composting, the compost changes color, namely dark black. The combination of bioactivator and biochar shows good physical characteristics of compost. Namely, it is dark black, is slightly damp, and does not look like raw material. Meanwhile, the control treatment was black and did not show good weathering of the compost material. According to Yuniwati & Padulemba (2012), the weathering of compost material shows the success of the composting process, which is followed by the characteristics of initial and final color differences, odorlessness, low air content, and being at room temperature.

Texture

Physical texture parameters based on observations in Table 13 show that the combination of cow bioactivator with 200 g and 300 biochar and banana hump bioactivator with 200 g and 300 biochar showed that it decomposed more quickly in the 2nd week compared to other combination treatments. Decomposer agents can decompose organic materials from waste by changing the quality of the physical properties of the resulting compost (Sulistyawati et al ., 2007). According to Ismayana et al. (2012), compost is successful if it is no longer shaped like raw material because it has been destroyed after being decomposed by microorganisms.

Texture changes are characterized by the complex chemical qualities of the composting material, one of which is the bioactivator content used. Ubaidillah et al. (2018) describe good compost as having a crumbly structure and not clumping. The particle size of good compost is the size of sawdust. It crumbles easily and is like soil. In general, microorganisms that play a role in decomposing organic materials in the three treatments consist of the same three groups, namely bacteria, fungi, and actinomycetes, but differ in species and abundance. Environmental conditions greatly influence the activity of these organism species. Bacteria act as initiators of the decomposition process of compounds into simple forms. Fungi and actinomycetes can decompose materials that are difficult to decompose (Graves et al., 2000).

Compost contains many microorganisms (fungi, actinomycetes, bacteria, and algae). By adding compost to the soil, millions of microorganisms are added, and microorganisms in the soil are also stimulated to grow. The further decomposition process by microorganisms will continue but will not interfere with plants. CO2 gas produced by soil microorganisms will be used for plant photosynthesis so that plant growth will be faster. Ammonification, nitrification, and nitrogen fixation also increase due to the provision of organic materials as a carbon source in the compost. The activity of various microorganisms in the compost produces growth hormones, such as IAA, gibberellin, ethylene, and cytokinins, that stimulate the growth and development of hair roots so that the food search area is more expansive. Providing compost in rice fields will help control or reduce the nematode population because organic materials stimulate the development of natural enemies of nematodes, namely fungi, and bacteria, and provide less favorable conditions for developing nematodes. The emergence of nematode attacks that cause root nodule disease on rice plant roots in several areas is triggered by the intensive use of urea fertilizer (Setyorini, 2016).

Functional microbes are a group of soil microbes that function as providers of nutrients in the soil by binding N2 from the air with the N available in the soil and by dissolving phosphate and other nutrients that are not available to make them available. Apart from functioning as a provider, nutrients can also suppress plant diseases from the soil (by producing siderophores glucanase, chitinase, and cyanide), increase nutrient absorption, increase plant tolerance to drought, stabilize soil aggregates, etc. (Sahwan et al. ., 2011).

Conclusions

The application of bioactivators and biochar in this study showed a decrease in effectiveness compared to their single applications. The combination of banana stem bioactivators and cow dung with 0 gr biochar (control) improved the quality of the chemical properties of the compost. In contrast, adding biochar at both 200 g and 300 g concentrations showed improvements in the physical quality of the compost texture. This is thought to be due to the incompatibility of the type of bioactivator with the dose of biochar used. Inappropriate biochar application can cause nutrient leaching and, if given in excessive doses, can fill the soil with carbon, which causes reduced nutrient availability for plants and inhibits growth.

Declaration statement

The authors reported no potential conflict of interest.

References

Anif, S., Rahayu, T., & Faatih, M. (2007). Pemanfaatan Limbah Tomat sebagai Pengganti Em-4 pada Proses Pengomposan Sampah Organik. *Journal of Science & Technology Research*, *8* (2), 119–143.

