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Influence of Bacillus subtilis Biomass on Composting Outcomes Using Decomposer Bacteria Across Various Compost Media with a Control Comparison

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Abstract

Bacteria play a role in processing agricultural waste into compost. Rice and corn straw waste has potential as organic fertilizer. This research aims to compare the effectiveness of decomposer bacteria in the composting process. The research was carried out in Bowan, Klaten, February-June 2023, using a completely randomized factorial design consisting of 8 treatments and 4 replications. The first factor is the type of bacteria consisting of no bacteria, cellulotic+rhizomonas, cellulotic+BRS, rhizomonas+subtilis, subtilis, while the second factor is the type of composting media, namely straw and corn. Observations include water hold capacity, time, weight and compost water content. The results of the research show that the type of bacteria influences the water hold capacity, time and weight of the compost. In the composting process, corn waste is more effective than straw. The interaction of the type of bacteria and composting media influences the water holding capacity, time and weight of the compost. In conclusion, subtilis bacteria play an important role in accelerating composting, increasing efficiency through the correct interaction of bacteria and waste. Corn waste is superior to straw in producing high quality compost.

Keywords: *Compost, corn waste, decomposing bacteria, straw waste, subtilis bacteria*.

Introduction

Organic farming is a cultivation method that utilizes natural ingredients and does not involve the use of synthetic chemicals. One way to implement organic farming is to use organic fertilizer. Processing organic waste into compost can provide benefits for plant growth (Murumkar, 2021).

Composting has long been applied to reduce organic waste, and adding compost to the soil can increase the formation of soil aggregates, as well as improve soil permeability and porosity (Kumar et al., 2024). Decomposition of organic matter is the process in which microbes, such as microorganisms, convert organic matter into energy and simpler inorganic elements, such as carbon, nitrogen, phosphorus, sulfur, and potassium. This process involves physical and chemical changes carried out by soil

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microorganisms, known as mineralization. This decomposition takes place dynamically and is strongly influenced by the presence of decomposers, both in terms of number and diversity (Guo et al., 2018).

Utilizing agricultural waste, especially rice straw, as organic fertilizer is a wise step to increase the organic matter content of the soil and meet plant nutrient needs. Even though rice straw is a very potential source of organic matter, the high C/N ratio is a major obstacle if it is used directly as soil organic matter (Murumkar, 2021).

Intensive corn planting not only produces seeds with a high weight, but also produces waste such as stalks, leaves, cobs and corn silk. This waste makes up more than 70 percent of the total plant biomass, but is still rarely used (Zhang et al., 2024).

Method

Place and Time of Research

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

Research Materials and Tools

The materials used are straw, corn waste, dolomite, bran, molasses, cellulotic bacteria, rhizomonas, subtilis and cow rumen. Tools used are sacks, spatulas, choppers, treatment nameplates, scales, scissors, labels, ovens, raffia, tarpaulins, MMT, pipettes, beakers, gallons, stationery, buckets, gloves, distilled water, pH meters and plastic

Research methods

This research was conducted descriptively qualitatively and quantitatively using a factorial Completely Randomized Design (CRD) with 8 treatments and 4 replications. The first factor is the type of bacteria, namely no bacteria, cellulotic+rhizomonas, cellulotic+BRS, rhizomonas+subtilis, subtilis, while the second factor is the type of waste consisting of rice straw and corn waste.

Research Implementation

This research was carried out using sack media. The research was carried out by mixing 0.7 kg of straw waste or corn waste, 0.1 kg of bran, 0.1 kg of dolomite and 100 ml of molasses in each sack. The bacteria used is 0.25 cc per sack. There are four groups of bacteria: B_1 (1.25 cc of cellulolytic bacteria + 1.25 cc of rhizomonas bacteria), B_2 (1.25 cc of cellulolytic bacteria + 1.25 cc of BRS bacteria), B_3 (1.25 cc of rhizomonas bacteria + 1.25 cc of subtilis bacteria), and B_4 (2.5 cc of subtilis bacteria). Observations were carried out every four days by turning the compost material and giving a mixture of molasses water. Parameters observed included composting time (days), water holding capacity (%), final compost weight (kg), and compost water content (%). Data were analyzed using variance and if there were significant differences between treatments, further tests were carried out using the Duncan Multiple Range Test (DMRT) with a level of 5%.

