Research Paper

The Effect of a Mixture of Leaf Waste and Ash with a Bioactivator on Compost Characteristics and Corn Growth

Didi Saidi*, Bambang Sugiarto, Imam Prabowo
Universitas Pembangunan Nasional Veteran Yogyakarta, Indonesia

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Abstract

This study aimed to analyze the characteristics of ash from waste combustion, the quality of compost made from leaf waste, ash, and various bioactivators, as well as their effects on corn growth. The research was conducted in two stages. The first stage focused on compost production using two factors: the proportion of leaf waste and ash (A0: 0% ash, A1: 5%, A2: 10%, A3: 15%, A4: 20%) and the type of bioactivator (B0: none, B1: EM4, B2: Stardec, B3: straw isolate, B4: Trichoderma). The second stage tested the resulting compost on corn plants using a completely randomized design with one factor and three replications. Data were analyzed using analysis of variance (5%) and the Duncan test (5%). The results showed that the combustion ash had varying qualities: the pH, NPK, Ca, Fe, and Zn contents met quality standards, while the organic carbon content was below the standard, and the C/N ratio exceeded it. Heavy metal Hg levels were below the limit, but Pb and Cd exceeded quality standards. The compost produced from a mixture of leaf litter, ash, and bioactivators also varied, with its pH, organic carbon, and total N+P+K content meeting the Indonesian National Standard (SNI) for organic fertilizer; however, the nitrogen and phosphorus contents were below the SNI requirements. Regarding corn growth, the highest plant height was observed in treatments with 5% ash and the Stardec bioactivator. In contrast, the lowest height was observed in compost without ash and with the Trichoderma bioactivator.

Keywords *ash, bioactivator, combination, corn, growth, leaf litter*

INTRODUCTION

The management of both organic and inorganic waste should aim to improve public health and environmental quality while transforming waste into an economically valuable resource. Waste management and processing are crucial because the decomposition of organic waste into high-quality compost takes a considerable amount of time. Therefore, bioactivators and ash from incineration are needed to improve compost quality.

Fertilizer is the result of separating organic and inorganic waste. Human and industrial activities generate increasing amounts of waste, contributing to environmental pollution. Environmental pollution caused by waste can be reduced by managing it into economically valuable and environmentally friendly resources (Government of the Republic of Indonesia, 2020). The process of decomposing organic waste using bioactivators into high-quality compost takes a considerable amount of time. If not managed promptly, the waste will accumulate. The resulting compost can be directly applied to the soil for plant growth. Compost is ready for use as fertilizer based on its carbon-to-nitrogen ratio. If the ratio of organic carbon to nitrogen is greater than 25, the compost is not ready for use as fertilizer. Improving the characteristics of compost and enhancing its readiness as a fertilizer can be achieved by treating a combination of organic waste and ash from combustion, with bioactivators, including EM4, Stardec, and Trichoderma.

The addition of ash from burning waste to leaf litter enriches nutrients, and microorganisms act as bioactivators to accelerate the decomposition process. Trichoderma, a fungus, plays a role in decomposing organic matter and inhibiting the growth of plant pests and diseases. Corn productivity is highly determined by soil fertility. Nutrients in the soil are supplied

Corresponding author's email: didi.saidi@upnyk.ac.id

externally through composting. Superior varieties require relatively high levels of nutrients.

Soil, as a growing medium, must have good quality and fertility. Soil derived from volcanic ash from Mount Merapi will affect the surrounding soil type. The soil will have a sandy texture, loose structure, poor water retention, low nutrient availability, and low biological activity. The addition of compost will improve the physical properties of the soil, increasing its moisture content and thereby enhancing chemical fertility, including the nutrients nitrogen, phosphorus, and potassium. Biological fertility is also expected to increase due to increased biological activity, including soil microorganisms, which play a vital role in nutrient cycling.