Balai Penelitian Tanah. (2005). Petunjuk Teknis Analisis Kimia Tanah, Tanaman, Air dan Pupuk. Balai Penelitian Tanah, Badan Penelitian dan Pengembangan Pertanian. Departemen Pertanian. Bogor

Białobrzewski I., Mikš-Krajnik M., Dach J., Markowski M., Czekała W., Głuchowska K. Model of the sewage sludge-straw composting process integrating different heat generation capacities of mesophilic and thermophilic microorganisms. *Waste Manag.* 2015;43:72–83. https://doi.org/10.1016/j.wasman.2015.05.036

Cahaya, TS, A., & Adi Nugroho, D. (2009). Pembuatan kompos dengan menggunakan limbah padat organik (sampah sayuran dan ampas tebu. *Journal of the Faculty of Engineering.* Diponegoro University.

Djaenudin, D. (2007). Potensi Sumber Daya Lahan untuk Perluasan Areal Tanaman Pangan di Kabupaten Merauke. *MIPA Journal*. 40(1): 1-6

Dwina Lubna, & Sembiring, E. (2013). Emisi Co2 Dan Penurunan Karbon Organik Pada Campuran Tanah Dan Kompos (Skala Laboratorium). *Journal of Environmental Engineering*, *19* (1), 23–33. https://doi.org/10.5614/jtl.2013.19.1.3

Dyasmara, SP, Syekhfani, & Nuraini, Y. (2016). Efektifitas kompos campuran ampas teh, kotoran sapi dan kotoran kambing terhadap serapan N pada tanaman bawang daun pada inceptisol. *Journal of Soils and Land Resources*, *3* (1), 285–292.

Glaser, B., Haumaier, L., Guggenberger, G., & Zech, W. (2001). The 'Terra Preta' phenomenon: A model of sustainable agriculture in the humid tropics. *Naturwissenschaften* , *88* , 37–41. https://doi.org/10.1007/s001140000193

Graves, R. E., Hattemer, G. M., Stetter, D., Krider, J. N., & Dana, C. (2000). *National Engineering Handbook*. United States Department of Agriculture.

Hartatik, W., & Setyorini, D. (2012). Pemanfaatan pupuk organik untuk meningkatkan kesuburan tanah dan kualitas tanaman. *Agricultural Research and Development Agency Soil Research Institute. Bogor*, 571–582.

Horwitz, W. (2000). *Official Methods of AOAC Internasional.* (17th Edition). Association of Official Analytical Chemists (AOAC) International.

Ismayana, A., Indrasti, NS, Suprihatin, AM, & TIP, AF (2012). Faktor rasio C/N awal dan laju aerasi pada proses co-composting bagasse dan blotong. *Journal of Agricultural Industrial Technology*, *22* (3), 173-179

Kaya, E. (2014). Pengaruh Pupuk Organik Dan Pupuk NPK terhadap pH dan K-tersedia Tanah serta Serapan-K , Pertumbuhan, dan Hasil Padi Sawah (Oryza sativa L.). *Buana Science* , *14* (2), 116–123. https://doi.org/10.33366/bs.v14i2.353

Kesumaningwati, R. (2015). Kegunaan MOL bonggol pisang (Musa paradisca) sebagai dekomposer untuk pengomposan tandan kosong kelapa sawit. *Journal of Zira'ah* , *40* (1), 40–45. http://dx.doi.org/10.31602/zmip.v40i1.96

Larasati, AA, & Puspikawati, SI (2019). Pengolahan sampah sayuran menjadi kompos dengan metode takakura. *Journal of Public Health Sciences*, 60–68. https://doi.org/10.19184/ikesma.v15i2.14156

Lu, W., Ding, W., Zhang, J., Li, Y., Luo, J., Bolan, N., & A, Z.X. (2014). Biochar suppresses organic carbon decomposition in cultivated sandy loam soil: Negative priming effect. *Soil Biology and Biochemistry*, *76*, 12–21. http://dx.doi.org/10.1016/j.soilbio.2014.04.029

Muliani, S. (2022). Uji karakteristik fisik (pH, suhu, tekstur, warna, bau dan berat) kompos tumbuhan pakis resam (*Gleichenia linearis*) yang di perkayakotoran sapi. *Green Swarnadwipa: Journal of Agricultural Science Development*, *11* (3), 511–522.

Murbandono, L. (2008). *Membuat Kompos.* Jakarta: Penerbit Penebar Swadaya..

Purwendro, S. (2006). *Mengolah Sampah u/Pupuk & Pestisida*. Penebar Swadaya.

Rosmarkam, A., & Nasih, W. (2009). *Ilmu Kesuburan Tanah*. Surabaya: Kanisius.

