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Potential Growth of Corn Plants in Vegetative Phase with Application of Volcanic Ash and Straw Compost in Karo Regency

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Abstract. Corn is third importance of the food crop group, behind rice and cassava. The demand has been rising yearly, especially for sweet corn. The aim of this research to determine of application volcanic ash (A), and straw compost (J), also the interaction of the two treatments in vegetative growth of maize plants. With a Randomized Complete Block Design (RCBD), in three levels for each treatment which of 9 treatments in three reps. R-Studio 4.3.2 was used to analize the data with DMRT test (5%), if the result was significant different. The study was showed that of two treatments had a real effect on plant height; stem diameter, number of leaves, and leaf area. Similarly the results for the interaction, between two and two treatments were significantly different. After application to corn plants of volcanic ash and straw compost were showed the better effects on vegetative growth of the plants. This indicated that the two treatments can used for corn vegetative growth.

Keywords: Volcanic Ash, Straw-Compost, Corn Plant

INTRODUCTION

Corn is the world's second most important cereal crop after wheat, rice, and other food sources, contributing 94% of the total cereal consumption (FAO 2012; Awata et al. 2019). The demand for corn consumption in developing countries is projected to increase by 1.3% per year until 2020 (Ortiz et al. 2010). Furthermore, it is estimated that by 2050, the demand for corn will rise to 3.3 billion tons, and globally, in developing countries, corn will become the highest-producing crop by 2025 (FAO 2016). Corn crop productivity in Indonesia from 2020 to 2023 fluctuated, with yields of 5.5, 5.8, 6.0, and 5.8 tons/ha, respectively (Central Bureau of Statistics 2023). Meanwhile, corn production in Indonesia during the same period also fluctuated, reaching 12.9, 13.4, 16.5, and 14.5 million tons (Central Bureau of Statistics 2024). In line with the increasing demand for corn, efforts are needed to boost corn productivity significantly. One factor contributing to the instability in corn productivity is suspected to be climate change and natural disasters such as volcanic eruptions.

Indonesia has the most active volcanoes in the world, with 127 volcanoes. One type of soil formed from volcanic material is called Andisol (Azizah et al. 2019; Saing et al. 2020). Andisol covers about 5.395 million hectares or 2.9% of the total land area in Indonesia. Andisol is utilized for productive agricultural land, particularly for horticultural crops, tea plantations, and coffee plantations (Arifin et al. 2022). Andisol has several unique properties that affect agricultural productivity, such as high phosphorus fixation, high organic matter concentration, a clay-size fraction dominated by variable charge depending

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on pH, low bulk density, high porosity, high water retention capacity, and high mesoporosity (Anda and Dahlgren 2020). Andisol soil in Karo Regency is known as a center for horticultural production, including vegetables, fruits, and ornamental plants. The majority of its residents rely on agriculture, including food crops, horticulture, and mixed plantations, for their livelihoods. In 2013, volcanic ash from the eruption of Mount Sinabung had a pH of 3.3-3.5 (acidic) due to high sulfate content, causing many crops affected by the ash to die and leading to crop failure (Tarigan and Hanum, 2019; Sukarman et al., 2020).

Volcanic ash is a rich source of nutrients, but it takes a long time to become available to plants. The weathering and mineralization mechanisms of volcanic ash are triggered by critical factors influencing soil formation processes (Nurlaeny and Simarmata 2014; Rudianto et al. 2017). Volcanic ash contains minerals needed by soil and plants, such as Ca, Na, K, Mg, P, S, Fe, Mn, Zn, and Cu. The chemical characteristics of Krakatau volcanic ash have a basaltic-andesitic composition, containing low concentrations of SiO2 and Al2O3 but higher concentrations of Fe, Ca, K, and P, along with higher levels of heavy elements (Mn, Zn, Cu, Ti, Sr, Cr) and Ag (Syamsiyah and Rahina 2017; Fiantis et al. 2021). However, volcanic ash can have adverse effects due to the high content of elements such as Si, Al, Mn, Ti, and Fe, which can be toxic to plants if land use is not managed correctly. For the problems caused by the abundant volcanic material in agricultural lands, alternative solutions are needed to mitigate the harmful effects of volcanic ash (Nurlaeny and Simarmata 2014).