LITERATURE REVIEW

Waste is the solid residue of daily human activities and/or natural processes. Waste consists of: household waste (waste originating from daily household activities, excluding feces and specific waste), household-like waste (waste from commercial areas, industrial areas, social facilities, public facilities, and other facilities), and specific waste (hazardous and toxic waste, disaster waste, building debris, and waste that cannot be processed technologically). Waste management should aim to enhance public health and environmental quality, and utilize waste as a valuable resource. The process of decomposing organic waste using bioactivators into high-quality compost takes a considerable amount of time. If not managed promptly, waste will accumulate. The resulting compost can be directly applied to the soil for plant growth (Government of the Republic of Indonesia, 2008).

The largest source of waste comes from market and household waste. Market and household activities generate tens of millions of tons of waste annually, comprising both organic and inorganic waste. Processing inorganic waste (plastic) into economically valuable crafts, such as flowers, brooches, and other skills, also discusses the importance of managing inorganic waste so as not to cause environmental pollution (Fathihani & Abdullah. 2021).

Increasing human activity will lead to an increase in waste production, resulting in the continuous accumulation of waste. Meanwhile, the decomposition process of organic waste is slower than its accumulation, which can cause environmental pollution. To mitigate the increasing accumulation of organic waste, effective and efficient bioactivators are necessary for the processing of organic waste. For organic waste decomposition to be effective and efficient, testing with superior bioactivators is necessary (Saidi et al., 2023). Liquid organic fertilizer from household waste contains relatively high levels of nutrients. However, its low carbon-to-nitrogen ratio indicates that the compost is suitable for use as fertilizer (Saidi & Lagiman, 2010). Research results from Saidi dan Novrido Charibaldi (2021) indicate that liquid organic fertilizer contains nutrients such as total nitrogen, available phosphorus, low levels of available potassium, and a neutral pH. Due to its low organic matter content, this liquid organic fertilizer is not yet suitable for use as a plant fertilizer, according to a 2017 report from the DIY Settlement Environmental Health System Development Work Unit (PSPLP).

The composition of waste at the Piyungan Landfill is dominated by organic waste, amounting to 38.8%. However, according to Saidi dan Purwanto (2015), the nutrient content of organic waste is relatively low, so it is necessary to add other nutrient-rich materials, such as ash and nutrient-rich livestock manure. The addition of Trichoderma spp. to several types of manure significantly affected the number of leaves, plant height, number of pods, fresh pod weight, dry pod weight, and seed weight of peanut plants (Wawan et al., 2023). Corn (Zea mays L.) is a food crop of high economic value, as it serves not only as a source of carbohydrates and protein but also as an alternative to rice and wheat, thereby supporting national food security. Indonesia's corn productivity remains low compared to other countries, such as Thailand, at 9 tons per hectare, and Japan, at 21 tons per hectare. Corn crop productivity experienced a slight decline from 30.26 kw/ha to 30.13 kw/ha. This decline in production was mainly due to a 39.77 percent decrease in harvested area, from 6,462 hectares in 2014 to 3,892 hectares in 2015 (Samad & Hasbullah, 2019).

Based on statistical data, the demand for food/vegetable commodities in Indonesia continues to increase in line with the country's growing population. In 2018, there was a 19.1% increase of 420,998 tons from the previous year (Badan Pusat Statistik, 2018).

The results of organic fertilizer testing on corn plants (Saidi, 2009) showed that plant height at 30 days after planting was achieved with solid organic fertilizer (POP plus). However, the highest was achieved with Ponska fertilizer (NPK). This is due to the superior quality of solid organic fertilizers compared to liquid organic fertilizers. The high nitrogen content in solid organic fertilizer plays a role in plant vegetative growth.