RESULT AND DISCUSSION

Based on the diversity analysis (Table 1), it shows that the influence of bacteria, waste and their interactions varies with the parameters of time, water hold capacity, final compost weight and final compost water content. The results of the analysis of variance showed that the bacterial combination treatment (B) was very significantly different with respect to time, water hold capacity, and final compost weight, not significantly different with respect to the final moisture content of the compost. Waste treatment (L) is very significantly different to time, final weight of compost, not significantly different to water hold capacity, final water content of compost. The interaction between bacteria and waste treatment (B)

Table. 1 Analysis of variations in composting parameters

No.	Treatment	Treatment		
		Bacteria (B)	Waste (L)	B X L
1.	Time	9,60 **	128,12 **	9,22 **
2.	*Water Hold Capacity*	12,94 **	2,23 ns	73,51 **
3.	Final Weight of Compost	6,74 **	101,55 **	12,89 **
4.	Final Moisture Content of Compost	2,03 ns	3,02 ns	0,97 ns

Note: ns = not significantly different, ** = very significantly different

Table. 2 Average parameters of observation time, water hold capacity, final weight of compost, and final water content of compost for Bacterial (B), Waste (L) treatment and interaction of bacteria and waste (BL) treatment

Treatment	**Time (day)**	***Water hold capacity* (%)**	**Compost weight (kg)**	**Water content (%)**
Bacteria (B)				
B0	42,00b	44,38a	0,67a	46,74a
B1	40,00a	60,63a	0,67a	58,43a
B2	40,38a	61,88a	0,73b	57,07a
B3	39,63a	58,13a	0,75c	58,65a
B4	39,50a	66,25b	0,72a	59,00b
Composting Media (L)				
L1	41,95b	54,75a	0,77b	52,41a
L2	38,65a	61,75b	0,64a	59,55b
Treatment Interactions BxL				
B_0L_1	42,00b	41,25a	0,79c	42,74a
B_1L_1	42,00b	57,50a	0,78c	54,69a
B_2L_1	42,75c	60,00a	0,79c	54,69a
B_3L_1	42,00b	56,25a	0,81d	54,99a
B_4L_1	41,00a	58,75a	0,71a	54,94a
B_0L_2	42,00b	47,50a	0,55a	50,75a
B_1L_2	38,00a	63,75a	0,56a	62,17b
B_2L_2	38,00a	63,75a	0,68a	59,45a
B_3L_2	37,25a	60,00a	0,69a	62,32c
B_4L_2	38,00a	73,75b	0,73b	63,07d

Source: Primary data processed, 2024

Composting Time

Obtaining decomposer bacteria treatment (B) has a very significant effect on composting time parameters. The highest treatment obtained for B0 (without bacteria) was 42.00 days, had a very significant effect on B1 (cellulolytic, rhizomonas) reached 40.00 days, B2 (cellulolytic, BRS) reached the highest 40.38 days, B3 (rhizomonas, subtilis) reached 39.63 days and B4 (subtilis) reached 39.50 days. . This effect is caused by the activity of microorganisms in decomposing organic materials more quickly.

The composting media treatment (L) had a very significant effect on the composting time parameters. The gain from treatment L1 (straw composting media) reached 41.95 days and L2 (corn composting media) reached 38.65 days. This difference is caused by raw material characteristics that influence microbial activity.

The interaction treatment of decomposer bacteria (B) and composting media (L) had a very significant effect on the composting time parameters. The highest treatment interaction obtained by B2L1 (cellulolytic bacteria, BRS and straw composting media) reached 42.75 days. The effectiveness of composting is influenced by the type of microorganisms and the characteristics of the raw materials, which determine the moisture balance and nutrient availability.

The success of composting depends on optimizing microorganisms as biological activators that accelerate decomposition and improve compost quality. These microorganisms play an important role in decomposing organic matter into essential mineral nutrients for the soil (Lubis, 2020).

The composting time analysis graph (Figure 6) shows the duration of the compost decomposition process. Time values range from 30.68 days to 31.75 days. Longer time may be required for treatment of certain decomposer bacteria and composting media to reach optimal maturity. Time parameters are important to ensure that all organic materials decompose and the compost is ready to be used as fertilizer.

