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The Influence of Types of Bacteria and Types of Compost Materials on Composting Results

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Abstract

Composting is a biological process in organic materials that are broken down by microorganisms into stable organic fertilizers and are useful as organic fertilizers or compost, microorganisms have the ability to produce enzymes needed to process organic waste into compost that can be reused as fertilizer. The purpose of this study was to determine the influence of cellulolytic bacteria, rhizomonas, subtilis and cow rumen using waste materials from rice straw and corn plant waste in the composting process.This research was conducted in Bowan Village, Delanggu District, Klaten Regency with an altitude of ± 130 meters above sea level in February to April 2024 and using a Completely Randomized Design (CRD) with 2 factors, namely: The first factor is a combination of bacteria consisting of 5 levels: D_0: without bacteria, D1: cellulolytic, rhizomonas and cow rumen, D2: cellulolytic and subtilis, D3: rhizomonas and cow rumen, D4: cow rumen, The second factor is the type of compost material consisting of 2 levels: P1: Rice straw and P2: Corn plants. The parameters observed were compost odor, compost color, compost temperature, compost pH, composting time, water hold capacity, final compost weight and final compost water content. The results of the study showed that the provision of cellulolytic bacteria, subtilis, rhizomonas and cow rumen significantly affected the temperature and pH of the compost but did not significantly affect the composting time, water hold capacity, final weight of the compost and final water content of the compost. The use of rice straw waste and corn waste had a very significant effect on pH and significantly affected the composting time, final weight of the compost and final water content of the compost but did not significantly affect the temperature and water hold capacity.

Keywords: Composting, Corn Waste, Cow Rumen Bacteria, Decomposer Bacteria, Rice Straw Waste

Introduction

Composting is the stage of organic material decomposing into compost (organic fertilizer) through a biological process involving the activity of microorganisms under controlled aerobic conditions. Composting is the process of decomposing compounds contained in organic waste, such as straw, leaves, and household waste, through special treatment. Almost all materials originating from living organisms, both plants and animals, will undergo decomposition in the compost pile (Indah Prawesti,H, 2022). Compost (organic fertilizer) is produced through a biological decomposition process, during which various microorganisms, such as bacteria and fungi, play an active role (Hamidah et al., 2023). Compost is a product of the incomplete decomposition of a mixture of organic materials, the process of which can be artificially accelerated by various types of microbes in warm, humid environmental conditions, and in aerobic or

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anaerobic conditions (Suhartawan et al., 2023). Compost is a type of fertilizer produced from the decomposition process of organic plant remains. This fertilizer functions to provide nutrients for the soil, so that it can be used to improve soil conditions both physically, chemically, and biologically. From a physical perspective, compost plays a role in stabilizing soil aggregates, increasing aeration and drainage, and improving the soil's ability to retain water. Chemically, compost can increase the content of macro and micro nutrients and increase the efficiency of nutrient absorption by plants. On the biological side, compost functions as a source of energy for soil microorganisms that play a role in releasing nutrients for plants (Dahlianah, I, 2015).

Turning agricultural waste into fertilizer can produce many benefits, especially for soil fertility and plant growth (Dewi et al., 2024). According to Bimasri & Murniati (2022) shows that the use of rice straw waste compost can reduce production costs, thereby increasing farmers' income.

The increase in corn production has an impact on the increasing volume of corn waste that must be managed. The remaining corn production can be used as the main ingredient in making compost. Utilizing corn waste as compost is a strategic step to return organic matter to the soil, which has a positive impact on soil fertility and crop yields, and provides sustainable benefits in maintaining soil fertility and sustainability (Nenobesi,D, 2017). Corn plant waste contains high amounts of cellulose, so that the C/N ratio in this waste reaches 59 (Dwiratna et al., 2021).

Rice straw is a type of agricultural waste that contains many nutrients and plays an important role in maintaining the stability of soil nutrients and meeting the nutrient needs of plants (Rhofita, 2016). Rice straw contains about 40% nitrogen, 30-35% phosphorus, 80-85% potassium, and 40-45% sulfur which are absorbed by rice plants from (Akmal & Karimuna, 2023). If rice straw is used as compost, it not only provides essential nutrients for plants, but also helps preserve the environment by managing waste properly. (Megasari et al., 2024). However, there are still many farmers in the field who are still unable to utilize or process straw into compost. This can cause damage to agricultural land if there is no effort to recycle agricultural waste (Aisyah, N 2016). Loss of nutrients due to poorly managed harvests, as well as the habit of farmers burning straw after harvest, can cause air pollution and disrupt the lives of organisms around it. Therefore, straw should be used as organic fertilizer in the form of compost (Istiqomah & Kusumawati, 2022).

