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The Effect of Eco Enzyme Concentration and NPK Fertilizer Dosage on the Growth and Yield of Sweet Potatoes (*Ipomoea batatas* L.) at the Urban Farming Planting System

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***Abstract*— *This research was conducted at Malang during rainy seasons from february until June 2023. The purpose of the study is to obtain optimum tuber yields by applying eco enzyme concentration and NPK fertilizer dosage through agronomic experiments in urban farming systems. The research used Factorial randomized block design. Eco enzyme concentration (E) as First factor: E0 = 0 ml.l^{-1}, E1 = 15 ml.l^{-1}, E2 = 30 ml.l^{-1}, E3 = 45 ml.l^{-1}. The second factor, NPK = (P) NPK fertilizer dose, namely: P1 = 3.75 g plant^{-1} NPK, P2 = 5.62 g plant^{-1} NPK, P3 = 7.50 g plant^{-1} NPK. This research was repeated three times. The results showed Eco enzyme concentration treatment affects the dose of NPK fertilizer on sweet potato plants. At an NPK fertilizer dose of 3.75 g plant^{-1}, the highest fresh tuber weight was produced at an eco enzyme concentration of 30 ml l^{-1}. At NPK fertilizer doses of 5.62 and 7.50 g plant^{-1}, the fresh weight of tubers was the same at all eco enzyme concentrations. The optimum eco enzyme concentration in the NPK fertilizer dose treatment of 3.75 g plant^{-1} was 27.05 ml l^{-1}, 5.62 g plant^{-1} was 25.44 ml l-^{1} and 7.50 g plant^{-1} was 26.54 ml l^{-1}. eco enzyme concentrations and NPK doses can increase the growth and yield of sweet potato plants, on the variables: leaf area, plant dry weight, tuber fresh weight, harvest index.*

Keywords*— eco enzyme, npk fertilizer, sweet potato, planter bag.

I. INTRODUCTION

Sweet potato (Ipomoea batatas L.) or often called sweet potato is a food plant that is widely cultivated in Indonesia. However, the availability of sweet potatoes in Indonesia, especially in East Java, is decreasing from year to year. According to the Central Statistics Agency (2018), sweet potato production in East Java in 2015-2017 was 350,516 tons, 288,039 tons, 257,414 tons. Another obstacle faced by farmers is the insufficient availability of fertilizer. The impact of continuous use of inorganic fertilizers will result in a decrease in land quality, therefore the government makes government regulations so that farmers do not depend on inorganic fertilizers. Regarding the scarcity of fertilizer, it is necessary to reduce dependence on NPK fertilizer, by using household waste in the form of Eco enzymes. Due to the scarcity of NPK fertilizer, its function is expected to improve soil properties and overcome the leaching of nutrients in the soil.

Limited agricultural land affects the ability of a region to meet the food needs of its population, thereby weakening food security conditions. Nutrient limitations also become an obstacle to agricultural productivity and weaken food security conditions. According to Sitawati et al. (2019) that limited land in urban areas occurs due to infrastructure development, which can reduce the area of agricultural land. Minimalist use of sleeping land and yards in urban areas can be done with verticulture or planting activities using polybags or planter bags.

To provide and meet food needs, urban farming can be done by farming, which is a farming activity carried out in urban areas or land. The decreasing amount of agricultural land in urban areas can be caused by the increasing population, so that land use for residential areas is also increasing. The availability of sufficient nutrients in the soil is one of the factors that supports plant growth and development. This can be done by utilizing household waste which can be used as eco enzymes in the form of liquids originating from the fermentation of household waste, namely fruit, vegetable, water and sugar residues. The role of eco enzymes as decomposers is very important in breaking down dead organic material and accelerating the nutrient cycle in the environment. According to Panataria *et al*., (2022), Eco enzyme contains several enzymes such as amylase, protease, and lipase, which help break down carbohydrates, proteins, fats, and plant fibers into compounds that are simpler and easier for microorganisms to take up. According to Arifin et al., (2009), the process of making eco enzymes which are fermented for 3 months, uses the formula 1:3:10, namely 1 part sugar, 3 parts fruit and vegetable waste, 10 parts air. Efforts to use eco enzymes in agriculture can speed up compound reactions and produce enzymes.

Urban farming practices can be a solution for providing food by utilizing planting containers, cow manure, and eco enzymes which have the status of household waste. It is estimated that there is an interaction between eco enzymes and NPK fertilizer, so that the use of eco enzymes can reduce the use of NPK fertilizer.