L1 (straw composting media) showed the highest composting time, namely 42.75 days in treatment B2 (cellulolytic, BRS) and the lowest composting time, namely 41 days in treatment B4 (subtilis). L2 (corn composting media) showed the highest composting time, namely 42 days in treatment B0 (without bacteria) and the lowest composting time, namely 37.25 days in treatment B3 (rhizomonas, subtilis). This difference in pattern shows that the L1 graph line (straw composting media) tends to have the highest composting time score compared to the L2 graph line (corn composting media).

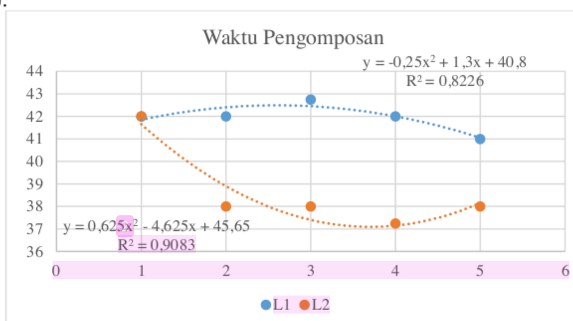

Figure 1 Compost Time Analysis Graph

Water Hold Capacity

Obtaining decomposer bacteria treatment (B) has a very significant effect on water hold capacity parameters. The treatment obtained for B4 (subtilis) reached 66.25%, had a very significant effect on B0 (without bacteria) reached 44.38%, B1 (cellulolytic, rhizomonas) reached 60.63%, B2 (cellulolytic, BRS) reached 61.88%, B3 (rhizomonas, subtilis) reached 58.13%. This effect is caused by the ability of bacteria such as Bacillus subtilis to produce exopolysaccharides (EPS) which increase water retention, as well as the production of hydrolytic enzymes by cellulotic bacteria which change the structure of the material to make it more porous.

The composting media treatment (L) has a very significant effect on the water hold capacity parameters. The results of treatment L2 (corn composting media) reached 61.75% and L1 (straw composting media) reached 54.75% of the difference in material characteristics. Corn media (L2) contains coarse fiber and a more porous structure than straw (L1), so it can absorb and retain water better. Additionally, the corn decomposition process produces more stable organic matter, which contributes to increased water retention capacity.

The interaction treatment of decomposer bacteria (B) and composting media (L) had a very significant effect on the water hold capacity parameters. The highest treatment interaction obtained by B4L2 (Bacteria subtilis and corn composting media) reached 73.75% due to the combination of Bacillus subtilis (B4) and corn composting media (L2) providing a synergistic effect. Bacillus subtilis produces exopolysaccharides that increase the material's ability to retain water, while corn media with its coarse fiber content and porous structure supports higher water retention.

Nutrient retention affects the addition of nutrients to plants. In addition, the use of decomposer bacteria is thought to increase soil porosity, water holding capacity, organic C content, and microbial activity in the soil. Providing decomposer bacteria that increase available organic C and P in soil with moderate organic C and high available P content can improve soil organic matter content and available P nutrients, which support the plant growth process (Lelu et al., 2018).

Increasing water holding capacity contributes to improved soil porosity, nutrient availability, and microbial activity that supports plant growth. Its effectiveness is more evident in sand-textured soil than clay, because organic matter plays a greater role in increasing water retention in soil with large pores (Widjajanto et al., 2021).

The water hold capacity analysis graph (Figure 7) shows the water holding capacity ranges from 41.25% to 73.75%. This parameter is important to determine the compost's ability to store moisture. Treatment of decomposer bacteria and composting media with higher capacity shows that the compost can maintain moisture better, which is beneficial for plant growth.

L1 (straw composting media) shows the highest water hold capacity of compost, namely 60.00% in treatment B2 (cellulolytic, BRS) and the lowest water hold capacity of compost, namely 41.25% in treatment B0 (without bacteria). L2 (corn composting media) showed the highest compost water hold capacity, namely 73.75% in the B4 (subtilis) treatment and the lowest compost water hold capacity, namely 47.50% in the B0 treatment (without bacteria). This difference in pattern shows that the L2 graph line (corn composting media) tends to have the highest compost water hold capacity score compared to the L1 graph line (straw composting media).