The nutrient content of rice straw at harvest time is influenced by several factors, including soil fertility, quality and quantity of irrigation water, amount of fertilizer used, and seasonal or climate conditions. In Indonesia, the average nutrient content of rice straw consists of 0.4% nitrogen (N), 0.02% phosphorus (P), 1.4% potassium (K), and 5.0% silicon (Si) (Istiqomah & Anam, C, 2021). Cellulolytic bacteria are microorganisms that have the ability to produce cellulase enzymes. The main role of cellulolytic bacteria is to hydrolyze cellulose into simpler compounds, namely glucose (Murtiyaningsih, H & Hazmi, M 2017) . Organic materials rich in cellulose become a substrate that supports the growth of cellulolytic bacteria, so that these bacteria can be found in compost that has a high cellulose content. Naturally, cellulolytic bacteria can be found in agricultural land, forests, compost, rotting plants, or in leaf litter. These bacteria have the ability to hydrolyze natural materials containing cellulose into simpler products. The use of cellulolytic bacterial inoculum in the fermentation process can help loosen the complex bonds of ligno-cellulose and ligno-hemicellulose in feed materials that have low digestibility. It is expected that the use of inoculants from buffalo rumen contents can improve the quality of rations optimally. The benefits of this fermentation process are increased protein content due to the addition of the number of microbes in the feed material and enzymes produced by microbial cells that support the digestibility of the material (Riskawati, R 2023).

Biofertilizers have unique advantages, namely containing biological agents such as bacteria that are needed to accelerate the availability of nutrients from the soil or organic fertilizers, including nitrogen. Nitrogen-fixing bacteria can be divided into two categories, namely symbiotic and non-symbiotic bacteria. One example of symbiotic bacteria commonly used in agriculture is Rhizomonas, which functions as a provider of nitrogen in the form of NH4+ or NO3-. These bacteria form a symbiotic bond with plant roots to obtain N2 from the atmosphere (Hasan et al., 2024).

Bacillus subtilis has several characteristics, including: can grow at temperatures above 50°C and below 5°C, can withstand the pasteurization process, can grow in high salt concentrations (>10%), has the ability to produce spores, and has higher proteolytic activity compared to other microbes. Bacillus is a genus of rod-shaped bacteria that is included in the Firmicutes division. These bacteria are obligate or facultative aerobes and show positive results in the catalase enzyme test. Bacillus can be found naturally in various environments and includes both free and pathogenic species. Some Bacillus species are able to produce extracellular enzymes such as protease, lipase, amylase, and cellulase, which play a role in the composting process (Hermawati, E 2017).

Rumen bacteria in cows play a very important role, namely to accelerate the process of breaking down and softening waste materials in the composting process. (Sangadji, I 2022). In addition, this fluid is also rich in bacteria and protozoa, with bacterial concentrations reaching around 10^9 /cc of rumen contents, while protozoa vary between 10^5 to 10^6 /cc, the number of bacteria in the rumen can reach 1-10 billion / mL of fluid. Cattle rumen bacteria still contain high organic matter, which has great potential to be used as compost or organic fertilizer. (Ratnawati et al., 2018).

Method

Place and Time of Research

The research was conducted in Bowan Village, Delanggu District, Klaten Regency at an altitude of ± 130 meters above sea level, from February to April 2024.

Research Materials and Tools

The tools used in the study were 15 kg sacks, measuring cups, scales, stationery, knives, scissors, labels, trowels, sprayers, rulers, raffia ropes, buckets. The materials used in this study were dry straw, dry corn waste, bran, dolomite, molasses, cellulolytic bacteria, rhizomonas bacteria, subtilis bacteria and cow rumen bacteria.

Research methods

This study was conducted descriptively qualitatively and quantitatively using a Completely Randomized Design (CRD) which was carried out with 4 replications. This study consisted of 2 factors, namely the first factor, a combination of bacteria consisting of 5 levels: Without Bacteria (D_0), Cellulolytic, Rhizomonas and Cow Rumen (D1), Cellulolytic and Subtilis (D2), Rhizomonas and Cow Rumen (D3), Cow Rumen (D4), the second factor is the type of compost material consisting of 2 levels: Rice Straw (P1) and Corn Plants (P2).

Research Implementation

The implementation of this research consists of several main stages, starting from the preparation of research materials, namely preparing 23 kg of straw waste and 23 kg of corn waste that have been chopped using a grinding machine, 4 kg of bran, 4 kg of dolomite, 3.21 ml of molasses and 4 bacteria.