Higher corn grain yields were obtained with a mixture of 200 kg/ha of NPK 15-15-15 fertilizer plus 2 tons/ha of wood ash compared to the application of 300 kg/ha of NPK 15-15-15 fertilizer or 4 tons/ha of wood ash (Dekayode & Olojugba, 2010). Rice husk ash has a very significant effect on increasing sweet corn yields. The application of 720 g/m^2 of rice husk ash resulted in the highest average growth and yield (Yulianingsih, 2020). Rice Husk Ash and Black Gold Fertilizer had a significant effect on plant height and cob diameter, but did not have a significant effect on the number of plant leaves, cob length, fresh cob weight, or dry cob weight (Florino et al., 2023)

Land as a place for plant growth must have both effective and efficient quality, in terms of the physical availability of water or humidity, as well as the chemical properties of nutrients available for plants, and biological properties, namely the presence of biological activity in the soil. Parent materials strongly influence regosol soil types, for example, volcanic ash comes from the eruption of Mount Merapi. Research results (Lelanti et al., 2020), the characteristics of Regosol soil are low Nitrogen content (0.15%), very low available N content (0.01%), low CEC (13.57%), low C-organic (0.99%), neutral pH (6.75) and sandy texture with sand content (44.96%), the size of the fraction is dominated by sand, so it has a problem of low fertility levels, this is due to low nutrient and water availability due to the ease of water and nutrients being leached, water and nutrients cannot be stored in Regosol soil because the soil porosity is large. To overcome the above problems, it is necessary to develop technology that improves the quality of compost from household waste, thereby enhancing the physical, chemical, and biological fertility of the soil. It is necessary to add organic materials. Providing water once every 3 days and treating organic materials with 300 g per pot is the optimal dose to increase N, P, and K (Nikiyuluw et al., 2018).

RESEARCH METHOD

The research was conducted in the greenhouse of the Faculty of Agriculture's practical garden on Jl. Pajajaran, Condongcatur campus. Plant, fertilizer, and soil analyses were conducted in the Soil and Environmental Biology Laboratory of the Soil Science Study Program, Faculty of Agriculture, UPN "Veteran" Yogyakarta, and in the Laboratory of the Yogyakarta Agricultural Instrument Standardization Agency.

The research was conducted in two stages: Stage 1, the composting process, with two factors: the first factor, the combination of leaf waste and ash from waste incineration: A0: leaf waste with 0% ash, A1: leaf waste with 5% ash, A2: leaf waste with 10% ash, A3: leaf waste with 15% ash, A4: leaf waste with 20% ash. The second factor included bioactivators: B0: no bioactivator; B1: EM4 bioactivator; B2: Stardec bioactivator; B3: Straw isolate bioactivator; B4: Trichoderma bioactivator. Stage 2 Testing the quality of compost on corn plants with a completely randomized design with one factor, with a combination of compost and ash from burning waste with a bioactivator, with three replications. Data processing with analysis of variance (ANOVA, 5%) and Duncan's test (5%) (Gomez & Gomez, 1995).

FINDINGS AND DISCUSSION

The study was conducted on Regosol soil with the following characteristics: sand texture dominated by sand fractions (92%), soil BV of 1.14 g/cm3. This makes Regosol soil susceptible to nutrient leaching. Analysis results showed a neutral pH (6.63), low CEC (0.90 cmol(+)/kg), very low organic carbon (0.44%), very low total nitrogen (0.09%), very low available nitrogen (0.0024), low available phosphorus (11.91 ppm), and very low available potassium (0.069 cmol(+)/kg). Laboratory analysis results of ash from organic and inorganic waste combustion used in the study (Table 1).

Table 1. Characteristics of Ash from Organic and Inorganic Waste Combustion Used in the Study

No	Parameters	Units	Analysis Results	Quality Standards
1	C-Organik	%	5,20	> 15
2	pH (H_2O)		8,8	4 - 9
3	Macro Nutrients			
	N-Organik	%	0,08	> 2
	N-NH_4	%	0,01	
	N-NO_3	%	0,03	
	N total	%	0,11	
	P_2O_5	%	0,92	
	K_2O	%	2,59	
4	Ca +	%	2,3	
5	Micro Nutrients			
	Fe	ppm	9663,1	< 15.000
	Zn	ppm	192,4	< 5000
6	Heavy metal			
	Hg +	ppm	0,1	< 1
	Pb +	ppm	91,2	< 59
	Cd +	ppm	4,9	< 2