Sagiarti, T., Okalia, D., & Markina, G. (2020). Analisis C-Organik, Nitrogen dan C/N Tanah pada Lahan Agrowisata Beken Jaya di Kabupaten Kuantan Singingi. *Journal of Agroscience and Technology*, *5* (1), 11–18. https://doi.org/10.24853/jat.5.1.11-18

Sahwan, F. L., Wahyono, S., & Suryanto, F. (2011). Evaluasi populasi mikroba fungsional pada pupuk organik kompos (POK) murni dan pupuk organik granul (POG) yang diperkaya dengan pupuk hayati. *Jurnal Teknologi Lingkungan*, *12*(2), 187–196. https://doi.org/10.29122/jtl.v12i2.1250

Saraiva, B., Pacheo, EBV, Visconte, LLY, Bispo, EP, Escocio, VA, de Sousa, AMF, Soares, AG, Junior, MF, Motta, LCDC, & Brito, GFDC (2012). Potential for Utilization of Waste Post Fiber Extraction for Tropical Fruit Production in Brazil-Example of Banana Pseudostem. *International Journal of Environment and Bioenergy*, *4* (2), 101–119.

Setyorini, D., Rasti, S., & Anwar, E. K. (2006). *Kompos*. Pupuk Organik dan Pupuk Hayati. Balai Besar Litbang Sumberdaya Lahan Pertanian. 76 hlm.

Subula, R., Uno, W.D., & Abdul, A. (2022). Kajian tentang kualitas kompos yang menggunakan bioaktivator EM4 (*effective microorganism*) dan mol (mikroorganisme lokal) dari keong mas. *Jambura Edu Biosphere Journal*, *4* (2), 54–64. https://doi.org/10.34312/jebj.v4i2.7753

Sulistyawati, E., Mashita, N., & Choesin, D. (2007). Pengaruh agen dekomposer terhadap kualitas hasil pengomposan sampah organik rumah tangga. *Science & Technology Research Journal, Bandung, Bandung Institute of Technology*.

Susetya, D. (2016). *Panduan Lengkap Membuat Pupuk Organik*. Yogyakarta: Pustaka Baru Press.

Trivana, L., & Pradhana, AY (2017). Optimalisasi Waktu Pengomposan dan Kualitas Pupuk Kandang dari Kotoran Kambing dan Debu Sabut Kelapa dengan Bioaktivator PROMI dan Orgadec. Journal of Veterinary Science, 35 (1), 136–144.

Ubaidillah, U., Maryadi, M., & Dianita, R. (2018). Karakteristik Fisik dan Kimia Phospho-Kompos Yang Diperkaya dengan Abu Serbuk Gergaji sebagai Sumber Kalium: Physical and Chemical Characteristics of Phospho-compost Enriched with Sawdust Ash as Potassium Source. *Scientific Journal of Animal Science*, 21 (2), 98–109. https://doi.org/10.22437/jiiip.v21i2.6774

Wahyudin, & Nurhidayatullah. (2018). Pengomposan Sampah Organik Rumah Tangga Menggunakan Mikroorganisme Lokal Bonggol Pisang sebagai Bioaktivator. *Agriovet Journal*, 1 (1), 11–14.

Widarti, BN, Wardhini, WK, & Sarwono, E. (2015). Pengaruh rasio C/N bahan baku pada pembuatan kompos dari kubis dan kulit pisang. Journal Integrasi Proses, 5 (2).

Wulandari, D., Fatmawati, D., Qolbaini, E., & Praptinasari, S. (2009). Penerapan MOL (Mikro-organisme Lokal) Bonggol Pisang sebagai Biostarter Pembuatan Kompos. PKM-P. Surakarta (ID): Sebelas Maret University .

Yuniarti, A., Solihin, E., & Arief Putri, AT (2020). Aplikasi pupuk organik dan N, P, K terhadap pH tanah, P-tersedia, serapan P, dan hasil padi hitam (Oryza sativa L.) pada inceptisol. *Journal Kultivasi,* 19 (1), 1040. https://doi.org/10.24198/kultivasi.v19i1.24563

Yuniwati, M., & Padulemba, A. (2012). Optimasi kondisi proses pembuatan kompos dari sampah organik dengan cara fermentasi menggunakan EM4. *Journal Teknologi*, 5 (2), 172–181.