Making a research plan by determining and preparing the research location, arranging the research plan and determining the distance per treatment.

The next stage of preparing compost materials is a sack filled with rice straw containing 0.7 kg (700 g) of rice straw + 0.1 kg (100 g) of bran + 0.1 kg (100 g) of dolomite + 100 ml of molasses so that the compost weighs 1 kg and a sack filled with dry corn plants containing 0.7 kg (700 g) of dry corn plants + 0.1 kg (100 g) of bran + 0.1 kg (100 g) of dolomite + 100 ml of molasses so that the compost weighs 1 kg.

The provision of bacteria with a dosage composition in each compost according to the treatment, namely D_0 = Without bacteria, D_1 = 0.84cc cellulolytic bacteria + 0.84cc rhizobium bacteria + 0.84cc cow rumen, D_2 = 1.25cc cellulolytic bacteria + 1.25cc subtilis bacteria, D_3 = 1.25cc rhizobium bacteria + 1.25cc cow rumen bacteria and D_4 = 2.5cc cow rumen bacteria.

Observations were carried out every 7 days from the start of the study until the compost had met the specified criteria by turning over each compost material in the sack.

Research Parameters

Observation parameters in this study include: The smell of compost is observed by comparing the unopened compost with the opened compost and is done until the smell is like soil, The color of the compost is observed once a week until there is no more change, the compost material is measured using the Munsell color table, The temperature of the compost is measured using a thermometer once a week until the compost temperature is 29°C, the pH of the compost is measured using a pH meter measured once a week until the neutrality level is 6-8, The duration of composting is measured by observing once a week until the compost has met the specified criteria, Water hold capacity the ability of the compost to hold water is measured at the end of the observation using filter paper and a measuring cup by taking 20g of compost material then mixing it with 20ml of water, leaving it for 5 minutes then filtering it using filter paper and calculating the water that drips into the measuring cup, The final weight of the compost is measured at the end of the study by weighing the finished compost and The final water content of the compost is measured by ovening the compost until a constant point is found (no difference) after the compost is finished.

Data analysis

This research method uses observation data obtained with 2 factors and 4 replications, then analyzed using analysis of variance (ANOVA), and if there is a significant difference between treatments, further testing is carried out using the Duncan Multiple Range Test (DMRT) with a level of 5% to differentiate between treatments.

RESULT AND DISCUSSION

The composting results are observed from several parameters such as odor, color, temperature, compost pH, composting time, water holding capacity, final compost weight and final compost water content..

The results of observations of the odor and color of the compost due to treatment are presented in Table 1.

Table 1. Results of observations of compost odor and color

Treatment	Compost Smell	Standard	Color	Standard

D_0P_1	Fresh Smell	Smells Like Earth	7,5 YR 3/2 (Dark brown)	Blackish Brown
D_1P_1	Smells Like Earth	Smells Like Earth	7,5 YR 3/2 (Dark brown)	Blackish Brown
D_2P_1	Smells Like Earth	Smells Like Earth	7,5 YR 3/2 (Dark brown)	Blackish Brown
D_3P_1	Smells Like Earth	Smells Like Earth	7,5 YR 3/2 (Dark brown)	Blackish Brown
D_4P_1	Smells Like Earth	Smells Like Earth	7,5 YR 2,5/1 (Black)	Blackish Brown
D_0P_2	Fresh Smell	Smells Like Earth	7,5 YR 3/2 (Dark brown)	Blackish Brown
D_1P_2	Smells Like Earth	Smells Like Earth	7,5 YR 2.5/2 (Dark brown)	Blackish Brown
D_2P_2	Smells Like Earth	Smells Like Earth	7,5 YR 2,5/1 (Black)	Blackish Brown
D_3P_2	Fresh Smell	Smells Like Earth	7,5 YR 2.5/2 (Dark brown)	Blackish Brown
D_4P_2	Smells Like Earth	Smells Like Earth	7,5 YR 2.5/2 (Dark brown)	Blackish Brown