The basic information above stated is deemed necessary to carry out research regarding the provision of eco enzyme concentrations and doses of NPK fertilizer on the growth and yield of sweet potato plants (Ipomoea batatas L.) in urban farming systems.

II. MATERIAL AND METHODS

The research was carried out from February to June 2023, located in Gading Kasri Village, Klojen District, Malang City, East Java.

Materials used in the research include: Cuttings of sweet potato varieties: Beta-2, Eco Enzyme (EE), NPK fertilizer (15:15:15), and cow manure. The research was conducted using two factors with a Factorial Randomized Block Design (RBD), placing Eco enzyme (E) concentration as the first factor and NPK fertilizer (P) as the second factor.

Based on the design used, the field experiment was repeated 3 (three) times so that there were 36 experimental units. These treatments are:

The first factor, Eco enzyme concentration (E) is:

1. E0 = No eco enzyme
2. E1 = 15 ml l^{-1}
3. E2 = 30 ml l^{-1}
4. E3 = 45 ml l^{-1}

Second Factor, NPK Fertilizer Dosage (P), namely:

1. P1 = 3.75 g $plant^{-1}$
2. P2 = 5.62 g $plant^{-1}$
3. P3 = 7.50 g $plant^{-1}$

Research activities include: Planting, Maintenance, and Harvest. Maintenance activities include replanting, watering, applying eco enzyme, controlling pests and diseases, and fertilizing. Sweet potato plants are harvested 16 weeks after planting. Research observation variables included: number of leaves, leaf area, fresh weight of plants, dry weight of plants, fresh weight of tubers, length of tubers, and number of tubers.

The collected data was analyzed using the analysis of variance (ANOVA) method at 5% level. If the observation data obtained is significantly different then proceed with the HSD Test (Honestly Significant Difference) level of 5% to determine the differences between treatments.

III. RESULT AND DISCUSSION

Leaf Area

Based on analysis of variations in leaf area at the observation ages 16 WAP, it showed that there are interaction between the eco enzyme concentration treatment and the NPK fertilizer dose treatment. The average leaf area influenced by eco enzyme concentration and NPK fertilizer dosage is presented in Table 1.

At the observation ages 16 WAP the leaf area patterns were the same (Table 1). In the treatment with an NPK fertilizer dose of 3.75 g $plant^{-1}$, the highest leaf area produced in the treatment with an eco enzyme concentration of 15 and 30 ml l^{-1}. By administering an NPK fertilizer dose of 5.62 g $plant^{-1}$, the highest leaf area produced in the treatment with an eco enzyme concentration of 15 to 45 ml l^{-1}. In the treatment with an NPK fertilizer dose of 7.50 g $plant^{-1}$, leaf area are not significantly different at all eco enzyme concentrations.

Observing the number of sweet potato leaves is important to determine the growth of sweet potato plants, this is because the leaves are a place to produce food through the process of photosynthesis. Sweet potato plants tend to invest most of their initial growth in the form of additional leaf area, due to the influence and use of solar radiation. This phase began since the plants are 8-17 weeks old. Between 8-12 weeks, the plant stops forming new tubers because it starts to grow the existing tubers. The characteristic of tuber plants is that they have a rapid tuber formation and growth, but the stem and leaf growth is decreased (Amao *et al*., 2018). Leaves are the main photosynthetic organs in plants in which the process of converting light energy into chemical energy and accumulating energy in the form of dry matter (Liu *et al*. 2021). Furthermore, Gong *et al*. (2013) stated that leaves can show the mechanisms of light radiation interception, transpiration, growth and crop yields.

Table 1. Interaction of Eco enzyme concentration treatment and NPK fertilizer dose on average leaf area

Plant Age (WAP)	NPK Fertilizer Dosage (g plant $^{-1}$)	Leaf Area (cm^2 plant^{-1})			
		Eco Enzyme Concentration (ml l^{-1})			
		0	15	30	45
16	3.75	3006.33 a A	3426.66 ab A	4131.00 b A	3051.00 a A
	5.62	2912.66 a A	4086.00 b A	3413.33 ab A	3851.00 b A
	7.50	3120.66 a A	3380.33 a A	3993.33 a A	3491.66 a A
HSD Eco Enzyme 5%		893.37			
HSD NPK Fertilizer 5%		927.79			

Note: Numbers followed by the same lowercase letter in the row and numbers followed by the same uppercase letter in the same row and column are not significantly different based on the 5% HSD test. WAP = week after planting.