Simple technologies can accelerate the weathering of volcanic ash by mixing it with organic materials or soil amendments. Organic fertilizers such as compost positively impact soil fertility and crop yields and help mitigate soil and water pollution. Compost enhances soil quality by improving soil structure, moisture retention capacity, cation exchange capacity, nutrient retention, and stimulating beneficial microbial activity (Phares and Akaba 2022). Therefore, the effect of applying Sinabung volcanic ash combined with compost fertilizer on corn plant growth must be demonstrated. The nutrient content in the compost is expected to meet the nutrient needs for corn growth and enhance nutrient uptake by the corn plants.

METHOD

Time and Location

This research was conducted from August to September 2024, using Andisol soil samples taken from Karo Regency, volcanic ash samples collected from the eruption area of Mount Sinabung, and vermicompost and straw compost. The chemical properties of the soil, volcanic ash, vermicompost, and straw compost were analyzed at the Palm Oil Research Center Laboratory.

Research Design

The research will use a factorial Randomized Block Design (RBD) consisting of 2 factors, with each factor having 3 levels, as follows: Factor I Volcanic ash (A) with 3 levels: A0 (0 tons/ha), A1 (10 tons/ha), A2 (20 tons/ha). Factor II straw compost fertilizer dosage (J) with 3 levels: J0 (0 tons/ha), J1 (10 tons/ha), J2 (20 tons/ha). This results in 9 treatment combinations, with 3 repetitions, totaling 27 experimental polybags using corn plants.

Planting Medium and Planting

Soil and volcanic ash samples were collected from areas affected by the eruption of Mount Sinabung in Karo Regency. The soil sampling, which will serve as the planting medium, was

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conducted in 2024. Soil samples were collected from the land using purposive sampling with a depth of 0-45 cm (Samsi and Pata 2017). Volcanic ash was taken from a thickness of 0-9 cm, air-dried for seven days, and then sieved using a 2 mm sieve (Nurlaeny and Simarmata 2014). The Andisol soil was crushed into fine particles, sieved, and weighed 10 kg per pot. The soil was then mixed with compost straw and volcanic ash that had been prepared according to the predetermined dosage levels. Corn seeds were germinated for four days or until they had two leaves. The corn seedlings were then transplanted into planting holes in each experimental polybag. Corn plant maintenance was carried out every five days to monitor and prevent potential drought and weed growth, which could inhibit plant development. Meanwhile, observations of corn growth during the vegetative phase were conducted every two weeks after planting (WAP). Observation parameters during the vegetative phase included plant height, number of leaves, stem diameter, and leaf area.

Data Analysis

The plant parameter data will be analyzed using Analysis of Variance (ANOVA) in RStudio version 4.3.2. If the ANOVA results show significant differences, Duncan's Multiple Range Test (DMRT) at the 5% significance level will follow.

RESULTS AND DISCUSSION

Vegetative Growth of Corn Plantas

The analysis of variance results from the treatments of volcanic ash, and straw on the vegetative growth of corn in terms of plant height (Table 1) showed a significant effect at 2 WAP, 4 WAP, and 6 WAP. The straw treatment had a significant effect on plant height at 2 WAP. At 4 WAP and 6 WAP, volcanic ash, and straw treatments significantly affected plant height. The best treatments were observed in V2 (20 tons/ha), A2 (20 tons/ha), and J2 (20 tons/ha).

Table 1. Corn Plant Height During the Vegetative Phase with Volcanic Ash, and Straw Compost Treatments

Treatments	Plant Height (cm)		
	2WAP	4WAP	6WAP
Volcanic Ash (A)			
A0 = control	30,10	75,33b	128,20b
A1 = 10 ton/ha	32,43	95,53a	158,70a
A2 = 20 ton/ha	35,30	90,93a	159,73a
Straw Compost Rice (J)			
J0 = control	30,10b	75,33b	128,20b
J1 = 10 ton/ha	31,35b	83,93a	154,37a
J2 = 20 ton/ha	36,25a	88,18a	155,10a

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% level (DMRT).