Source: Primary data analysis 2024

Observations of color and odor were carried out after the waste had turned into compost with a composting time of ± 3 months with the physical characteristics of the compost smelling like soil and being dark brown or dark black in color indicating that the organic material had completely decomposed and a good decomposition process would produce a homogeneous color. The results of observations of the odor and color of the compost in table 1 show that the same compost smells like soil even though the types of bacteria and types of waste are different. However, composting that does not use bacteria (D_0) turns out to produce a compost odor that resembles the smell of fresh waste and is blackish brown in color. This shows that the use of bacteria in composting will accelerate the decomposition of waste into compost. According to Rauf, W (2024) They found that microbial communities, including bacteria, play a major role in accelerating the decomposition of organic matter in the soil. This study shows that thermophilic bacteria can live at high temperatures formed during composting can accelerate the decomposition process in organic matter. So that the addition of bacteria will accelerate the formation of compost. This is in accordance with research Widiyaningrum, P (2016) where the smell produced after the composting process is the smell of soil. SNI compost states that mature compost has a neutral pH and does not smell or smell like soil. Compost is odorless anywhere after being processed, so that SNI compost has been met, mature compost has the characteristic smell of soil and is blackish brown in color which occurs due to the influence of organic material that has decomposed and become stable so that the final form is not like all and microorganisms that live in the compost carry out the decomposition process.

The results of observations of temperature, pH, composting time, water holding capacity, final compost weight and final compost water content due to treatment are presented in Table 2.

Table 2. Results of observations of temperature, pH, composting time, water holding capacity, final compost weight and final compost water content.

Treatment	Temperature (°C)	pH	Composting Time (weeks)	Water Hold Capacity (%)	Final Weight (kg)	Final Water Content (%)
Bacteria (D)						
D_0	29,87a	5,98a	9,25	42,19	0,64	27,22
D_1	29,90a	6,48a	8,50	53,44	0,71	33,70
D_2	30,25b	6,42a	8,75	60,32	0,73	38,55
D_3	30,00a	6,47a	8,75	57,82	0,76	39,27
D_4	30,16a	6,53b	8,62	69,38	0,79	50,55
Waste (P)						
P_1	29,98	6,33a	9,25b	51,75	0,76b	38,45b
P_2	30,09	6,45b	8,3a	61,50	0,68a	37,26a
Combination Treatment (DP)						
D_0P_1	29,78a	5,90a	9,75	38,13a	0,67	27,19a
D_1P_1	29,80a	6,39a	9	51,88c	0,80	32,44a
D_2P_1	30,35e	6,28a	9,25	56,25c	0,79	41,53b
D_3P_1	29,95a	6,43a	9	50,00b	0,83	41,65b
D_4P_1	30,03c	6,65a	9,25	62,50c	0,72	49,44b
D_0P_2	29,95b	6,05a	8,75	46,25b	0,60	27,25a
D_1P_2	30,00c	6,75b	8	55,00b	0,62	34,96a
D_2P_2	30,15d	6,55a	8,25	64,38c	0,66	35,56a
D_3P_2	30,05d	6,51a	8,5	65,63c	0,68	36,88a
D_4P_2	30,28d	6,40a	8	76,25d	0,86	51,65c

Source: Primary data analysis 2024

Information :

- Numbers followed by letters in the same column indicate no significant difference based on the multiple range test (DUNCAN).
- If the letters in the symbol are the same, it means no significant difference
- If the letters in the symbol are different, it means they are significantly different

Observations of temperature and pH are carried out every time observations are made until the waste turns into compost for ± 3 months with the characteristics of the compost temperature ranging from 20°C to 30°C. The composting temperature determines the quality of the compost produced. If the composting process does not produce heat, it indicates that microbial activity is not going as expected. The compost temperature has a good effect because it is able to reduce pathogens (harmful microbes/weeds). If the temperature in the composting process is only around less than 20°C then the compost is declared a failure, so it needs to be repeated. Check again the amount of compost material whether it is enough, the humidity of the compost is not too dry, or the compost cover is tight enough. If the composting temperature is more than 20°C then it shows that microbial activity is quite good and the metabolic rate is increasing rapidly (Fitriani J, 2024).

Increasing the dose of bacteria in straw waste has a very significant effect between (D_0) and (D_1) because the initial compost pH is slightly acidic and forms organic acids, then the pH increases due to the decomposition of proteins, the interaction between (D_2), (D_3) and (D_4) continues to increase, with a combination of cow rumen bacteria, The increase in the pH value of the compost is thought to be due to the decomposition process that has been evenly distributed, causing an increase in pH and is also influenced by compost materials originating from rice straw waste. The increase in pH is thought to be due to the addition of several composting activators causing the composting process to be higher so that the compost can be completely decomposed which affects the pH properties of the compost and there is a decrease, without the provision of bacteria (control), While the provision of bacterial doses in corn plant waste has a very significant effect between (D_0) and (D_1) experiencing a significant increase and decreasing in the doses of bacteria (D_2), (D_3) and (D_4) so that the interaction of the three doses has a significant effect because the bacteria can accelerate the composting process and help release ammonia.