The ash from the waste incineration used in the study varied in quality: pH 8.8 (4-9) met the quality standard, Organic Carbon 5.2% (>15%) below the quality standard, N + P2O5 + K2O) >2 met the quality standard, C/N ratio 47.37 (<25) above the quality standard, Ca+ content 2.3% above the quality standard, micronutrients Fe (9,663.1 ppm) and Zn (192.4 ppm) met the quality standard, heavy metal Hg (0.1 ppm) was below the quality standard, but Pb (91.2 ppm) and Cd (91.2 ppm) were above the quality standard. The characteristics of the ash from the waste incineration indicated no decomposition/mineralization. The characteristics of the compost resulting from the combination of leaf waste and incineration ash with bioactivator are presented in Table 2.

The characteristics of compost from a combination of leaf litter and ash from waste incineration, supplemented with bioactivators, varied widely. The resulting compost had a moisture content ranging from 29.12% to 67.54% (high), a pH of 8.1 to 8.3 (slightly alkaline), and an organic carbon content of 16.37% to 34.37% (high). The highest was in A2BS, with 10% ash and Stardec bioactivator. The nitrogen content ranged from 0.67 to 2.37%, with the highest value in A3BJ, which had 15% ash and Straw Isolate bioactivator. Phosphorus content ranged from 0.29 to 1.31%. The highest value was achieved in A4B0, with 20% ash, without a bioactivator. Nutrient levels met SNI standards for organic fertilizers.

Table 2. Compost Characteristics after Treatment

NO	Sample	MC (%)	pH	C-Org (%)	OM (%)	Tot N (%)	C/N Ratio	P_2O_5 (%)	K_2O (%)	N+P+K (%)
1	A0-BO	48,39	8,1	18,55	31,98	1,75	10,63	0,39	1,26	3,4
2	A1-BO	67,54	8,1	23,74	40,92	2,46	9,637	0,29	1,22	3,97
3	A2-BO	47,86	8,2	23,41	40,36	2,17	10,77	0,38	1,21	3,76
4	A3-BO	53,76	8,2	26,91	46,39	2,26	11,9	0,42	1,26	3,94
5	A4-BO	38,82	8,2	25,45	43,88	1,9	13,36	1,31	1,25	4,46
6	A0-BE	66,9	8,1	20,43	35,22	1,7	12,05	0,38	1,13	3,21
7	A1-BE	38,84	8,1	22,3	38,44	0,83	26,93	0,56	1,51	2,9
8	A2-BE	33,06	8,1	19,62	33,82	1,09	18,07	0,38	1,14	2,61
9	A3-BE	29,12	8,1	19,36	33,38	0,71	27,21	0,5	1,51	2,72
10	A4-BE	31,16	8,1	18,73	32,3	1,04	18,07	0,39	1,12	2,55
11	A0-BS	62,5	8,1	27,82	47,96	1,47	18,9	0,42	1,48	3,37
12	A1-BS	58,14	8,1	23,14	39,9	1,36	17,01	0,79	1,12	3,27
13	A2-BS	37,76	8,1	34,37	59,26	1,7	20,28	0,85	1,21	3,76
14	A3-BS	47,1	8,1	17,22	29,68	1,65	10,47	0,96	1,02	3,63
15	A4-BS	36,43	8,1	18,58	32,04	1,8	10,33	0,73	0,98	3,51
16	A0-BJ	61,16	8,1	24,17	41,68	1,26	19,13	0,5	1,58	3,34
17	A1-BJ	31,37	8,2	18,61	32,09	1,93	9,637	0,46	1,41	3,8
18	A2-BJ	49,23	8,2	18,65	32,16	1,02	18,22	0,7	1,36	3,08
19	A3-BJ	51,13	8,2	16,37	28,23	2,37	6,909	0,47	1,38	4,22
20	A4-BJ	56,74	8,2	19,59	33,78	1,54	12,76	0,59	1,68	3,81
21	A0-BT	44,2	8,3	21,67	37,36	1,75	12,37	0,33	1,23	3,31
22	A1-BT	40,82	8,2	23,72	40,9	1,39	17,01	0,3	1,31	3
23	A2-BT	38,46	8,3	20,66	35,63	1,62	12,76	0,36	1,16	3,14
24	A3-BT	45,19	8,2	22,06	38,04	0,86	25,51	0,35	1,25	2,46
25	A4-BT	32,22	8,2	19,33	33,32	0,67	28,91	0,35	1,38	2,4
	Standar SNI	20	4 - 9	> 15	> 25	-	< 20	-	-	>2