The analysis of variance results (Table 2) for observing corn plant stem diameter at 2 WAP and 4 WAP showed no significant differences among the treatments. However, at 6 WAP, volcanic ash, and straw compost treatments showed significant differences in corn stem diameter.. In comparison, the highest stem diameter in the volcanic ash treatment was

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observed in A2 (20 tons/ha), and the highest value in the straw compost treatment was found in J2 (20 tons/ha).

Table 2. Stem Diameter of Corn Plants During the Vegetative Phase with Volcanic Ash, and Straw Compost Treatments

Treatments	Stem Diameter (mm)		
	2WAP	4WAP	6WAP
Volcanic Ash (A)			
A0 = control	0,85	2,17	2,30b
A1 = 10 ton/ha	0,89	2,44	3,34a
A2 = 20 ton/ha	0,87	2,39	3,90a
Straw Compost Rice (J)			
J0 = control	0,85	2,17	2,30b
J1 = 10 ton/ha	0,92	2,17	3,31a
J2 = 20 ton/ha	0,76	2,37	3,56a

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% level (DMRT).

The results of the variance analysis (Table 3) for observations at 4 WAP and 6 WAP showed significant differences in the number of leaves in the volcanic ash, and straw compost treatments. The highest number of leaves observed at 4 WAP was found in treatments , A1, J1, and J2, all having nine leaves. In the observation at 6 WAP, the most significant number of leaves was recorded in the volcanic ash, and straw compost treatments at both the 10 tons/ha and 20 tons/ha levels. These findings indicate that applying organic amendments positively impacts leaf development in corn plants, which is crucial for overall plant health and productivity during the vegetative phase.

Table 3. Number of Leaves of Corn Plants During the Vegetative Phase with Volcanic Ash, and Straw Compost Treatments

Treatments	Number of Leave		
	2WAP	4WAP	6WAP
Volcanic Ash (A)			
A0 = control	5,67	8,33b	8,45b
A1 = 10 ton/ha	5,67	9,00a	10,33a
A2 = 20 ton/ha	6,33	8,66ab	10,33a
Straw Compos Rice (J)			
J0 = control	5,67	8,33b	8,45b
J1 = 10 ton/ha	6,00	9,00a	10,00a
J2 = 20 ton/ha	5,67	9,00a	10,00a

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% level (DMRT).

The analysis of variance (Table 4) indicates no significant differences in the leaf area of corn plants at 2 WAP and 4 WAP across all treatments. However, significant differences

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Vol. 3 No. 2 (2024)
Page : 577-584
ISSN:2828-4925
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were observed at 6 WAP among the treatments involving volcanic ash, and straw compost. This suggests that these organic amendments have a more pronounced effect on leaf area as the plants mature. This finding highlights the importance of nutrient availability and soil amendments in enhancing leaf area development, which is crucial for optimizing photosynthesis and overall plant growth. The differing impacts at various stages of plant growth underscore the dynamic nature of nutrient uptake and utilization in response to the applied treatments.

Table 4. Leaf Area of Corn Plants During the Vegetative Phase with Volcanic Ash, and Straw Compost Treatments

Treatments	Leaf Area (cm^2)		
	2WAP	4WAP	6WAP
Volcanic Ash (A)			
A0 = control	57,09	340,87	674,81b
A1 = 10 ton/ha	68,56	387,56	877,22a
A2 = 20 ton/ha	65,41	375,63	827,25a
Straw Compost Rice (J)			
J0 = control	57,09	340,87	674,81b
J1 = 10 ton/ha	65,31	355,25	780,81a
J2 = 20 ton/ha	52,25	328,94	786,44a

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% level (DMRT).

Interaction of Treatments

The analysis of variance results (Table 5) show that the interaction between volcanic ash treatment and straw compost significantly affects the growth of corn plants at 6 MST, as observed in plant height, number of leaves, stem diameter, and leaf area.

