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Growth and yield of Okra (*Abelmoschus esculentus* L. Moench) treated with vermicompost and eco-enzyme in histosol soil

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Abstract

This study explores the efficacy of eco-enzyme and vermicompost on the growth and yield of Okra plants (*Abelmoschus esculentus* L. Moens). The eco-enzyme, derived from three types of fruit peels and two local vegetable wastes in Central Kalimantan, is proposed as an organic liquid fertilizer to replace chemical alternatives, promoting environmentally friendly agricultural practices. Simultaneously, the incorporation of eco-enzyme, along with vermicompost, is anticipated to enhance the physical, chemical, and biological properties of peat soils, serving as a growth medium for Okra plants. The experimental setup involves a completely randomized design with four stages of POC eco-enzyme and vermicompost administration. Treatments range from a control group (E0V0) to various combinations of eco-enzyme and vermicompost in different doses (E1V1, E2V2, E3V3). Observations, including plant height, leaf characteristics, and fruit metrics, were conducted at multiple intervals. Results indicate that the treatment with 60 ml of eco-enzyme and 125 gr of vermicompost per plant significantly influenced Okra growth and yield. Higher doses, as in V2E2 and V3E3, were deemed excessive. The study suggests further exploration of the interaction between eco-enzymes and vermicompost using a two-factorial complete randomized design for comprehensive insights.

1. Introduction

Okra (*Abelmoschus esculentus* L. Moench) is one of the functional vegetable commodities with high economic value but is not widely cultivated in Indonesia compared to other vegetable commodities[1]. In addition to being a nutritious food source, okra also has benefits in the industrial and health sectors[2]. Okra plants do not require specific soil types to grow optimally; they are tolerant to pH levels ranging from 5 to 7 and resistant to drought and shade stress, making them suitable for year-round cultivation, both in the dry and rainy seasons[3].

The expansion of cultivation areas faces challenges due to limited productive land, particularly in Palangka Raya City, where available land is shrinking due to land conversion for residential areas, industrial zones, and other economic activities. An alternative solution for meeting the cultivation land demand is the utilization of less productive land with low fertility levels, such as sandy soil (spodosol) and peat soil (histosol).

There is a significant opportunity for the development of okra cultivation on peat soil (histosol) in Palangka Raya City, given the extensive presence of peat soil, totaling 132,315.2 hectares, including sapric peat[4]. Although peat soil has substantial potential in terms of area, its land productivity is relatively low. The productivity of peat soil depends on the management practices and technology applied[5].

Based on the maturity level, peat soil consists of sapric peat (mature), hemik peat (semi-mature), and fibric peat (immature). Sapric peat refers to decomposed peat where the original materials are no longer recognizable. It has a dark brown to black color, and when squeezed by hand, its fiber content is < 15%. Peat soil generally has low pH levels, high cation exchange capacity, low base saturation, low levels of essential nutrients such as K, Ca, Mg, and P, and low levels of micronutrients (such as Cu, Zn, Mn, and B)[6]. One technological input to enhance peat soil productivity and address the low availability of nutrients is to improve the physical, chemical, and biological properties of the soil by adding eco-enzymes and casing (vermicompost) containing microorganisms as biological agents to accelerate the decomposition process of organic and inorganic matter in peat.

The technology aims to address the challenges posed by the characteristics of peat soil, providing a solution for its low nutrient availability. The addition of eco-enzymes and vermicompost, containing beneficial microorganisms, is crucial for enhancing the physical, chemical, and biological aspects of peat soil. This approach facilitates the decomposition of both organic and inorganic components of peat, contributing to improved soil fertility and, consequently, increased productivity.

Eco-enzyme is a product derived from the fermentation of organic waste, specifically fruit and vegetable peels[7,8]. It is easy to use and can be made by the community. Throughout the eco-enzyme production process, it releases ozone (O_3) gas, which can reduce carbon dioxide (CO_2) in the atmosphere, thereby mitigating the greenhouse effect and global warming. According to Fadilla et al. (2023), at a dosage of 30 ml of eco-enzyme per 2 liters of water, it can enrich the soil and plants, eliminate pests, and enhance the quality and taste of fruits and vegetables[9]. Another advantage of eco enzyme liquid is its ability to convert ammonia (NH_4) into nitrate (NO_3) and convert CO_2 into carbon trioxide (CO_3), which is beneficial for plants. As a result, it can be utilized as liquid organic fertilizer (LOF) since it contains both macro and micro nutrients[10,11].