Description:
A0: Leaf litter without ash
A1: Leaf litter with 5% ash
A2: Leaf litter with 10% ash
A3: Leaf litter with 15% ash
A4: Leaf litter with 20% ash
B0: Without bioactivator
BE: EM4 Bioactivator
BS: Stardec Bioactivator
BJ: Straw Isolate Bioactivator
BT: Trichoderma Bioactivator

Table 3. Effect of the Combination of Compost and Ash from Waste Incineration with Bioactivator on Corn Plant Height

Treatment,	BO	BE	BS	BJ	BT	Average
AO	85,3	90	75	82,4	66,5	79,84 b
A1	105	86	105,1	86	76	91,62 a
A2	78,4	93,7	80	67,8	84,6	80,90 a
A3	77	76,8	79,2	91	81,1	81,02 a
A4	94,3	85	90	82,5	66,1	83,58 a
Average	88 a	86,3 ab	85,86 ab	81,94 ab	74,86 b	-

Note: Numbers followed by the same letter in the same column and row indicate no significant difference based on the DMRT test at the 5% level.

In Table 3. The combination of compost and ash from burning waste with bioactivator affects the height of corn plants. The ash treatment was significantly different from the control without ash, but the amount of added ash did not significantly affect the height of the corn plants. The highest average was achieved in the A1 ash treatment (5% ash), which is attributed to the role of heavy metals that inhibit plant growth. The bioactivator treatment was also significantly different from the control in terms of plant height. The lowest plant height was achieved in the treatment with Trichoderma bioactivator, while the highest was achieved in the treatment without bioactivator. This indicates that ash levels containing heavy metals also suppress the role of bioactivators in the decomposition of organic matter. Trichoderma bioactivator is most sensitive to heavy metals, as indicated by the lowest growth rate.

The combination of compost and ash from waste incineration with bioactivator had no significant effect on the average number of leaves in corn plants. This was due to the slightly alkaline pH, low organic matter content, and heavy metal levels above quality standards. This affected plant growth and the ineffectiveness of microorganisms acting as bioactivators. The effect of the combination of compost and ash from waste incineration with bioactivator on the number of leaves in corn plants is shown in Table 4.

Table 4. Effect of the Combination of Compost and Ash from Waste Incineration with Bioactivator on the Number of Leaves in Corn Plants

Treatment	BO	BE	BS	BJ	BT	Average
AO	6	6,3	6,7	5,7	5,7	6,1 a
A1	5,7	6,7	5,7	6,7	6	6,1 a
A2	5	6,7	6,7	5,7	5,7	5,9 a
A3	6	5,7	6,7	6,3	5	5,9 a
A4	5,7	6	4,7	6	6,3	5,7 a
Average	5,7 a	6,3 a	6,1 a	6,1 a	5,7 a	-

Note**:** Numbers followed by the same letter in the same column and row indicate no significant difference based on the DMRT test at the 5% level.

The effect of the combination of compost and ash from waste incineration with bioactivator on plant height and leaf number of corn is shown in Figure 1.