Table 2 shows that waste without bacteria tends to have no effect on the composting process, but waste that is given a combination of bacteria has a very big effect, where the higher the temperature in the compost, the more it will neutralize the pH and shorten the composting process, and the better the water holding capacity of the compost, which will produce compost that has a high water content and also has high nutrients.

The Effect of Bacteria Types and Compost Materials on Composting Results

Table 3 Analysis of Results of Variation in Composting Results Due to Treatment

No	Observation Parameters	Bacteria (D)	Waste (P)	Combination (DP)	Mark	
					Highest	Lowest
1	Temperature (°C)	*	ns	*	30,35 (D_2P_1)	29,78 (D_0P_1)
2	pH	*	**	**	6,75 (D_1P_2)	5,90 (D_0P_1)
3	Composting Time (Weeks)	ns	*	ns	9,75 (D_0P_1)	8,00 (D_4P_2)
4	Water Hold Capacity (%)	ns	ns	**	76,25 (D_4P_2)	38,13 (D_0P_1)
5	Final compost weight (kg)	ns	*	ns	0,86 (D_4P_2)	0,60 (D_0P_2)
6	Final moisture content of compost (%)	ns	*	*	51,65 (D_4P_2)	27,19 (D_0P_1)

Description:
* : Significantly influential
** : Very significantly influential

ns : No significantly influential

From the results of the analysis of variance, it can be seen that the provision of cellulolytic bacteria, rhizomonas, subtilis and cow rumen significantly affected the temperature and pH, but did not significantly affect the composting time, water hold capacity, final compost weight and final compost water content. While for the utilization of rice straw and corn waste did not significantly affect the temperature and water hold capacity, but significantly affected the composting time, final compost weight and final compost water content and had a very significant effect on the pH of the compost, while for the combination of cellulolytic bacteria, rhizomonas, subtilis, cow rumen and corn waste and rice straw significantly affected the temperature and final compost water content, had a very significant effect on pH and water hold capacity and did not significantly affect the composting time and final compost weight. For treatments that had a significant effect on the analysis of variance, a further DMRT test was carried out to determine the differences between treatments. Table 3 Proves that the results of temperature parameter observations found the highest value of (30.35) with the treatment of cellulolytic bacteria and subtilis bacteria with rice straw compost while the lowest value was (29.78) with treatment without bacteria in rice straw compost, pH parameters in compost found the highest value of (6.75) in the treatment of cellulolytic bacteria, rhizomonas bacteria, and cow rumen bacteria with corn plant compost while the lowest value was (5.90) in the treatment without bacteria with rice straw compost, The duration of composting found the highest or longest value of (9.75) with treatment without bacteria with rice straw compost while the lowest or fastest value (8) was in cow rumen bacteria with corn plant compost. The Water Hold Capacity parameter found the highest value of (76.25) with the treatment of cow rumen bacteria with corn plant compost while the lowest value (38.13) was in the treatment without bacteria with rice straw compost. The final compost weight parameter found the highest value of (0.86) with the treatment of cow rumen bacteria with corn plant compost while the lowest value (0.60) was found in the treatment without bacteria with corn plant compost. The final compost water content parameter found the highest value of (51.65) in the treatment of cow rumen bacteria with corn plant compost while the lowest value was (27.19) in the treatment without bacteria with rice straw.

During the composting process, organic matter is converted into carbon dioxide and water, accompanied by the release of energy by microbes. Some of this energy is used by microorganisms for cell growth and some causes an increase in temperature, microorganisms take energy for their activities, from the calories produced in the biochemical reaction of changes in biological waste materials, especially carbohydrate substances, continuously so that the carbon content of organic waste decreases lower and lower, because the end of the respiratory reaction releases CO2 and H2O gases that evaporate (Hamidah et al., 2023). The temperature in a compost pile is usually cool or the same as the ambient temperature when the organic material was first collected there. As the decomposition process progresses, the activity of decomposing microorganisms such as bacteria, fungi, and actinomycetes increases, which produces heat as a by-product of the activity of the microorganisms and the chemical reactions that occur during the decomposition process. As a result, the temperature in the compost pile (Fitriani, J 2024)

Conclusion

The provision of cellulolytic bacteria, subtilis, rhizomonas and cow rumen significantly affected the temperature and pH of the compost but did not significantly affect the composting time, water hold capacity, final compost weight and final compost water content, but the use of rice straw waste and corn waste had a very significant effect on pH and significantly affected the composting time, final compost weight and final compost water content but did not significantly affect the temperature and water hold capacity and the combination of bacteria administration turned out to have an effect so that corn waste experienced composting faster than rice straw waste because decomposing microorganisms can develop faster compared to composting rice straw waste which is denser and takes longer to decompose.

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