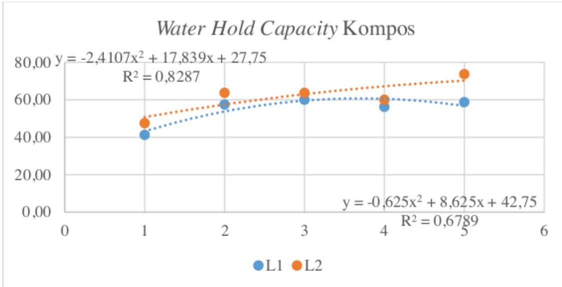

Figure 2 Compost Water Hold Capacity Analysis Graph

Compost Weight

Obtaining decomposer bacteria treatment (B) had a very significant effect on the compost weight parameters. The highest treatment yield of B3 (rhizomonas, subtilis) reached 0.75 kg, which had a very significant effect on B0 (without bacteria) reaching 0.67 kg, B1 (cellulolytic, rhizomonas) reaching 0.67 kg, B2 (cellulolytic, BRS) the highest reaching 0.73 kg, and B4 (subtilis) reaching 0.72 kg. This influence is caused by the ability of these two types of bacteria to increase the decomposition process and accelerate the breakdown of complex compounds into simpler forms, thus producing heavier and better quality compost.

The composting media treatment (L) had a very significant effect on the compost weight parameters. The gain from treatment L1 (straw composting media) reached 0.77 kg and L2 (corn composting media) reached 0.64 kg due to differences in the physical and chemical properties of the two media. Straw media has a higher fiber content and is more easily decomposed, while corn media is less efficient in providing nutrients and structure for microbial growth.

The interaction treatment of decomposer bacteria (B) and composting media (L) had a very significant effect on the final weight parameters of the compost. The highest treatment interaction obtained by B3L1 (Rhizomonas, subtilis bacteria) and straw composting media) reached 0.81 kg. This effect was caused by the effective combination of the two types of bacteria which accelerated the decomposition process of organic material in straw media, which is rich in fiber and easily decomposed.

The decrease in compost weight is directly related to the decrease in compost pile height. This process converts the compost material into small particles, which causes a reduction in the volume of the pile. Apart from that, the weight of the compost is also reduced because during digestion by microorganisms, heat is formed which evaporates the water and carbon dioxide (CO_2) content of the waste (Hanafi & Yulipriyanto, 2014).

The reduction in compost weight occurs due to the process of decomposing the material by microorganisms, which causes a decrease in water content and evaporation due to the heat produced during composting. In the process of decomposing organic materials, microbes need water, oxygen from the air, and nutrients from organic materials as energy sources. During this process, microbes will release CO2, water and heat energy, which ultimately causes a reduction in the weight of the compost material (Kurniawan et al., 2021).

The compost weight analysis graph (Figure 8) shows that the compost weight varies from 0.55 kg to 0.81 kg. This increase in weight may be due to the addition of organic material or the success of an efficient decomposition process. A higher compost weight is generally desirable because it indicates a more nutrient-rich compost result. Compost weight shows the highest graph showing that the treatment of decomposer bacteria and certain composting media in the composting process has succeeded in producing compost that is denser and richer in nutrients.

L1 (straw composting media) showed the highest compost weight, namely 0.81 kg in treatment B3 (rhizomonas, subtilis) and the lowest compost weight, namely 0.71 kg in treatment B4 (subtilis). L2 (corn composting media) showed the highest compost weight, namely 0.73 kg in treatment B4 (subtilis) and the lowest compost weight, namely 0.55 kg in treatment B0 (without bacteria). This difference in pattern shows that the L2 graphic line (corn composting media) tends to have the highest compost weight score compared to the L1 graphic line (straw composting media).

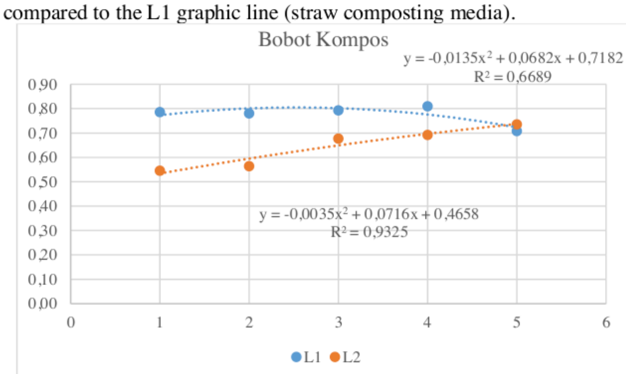

Figure 3 Compost Final Weight Analysis Graph

Water content

Obtaining decomposer bacteria treatment (B) has a very significant effect on water content parameters. The treatment obtained by B4 (subtilis) reached 59%, which had a very significant effect on B0 (without bacteria) reaching 46.74%, B1 (cellulolytic, rhizomonas) reaching 58.43%, B2 (cellulolytic, RBS) reaching 57.07%, B3 (rhizomonas, subtilis) reaching 58.65% due to the activity of different microorganisms in each type of bacteria used. Bacteria such as Bacillus subtilis, cellulotic, and rhizomonas have an important role in the decomposition process of organic material, which produces heat and accelerates decomposition.