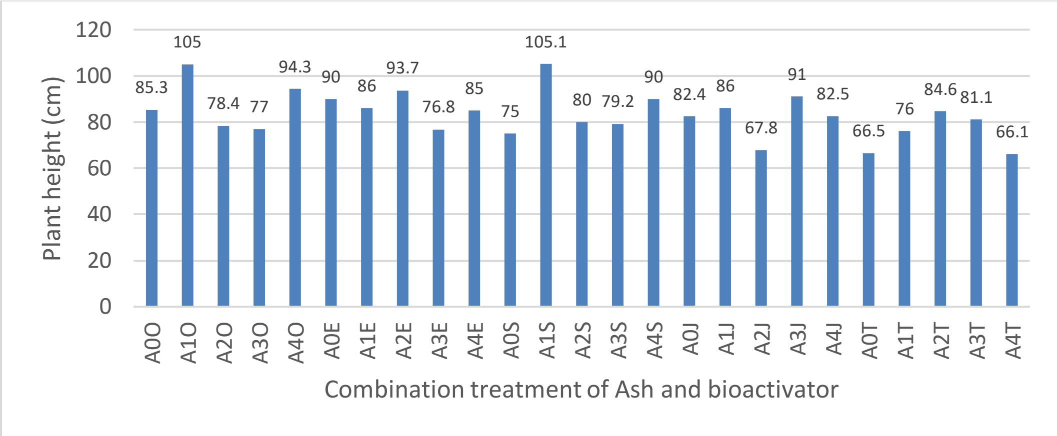

Figure 1. Effect of a Combination of Compost and Ash from Waste Incineration with Bioactivator on Plant Height and Leaf Number of Corn

The combination of compost and ash from waste incineration with bioactivator affected plant height but did not affect the number of corn leaves. The highest plant height was achieved in the 1O (5% ash treatment without bioactivator) and 1S (5% ash treatment with Stardec bioactivator) combinations. The lowest plant height was achieved in the 0T treatment (without ash with Trichoderma bioactivator) and the 4T treatment (20% ash with Trichoderma bioactivator). This was due to the presence of heavy metals in the ash exceeding the threshold, rendering the bioactivator ineffective due to toxicity. The higher the ash content, the lower the plant height. Optimal plant height was achieved in the 5% ash combination without bioactivator and with Stardec bioactivator.

CONCLUSIONS

The study's results showed that the ash from waste incineration exhibited varying characteristics. The pH (8.8) met the quality standards, while the organic carbon content (5.2%) was below the required threshold (>15%). The total nutrient content ($N + P_2O_5 + K_2O > 2\%$) met the quality standards. However, the C/N ratio (47.37) exceeded the acceptable limit (<25), the calcium content (2.3%) was above the quality standards, and the micronutrients Fe (9,663.1 ppm) and Zn (192.4 ppm) met the quality requirements. The heavy metal Hg (0.1 ppm) was below the threshold, while Pb (91.2 ppm) and Cd (91.2 ppm) were above the permitted threshold. Compost made from leaf waste, ash, and bioactivator showed considerable variation.

Moisture content ranged from 29.12% to 67.54% (high), pH from 8.1 to 8.3 (slightly alkaline), and organic carbon from 16.37% to 34.37% (high), with the highest value at 10% ash with Stardec bioactivator. Nitrogen content ranged from 0.67% to 2.37%, highest at 15% ash with Straw Isolate bioactivator, while phosphorus ranged from 0.29% to 1.31%, highest at 20% ash without bioactivator. The overall nutrient composition met the Indonesian National Standard for organic fertilizer. In corn growth tests, the lowest plant height occurred in the treatment without ash and with 20% ash using Trichoderma bioactivator. The highest plant height was achieved with 5% ash without bioactivator and with Stardec bioactivator. Overall, increasing ash concentration tended to reduce plant height.

LIMITATIONS & FURTHER RESEARCH

Managing organic and inorganic waste is crucial to prevent the ever-increasing accumulation of waste. Organic waste management must begin with household waste, and integrated waste processing is necessary. The use of ash from waste incineration requires further investigation, as it contains levels of the heavy metals Pb and Cd above quality standards.

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