Plant dry weight

Based on analysis of variations in dry weight of plants aged 16 WAP, it showed that there was a significant interaction (p=0.05) between the eco enzyme concentration treatment and the NPK fertilizer dose treatment. The average dry weight of plants which is influenced by the concentration of eco enzyme and the dose of NPK fertilizer is presented in Table 2.

At the observation age of 16 WAP, treatment without eco enzyme and eco enzyme concentrations of 15 and 45 ml l^{-1} showed that the dry weight value of sweet potato plants is not significantly different at all doses of NPK fertilizer. Treatment with an eco enzyme concentration of 30 ml l^{-1} at a fertilizer dose of 3.75 g plant-1, showed the highest dry weight of plants and experienced a decrease at NPK fertilizer doses of 5.62 and 7.50 g plant^{-1}. Treatment with an NPK fertilizer dose of 3.75 g plant^{-1}with the addition of an eco enzyme concentration of 30 ml l^{-1} can increase the dry weight value of sweet potato plants. In the treatment with a fertilizer dose of 3.75 g plant^{-1}, the treatment with an eco enzyme concentration of 15 ml l^{-1} had plant dry weight values that were not significantly different from those without eco enzyme and an eco enzyme concentration of 45 ml l-1. In the treatment with NPK fertilizer doses of 5.62 and 7.50 g ton-1, the dry weight of sweet potato plants was not significantly different at all eco enzyme concentrations.

The increase in plant growth rate is influenced by the total dry weight of plants produced per unit of time. Plant dry weight reflects the accumulation of organic compounds that plants successfully synthesize from inorganic compounds, especially water and carbon dioxide. Nutrients including eco enzymes that have been absorbed by the roots contribute to the increase in plant dry weight. According to Sitompul and Guritno (1995) the main reason for using total plant biomass is that plant dry matter is seen as a manifestation of all processes and events that occur in plant growth. Biomass measurement is the total dry weight of all plant parts and increases due to plants absorbing CO_2 from the air and converting this substance into organic material through the process of photosynthesis. If the dry matter produced by plants is low, then the assimilate produced by plants will also be low (Ogbonna and Nweze, 2012). When plants enter the reproductive phase, assimilation will be carried to reproductive parts such as leaves. Reproduction is the plant organ that absorbs the most assimilation compared to other places (Ravi and Saravanan, 2012).

Table 2. Interaction of Eco enzyme concentration treatment and NPK fertilizer dose on average plant dry weight

Plant Age (WAP)	NPK Fertilizer Dosage (g plant $^{-1}$)	Plant dry weight (g plant^{-1})			
		Eco Enzyme Concentration (ml l^{-1})			
		0	15	30	45
16	3.75	168.83 a A	234.48 a A	407.35 b B	248.81 a A
	5.62	190.83 a A	262.51 a A	280.65 a A	235.32 a A
	7.50	201.78 a A	242.41 a A	260.93 a A	236.72 a A
HSD Eco Enzyme 5%		82.12			
HSD NPK Fertilizer 5%		90.77			

Note: Numbers followed by the same lowercase letter in the row and numbers followed by the same uppercase letter in the same row and column are not significantly different based on the 5% HSD test. WAP = week after planting.

Tuber fresh weight

Based on analysis of variations in fresh weight of tubers at 16 WAP, it showed that there is a significant interaction (p=0.05) between the eco enzyme concentration treatment and the NPK fertilizer dose treatment. The average fresh weight of tubers which is influenced by the interaction between eco enzyme concentration and NPK fertilizer dose is presented in Table 3. At the observation age of 16 WAP, treatment without eco enzyme and eco enzyme concentrations of 15 and 45 ml l^{-1} showed that the fresh weight value of sweet potato tubers is not significantly different at all doses of NPK fertilizer. The treatment with eco enzyme concentration of 30 ml l^{-1} showed the highest fresh weight of tubers at a fertilizer dose of 3.75 g plant^{-1}, and significantly different from all treatments.