Eco-enzyme, produced through the fermentation of organic waste, stands out as a user-friendly and community-made solution. Not only does the production process release ozone gas, contributing to the reduction of carbon dioxide in the atmosphere, but the resulting liquid has various benefits for soil, plants, and agriculture. The eco-enzyme liquid, when applied in recommended doses, proves effective in enhancing soil fertility, pest control, and improving the overall quality and flavor of fruits and vegetables. Moreover, its capacity to transform ammonia into nitrate and convert carbon dioxide into carbon trioxide makes it a valuable liquid organic fertilizer, containing essential macro and micro nutrients for plants.

Vermicompost organic fertilizer, on the other hand, is the result of the breakdown of organic materials facilitated by microorganisms and soil-dwelling worms. The use of vermicompost is intended to reduce dependence on relatively expensive chemical fertilizers and prevent further land and environmental damage in areas that have been degraded due to extensive cultivation. The outcome of the decomposition process of compost materials by earthworms contains plant growth regulators such as gibberellin, cytokinin, and auxin, along with essential nutrients N, P, K, Mg, and Ca. Additionally, Azotobacter sp, a non-symbiotic nitrogen-fixing bacterium present in vermicompost, helps enrich the nitrogen content needed by plants. Vermicompost also contains various micro-nutrients essential for plant health, including Fe, Mn, Cu, Zn, Bo, and Mo[12–14]. The management of peat soil through appropriate inputs, namely the application of amendments such as liquid organic fertilizer (eco-enzyme) and vermicompost, is anticipated to ameliorate the physical, chemical, and biological properties of peat soil, serving as a conducive growth medium for okra plants (*Abelmoschus esculentus* L. Moench). If the growth of okra plants can be optimized, their contribution as oxygen producers and carbon dioxide absorbers through the processes of photosynthesis and respiration is expected to improve. The research aims to investigate the interaction between the application of vermicompost and eco-enzymes concerning the growth, yield, and estimation of carbon dioxide uptake by okra plants (*Abelmoschus esculentus* L. Moench).

2. Methods

This research consist of two phases. The first phase of the research involved a three-month fermentation process of organic materials, namely pineapple (*Ananas comosus*) peels, citrus (*Citrus*) peels, watermelon (*Citrullus lanatus*) peels, and remnants of fern (*Polypodiophyta*) and kelakai (*Stenochlaena palustris*) vegetables, with a composition of 80% fruit peels and 20% vegetable remnants, mixed with a ratio of 10 water : 1 brown sugar : 3 fruit peels and vegetable remnants (Figure 1). The harvested eco-enzyme from the first phase was then applied to the second phase of the research, focusing on the growth and production of okra plants cultivated in histosol soil.

The second phase of the research employed a Completely Randomized Design (CRD) with four levels of application, including E0V0 (control without application), E1V1 (60 ml POC eco-enzyme per plant and 10 tons Vermicompost per hectare), E2V2 (120 ml POC eco-enzyme per plant and 20 tons Vermicompost per hectare), and E3V3 (180 ml POC eco-enzyme per plant and 30 tons Vermicompost per hectare). Each treatment was replicated four times, resulting in a total of 16 experimental units.

Fertilizer application was conducted by watering around the plants three times at 2, 4, and 6 weeks after planting (WAP), each time providing one-third of the treatment volume. Each dose of the POC eco-enzyme treatment was mixed with water to reach a total volume of 1000 ml, while vermicompost was blended with the soil medium before planting. Okra plants of the *Lucky Five* variety could commence harvesting at 7 WAP. Harvesting was performed after 7 days of flowering by cutting the fruit stalks using scissors.

The observation variables to assess the growth and yield response of okra plants to the application of vermicompost and POC eco-enzyme are as follows: plant height, number of leaves, leaf width, stem diameter, number of fruits (fruit), and fruit weight. Subsequently, the obtained data were subjected to analysis of variance using an F-test at a significance level of 1%, and if the F-test results indicated a significant effect, a Tukey's Honestly Significant Difference (HSD) test at a significance level of 5% would be conducted.