The composting media treatment (L) had a very significant effect on water content parameters. The results of treatment L2 (corn composting media) reached 59.55% and L1 (straw composting media) reached 52.41% due to the different composition of materials in the corn composting media (L2) and straw (L1). Corn media has a higher fiber content and porosity, so it can increase air circulation and reduce moisture trapped in the compost. In contrast, straw media tends to absorb more water, leading to a higher final moisture content.

The interaction treatment of decomposer bacteria (B) and composting media (L) had a very significant effect on water content parameters. The highest treatment interaction obtained by B4L2 (subtilis bacteria and corn composting media) reached

63.07% because subtilis bacteria have high decomposition capabilities, being able to break down organic materials into simple compounds such as water. Corn media provides a source of fiber that supports bacterial activity, speeds up the composting process, and results in a significant reduction in water content.

The water produced by microorganisms during the composting process will evaporate into the air. If the compost pile is too moist, the decomposition process can be hampered because high humidity will fill the air spaces in the pile, thereby reducing oxygen levels. Water content fluctuations are influenced by various environmental factors such as temperature, weather and climate. High water content tends to indicate that the temperature produced during the composting process is lower (Rani et al., 2021).

Water content is influenced by the process of breaking down materials by microbes and the heat produced during composting. This process causes a decrease in water content through evaporation. When using cellulolytic and xylanolytic bacterial isolates, the final compost water content tended to be lower, with the most significant final water content, namely 51.51%, compared to the control which showed a final water content of 15.55%. The moisture content of the compost material can be reduced by up to 60-82% of the initial moisture content of the compost material. This decrease in water content is caused by the process of destroying the compost material during decomposition (Kurniawan & Gusmawartati, 2021).

Water content analysis graph (Figure 9) Water content ranges from 42.74% to 63.07%. The right moisture content is very important for the quality of the compost, too high a water content can cause anaerobic rot, while too low a level can inhibit the activity of microorganisms. Optimal water content supports the decomposition process and improves compost quality. The moisture content showing the lowest graph indicates that the composting process may not be able to maintain optimal humidity.

L1 (straw composting media) showed the highest water content, namely 54.99% in treatment B3 (rhizomonas, subtilis) and the lowest water content was 42.74% in treatment B0 (without bacteria). L2 (corn composting media) showed the highest water content of 63.07% in treatment B4 (subtilis) and the lowest water content of 50.75% in treatment B0 (without bacteria). This difference in pattern shows that the L2 graph line (corn composting media) tends to have the highest water content score compared to the L1 graph line (straw composting media).).

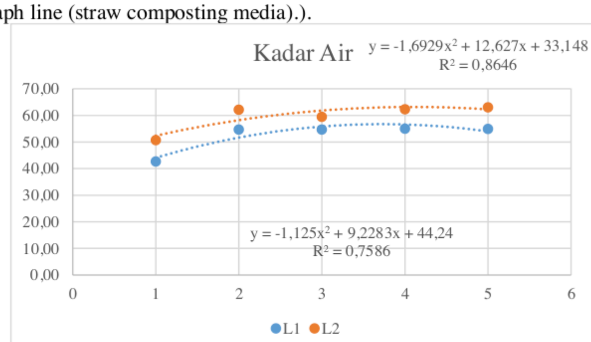

Figure 4 Graphic of Final Water Content Analysis of Compost

Conclusion

Decomposer bacteria, including subtilis bacteria, have a significant effect on the composting process, increasing parameters such as time, water holding capacity, final weight of compost. Other variations of bacteria also make a positive contribution, and selecting the right combination of bacteria and waste is important for composting efficiency. Corn waste showed a greater impact than straw in composting with bacteria, increasing the time and final weight of compost. The use of bacteria accelerates decomposition and improves the quality of the compost, with the interaction between waste and bacteria influencing the final result.

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