Table 3. Interaction of Eco enzyme concentration treatment and NPK fertilizer dose on average tuber fresh weight

Plant Age (WAP)	NPK Fertilizer Dosage (g plant $^{-1}$)	Plant dry weight (g plant^{-1})			
		Eco Enzyme Concentration (ml l^{-1})			
		0	15	30	45
16	3.75	671.00 a A	994.87 a A	1720.00 b B	972.17 a A
	5.62	724.53 a A	1062.13 a A	1046.20 a A	891.00 a A
	7.50	709.77 a A	978.47 a A	1033.80 a A	880.93 a A
HSD Eco Enzyme 5%		314.25			
HSD NPK Fertilizer 5%		347.36			

Note: Numbers followed by the same lowercase letter in the row and numbers followed by the same uppercase letter in the same row and column are not significantly different based on the 5% HSD test. WAP = week after planting.

In the treatment fertilizer doses of 5.62 and 7.50 g plant^{-1}, leaf area is not significantly different at all eco enzyme concentrations. who states that the growth of sweet potato plants requires different nutrient intake in each growth phase. In the initial growth phase, balanced N, P, K nutrients are needed, then in the tuber formation phase an increased amount of N, P, K nutrients is needed from the initial growth phase. The tuber filling phase requires a higher amount of nutrients than the initial growth phase, and lower than the tuber formation phase. This is supported by the statement of trimunghan (2016), who stated that the formation of tubers is influenced by the K nutrient in the growth and development of plant roots, the P nutrient has a role in cell division and plant tissue development.

Based on the results of the regression analysis, it shows that there is a high degree of relationship between the concentration of eco enzyme and the dose of NPK fertilizer. Treatment doses of NPK fertilizer 3.75, 5.62 and 7.5 g.plant^{-1} respectively had quite large coefficient of determination values, including 0.70, 0.97 and 1, which shows the suitability of the data with the quadratic regression model (Figure 1). In the treatment with NPK fertilizer doses of 3.75, 5.62 and 7.5 g.plant^{-1} respectively the quadratic equation y = -1.1908x2 + 64.443x + 577.29, y = -0.5476x2 + 27.863x + 735.24, and y = -0.4684x2 + 24.871 x + 710.03. From this equation, the optimum eco enzyme concentration requirement can be calculated. The optimum eco enzyme concentration in the NPK fertilizer dose treatment of 3.75 g.plant^{-1} was 27.05 ml l^{-1}, 5.62 g.plant^{-1} was 25.44 ml l^{-1} and 7.5 g.plant^{-1} was 26.54 ml l^{-1}.

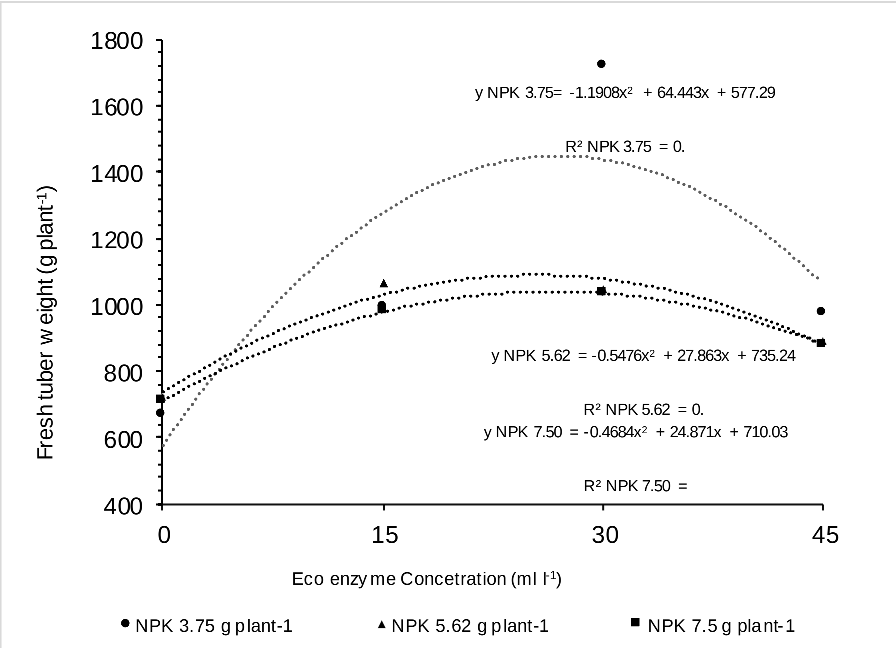

Fig 1. Regression of tuber fresh weight with eco enzyme concentration on NPK fertilizer dose