Figure 1. (a) Organic materials from the environment and household waste
(b) 3-month fermented eco-enzyme

3. Results

3.1. Plant Height, Number of Leaves and Leaf Width

Table 1 displays the plant height, number of leaves, and leaf width of okra plants treated with vermicompost at different time points after planting. The treatments are labeled as V0E0, V1E1, V2E2, and V3E3, and the variables are observed on 17, 34, 51, and 68 days after planting. The results show that the treatments had varying effects on the plant height, number of leaves, and leaf width of the okra plants at different stages after planting. The highest values were generally observed in the V3E3 treatment, while the lowest values were in the V0E1 treatment.

Regarding plant height, the V3E3 treatment resulted in the tallest plants (65.58 cm) on the 68th day after planting, while the shortest plants were observed in the V0E0 treatment (42.33 cm). The number of leaves was highest in the V3E3 treatment (13.67) and lowest in the V0E0 treatment (9.50) on the 68th day after planting. The leaf width was widest in the V3E3 treatment (177.67 cm) and narrowest in the V0E0 treatment (88.44 cm) on the 68th day after planting. The HSD 5% values for plant height, number of leaves, and leaf width varied across different time points. Overall, the results suggest that the use of vermicompost had a positive effect on the growth and development of okra plants.

3.2. Stem Diameter

Table 2 presents the average stem diameter of okra plants treated with vermicompost and eco-enzyme at different doses on 68 day after planting. The Anova test was conducted to determine the effect of planting media composition treatment on stem diameter. The results showed that the treatment had no significant effect on stem diameter, as the F-value was 1.401 and the significance level was 0.272.

Table 1. Plant height, number of leaves and leaf width of okra treated with vermicompost and eco-enzyme at different doses on 17, 34, 51 and 68 day after planting

Variable observed	Treatment	Day after planting			
		17	34	51	68
Plant height (cm)	V0E0	20,00 a	29,83 a	39,42 a	42.33 a
	V1E1	22,92 ab	37,00 b	51,67 b	63.92 b
	V2E2	22,25 ab	36,42 b	52,83 b	64.58 b
	V3E3	23,17 b	34,83ab	50,58 b	65.58 b
	HSD 5%	3,01	6,20	8,40	5,54
Number of leaves (leaves)	V0E0	5,83	9,50	8,17	9,50a
	V1E1	6,33	10,,67	10,33	12,00 b
	V2E2	6,33	10,67	10,17	12,67 b
	V3E3	6,17	9,67	10.33	13.67 b
	HSD 5%	ns	ns	ns	1,74
Leaf width (cm)	V0E0	25,5	61,58 a	83,83 a	88,44 a
	V1E1	29,5	99,92 b	151,17 b	172,08 b
	V2E2	28,5	90,25 ab	157,08 b	176,12 b
	V3E3	26,25	86,83 ab	153,42 b	177,67b
	HSD 5%	ns	32,60	67,05	40,32

Table 2. Average stem diameter (in cm) of okra plants treated with vermicompost and eco-enzyme at different doses on 68 day after planting

Anova test					
Stem diameter	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.048	3	0.016	1.401	0.272
Within Groups	0.230	20	0.012		
Total	0.278	23			

Table 3. Average number and weight of fruits of okra plants treated with vermicompost and eco-enzyme at different doses on 68 day after planting

Treatment	Average number of fruits (fruit)	Average fruit weight (gr)
VoEo	0,33a	2,73a
V1E1	1,67b	22,28b
V2E2	1,83b	23,88b
V3E3	2,00b	25,19b
HSD 5%	1,00	1,00

3.3. Average Number and Weight of Fruits

Table 3 shows the average number and weight of fruits of okra plants treated with vermicompost and eco-enzyme at different doses on the 68th day after planting. The treatments are labeled as V0E0, V1E1, V2E2, and V3E3. The average number of fruits and average fruit weight are measured in fruit and grams, respectively. The results indicate that the treatment V3E3 had the highest average number of fruits (2.00) and average fruit weight (25.19gr), while the treatment V0E0 had the lowest average number of fruits (0.33) and average fruit weight (2.73gr). The HSD 5% values for average number of fruits and average fruit weight are 1.00 and 1.00, respectively.

Pictures of the growth of okra plants that have been treated with eco-enzyme are presented in the Appendix.