Table 5. Interaction of Volcanic Ash Treatment with Straw Compost at 6 MST

Treatments		Plant Height (cm)	Number of Leaves (helai)	Stem Diamter (mm)	Leaf Area (cm^2)
Volcanic Ash	Straw Compost Rice				
A0	J0	128,63c	8,00b	2,30d	674,81b
A0	J1	154,37a	10,00a	3,31bc	780,81a
A0	J2	155,10a	10,00a	3,56ab	786,44a
A1	J0	158,70a	10,00a	3,43ab	877,22a
A1	J1	148,77ab	10,33a	3,61ab	846,94a
A1	J2	148,92ab	10,00a	3,29bc	827,56a
A2	J0	159,33a	10,00a	3,90a	827,25a
A2	J1	159,33a	10,00a	3,45ab	830,81a
A2	J2	139,63bc	9,67a	3,18bc	875,13a

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% level (DMRT).

There is an interaction of treatments (AxJ) indicating that the treatments A2J0, A2J1, A1J0, A0J1, and A0J2 are significantly different from the treatment A0J0 regarding the height

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Page : 577-584
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of corn plants in the vegetative phase. In observing the number of leaves and leaf area, all treatment interactions show significant differences compared to the treatment A0J0. In observing stem diameter, treatment A2J0 (3.90 mm) interaction is significantly different from treatment A0J0 (2.30 mm). These results indicate that combining volcanic ash and straw compost can enhance the growth of corn plants in the vegetative phase.

DISCUSSION

The tallest plant height was found in the treatment J2 (application of straw at 20 tons/ha). The application of straw compost increased plant height, leaf number, nitrogen uptake, and dry weight of sweet corn during the vegetative phase (Pangaribuan et al. 2022). Applying biofertilizers and organic fertilizers did not significantly affect corn plant height (Azri 2020). Adding organic materials can accelerate the weathering of volcanic ash (Narka et al. 2022), which explains the significant effect of applying volcanic ash at 20 tons/ha on corn plant height at 4 WAP and 6 WAP.

The highest leaf area of corn plants was observed while the highest diameter in the volcanic ash treatment was found at A1 (10 tons/ha), and the highest value in the straw compost treatment was at J2 (20 tons/ha). In another study, Armando et al. (2020) found that the application of volcanic ash to Liberica coffee plants grown in peatlands significantly affected leaf area, particularly with a 250 g volcanic ash treatment. Additionally, research by Sembiring (2019) indicated that applying straw compost positively influenced the growth of kailan plants, including the leaf area, 28 days after planting. These findings emphasize the beneficial effects of various organic amendments, such as , volcanic ash, and straw compost, on enhancing plant growth parameters like leaf area, essential for efficient photosynthesis and overall productivity.

The interaction between volcanic ash and straw compost can positively impact the growth of corn plants in the vegetative phase. Volcanic ash contains various beneficial minerals such as silica, calcium, and magnesium (Syamsiyah and Rahina 2017; Fiantis et al. 2021). Meanwhile, straw compost serves as a source of organic matter that enriches the nutrient content of the soil and aids in nutrient absorption (Nengsih et al. 2024). Both treatments can synergize when volcanic ash and straw compost are applied together. Volcanic ash can improve soil drainage and aeration, while straw compost enriches the soil with organic nutrients. This interaction can enhance crop productivity (Fitroh 2017; Nengsih et al. 2024).. Increasing nutrient content in the soil, especially nitrogen, will enhance chlorophyll content and boost photosynthetic production. Increased photosynthates will accumulate in plant growth indicators such as height and leaf area (Widodo et al. 2024).

CONCLUSION

Treatment with 2 factorials (volcanic ash and straw compost) showed a significant effect on the growth of corn plants in the vegetative phase. Treatments A1 (10 tons/ha), and J1 (10 tons/ha) gave better results in the parameters of plant height, stem diameter, number of leaves, and leaf area of corn plants.

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