Harvest index

Based on the analysis of various harvest index at 16 WAP, it shows that there is no significant interaction (p=0.05) between the eco enzyme concentration treatment and the NPK fertilizer dose treatment. The harvest index of sweet potato plants only influenced by the eco enzyme concentration treatment (Figure 2). The results of observations of the harvest index at the age of 16 WAP showed that the treatment without eco enzyme have the lowest harvest index value. Treatments with eco enzyme concentrations of 15 and 30 ml l^{-1} have the highest harvest index values and significantly different results compared to treatments without eco enzyme. Treatment with eco enzyme concentration of 15 to 45 ml l^{-1} can increase the fresh weight of plants and have values that are not significantly different. The treatment without eco enzyme have a harvest index value that is not significantly different from the treatment with a concentration of 45 ml l^{-1}. The average harvest index which is influenced by eco enzyme concentration is presented in Figure 2.

Based on the results of the regression analysis, it shows that there is a high degree of relationship between the concentration of eco enzyme and the dose of NPK fertilizer. The control eco enzyme concentration treatment, 15 ml.l^{-1}, 30 ml.l^{-1}, 45 ml.l-1 has a fairly large coefficient of determination value, namely 0.99, which shows the suitability of the data to the quadratic regression model (Figure 2). In the control eco enzyme concentration treatment, 15 ml.l^{-1}, 30 ml.l^{-1}, 45 ml.l-1 has a quadratic equation y = -0.0325x2 + 0.1795x + 0.6025. From this equation, it can be concluded that the optimum eco enzyme concentration is an eco enzyme concentration of 30 ml.l^{-1}.

The results of the observations show that without giving eco enzyme the IP results are smaller than when giving eco enzyme. According to Jha (2012) that tuber yield is positively correlated with IP, weight of the entire plant and number of tubers per plant. A high IP indicates greater distribution of assimilate to the tuber while a low IP indicates greater distribution of assimilate to the top of the plant. According to Gu *et al*., (2021), the use of eco enzymes can regulate the growth pattern of sweet potato plants by maintaining a balance of vegetative and generative growth, so that competition for source utilization by vegetative and generative growth which results in low levels of assimilate distributed into the sink can be suppressed.

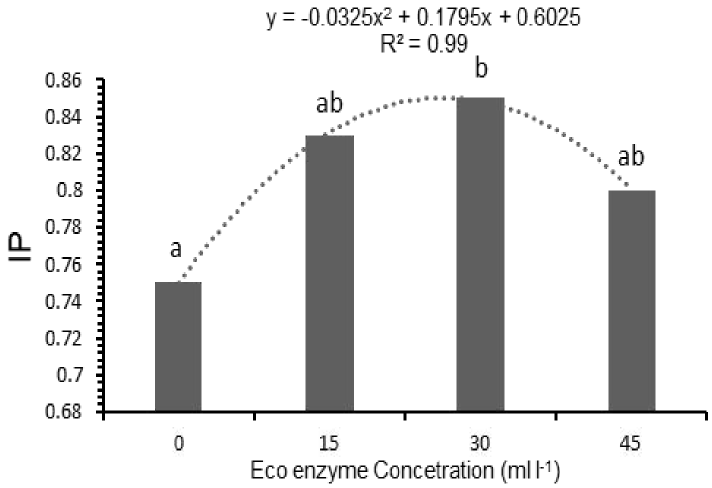

Fig 2. Regression of harvest index with eco enzyme concentration on NPK fertilizer dose

IV. CONCLUSION

Eco enzyme concentration treatment affects the dose of NPK fertilizer on sweet potato plants. At an NPK fertilizer dose of 3.75 g plant^{-1}, the highest fresh tuber weight was produced at an eco enzyme concentration of 30 ml l^{-1}. At NPK fertilizer doses of 5.62 and 7.50 g plant^{-1}, the fresh weight of tubers was the same at all eco enzyme concentrations. The optimum eco enzyme concentration in the NPK fertilizer dose treatment of 3.75 g plant^{-1} was 27.05 ml l^{-1}, 5.62 g plant^{-1} was 25.44 ml l^{-1} and 7.5 g plant^{-1}was 26.54 ml l^{-1}. Eco enzyme concentrations and NPK doses can increase the growth and yield of sweet potato plants, on the variables: leaf area, plant dry weight, tuber fresh weight, and harvest index.

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