4. Discussion

Based on the observation data and the ANOVA analysis, it is clear that the composition of the planting substrates with vermicompost and POC eco-enzyme has a significant influence on plant height. A further investigation using the Tukey test (Honestly Significant Difference, HSD) shows that the plant components V3E3, V2E2 and V1E1 do not differ significantly in terms of plant height. However, these three composition media differ significantly in plant height compared to the medium V0E0, which contains no vermicompost and no POC eco-enzyme. The average values for plant height in descending order are as follows: V1E1, followed by V2E2, V3E3, and V0E0.

The results of the ANOVA analysis indicate that the application of vermicompost and POC eco-enzyme in the soil composition significantly affects the number of leaves. Further testing using Tukey's Honestly Significant Difference (HSD) reveals that the plant components V3E3, V2E2, and V1E1 do not differ significantly in terms of the number of leaves. However, these soil composition components significantly differ in the number of leaves compared to the V0E0 planting medium, which did not receive vermicompost and POC eco-enzyme. The average leaf width is highest in the planting medium with the composition V3E3, followed by V1E1, V2E2, and V0E0, respectively.

There is no significant difference observed in the diameter of the stem among the tested soil composition parameters.

The soil composition significantly influences the yield of okra, both in terms of quantity and fruit weight. Further analysis using Tukey's Honestly Significant Difference (HSD) indicates that the plant components V3E3, V2E2, and V1E1 do not significantly differ in terms of fruit quantity and weight. However, these soil composition components significantly differ in both fruit quantity and weight compared to the V0E0 planting medium, which did not receive vermicompost and POC eco-enzyme. The average values for both fruit quantity and weight are highest in the planting medium with the composition V1E1, followed by V3E3, V2E2, and V0E0, respectively. There is no significant difference observed in the stem diameter among the tested soil composition parameters.

Based on the observation data and the data analysis above, for all growth and yield parameters of okra plants, the treatment of soil composition with 8 kg of histosol per polybag mixed with 84.75 gr of vermicompost and 60 ml of POC eco-enzyme is the ideal soil composition and the best dosage that significantly affects the growth and yield of okra plants. Vermicompost helps maintain the density of histosol, improves a suitable structure for the root growth of okra plants, allowing the roots to penetrate the soil more effectively, thus enhancing the efficiency of water and nutrient absorption.

The higher dosage treatment of eco-enzyme in V2E2 and V3E3 did not affect the growth and yield, suggesting a potential overdose that could induce stress in plants. Excessive eco-enzyme can elevate salt content in the soil. High salt concentration may hinder water absorption by plant roots, leading to dehydration[15–17].

Excessive application of eco-enzyme can also induce changes in soil pH. If the dosage is too high, it may alter the soil acidity level, potentially mismatching the requirements of specific plants[18]. The research results by Sugiyanto et al. indicate that the application of eco-enzyme at a 10% dosage can increase soil salt content by 0.3%[19]. Elevated salt content can impede water absorption by plant roots, leading to dehydration. Moreover, an overdose of eco-enzyme poses a risk of soil and water pollution, especially if the materials used in its production are not fully decomposed[18]. Excessive doses of eco-enzyme can disrupt the balance of microorganisms in the soil. These microorganisms are crucial for the decomposition of organic matter and overall soil health[20,21]. An overdose of eco-enzyme can cause stress in plants due to unfavorable environmental conditions[22].

5. Conclusion

The application of vermicompost and POC eco-enzyme on histosol significantly influences the height of okra plants, number of leaves, width of leaves, as well as the quantity and weight of okra fruits. The recommended dosage for vermicompost is 10 tons per hectare or equivalent to 84.75 gr per polybag, while the recommended dosage for POC eco-enzyme is 60 milliliters per plant.

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Appendix 1. Growth of Okra plants in various treatments and days after planting


V0E0 at 34 DAP


V3E3 at 34 DAP


V1E1 at 34 DAP

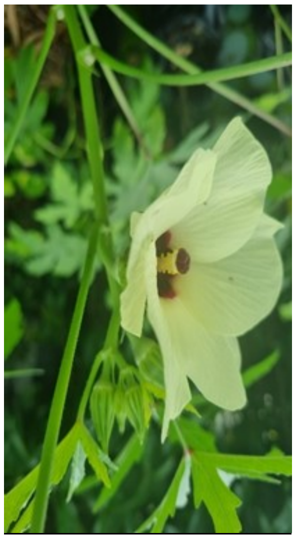

Okra at 52 DAP

Appendix 2. Okra plants at the age of 68 days after planting (at the first harvest)


V0E0


V1E1


V2E2


V3E3