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UTILIZATION OF ECO-ENZYME FERTILIZER FROM FRUIT WASTE TO IMPROVE THE GROWTH OF GLUTENOUS CORN PLANTS (*Zea mays* L. var. Ceratina)

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Abstract

This study aimed to determine the effect of the eco-enzyme on waxy corn growth. The research was conducted at the Field Laboratory of Experimental Garden 2, Faculty of Agriculture, Halu Oleo University, from August to November 2025. The experiment was arranged using a Randomized Block Design (RBD) with a single factor. The factor consisted of five levels of eco-enzyme concentration (E), namely: 0 mL + 1000 mL water (E0), 10 mL + 990 mL water (E1), 20 mL + 980 mL water (E2), 30 mL + 970 mL water (E3), and 40 mL + 960 mL water (E4). Each treatment was replicated four times, resulting in 20 experimental units. Each unit consisted of 30 plants, giving a total of 600 plants. The observed variables included plant height, stem diameter, number of leaves, total leaf area, number of stem segments, stem segment length, shoot dry weight, root dry weight, and total dry weight. The data were analyzed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a 95% confidence level. The results showed that the eco-enzyme concentration of 20 mL + 980 mL water (E2) produced better growth in terms of number of leaves, total leaf area, shoot dry weight, root dry weight, and total plant dry weight compared to other concentration treatments.

Keywords: bio-fertilizer, eco-enzyme, glutinous corn, organic fertilizer

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INTRODUCTION

Glutinous corn is a popular food crop, serving as the primary source of carbohydrates after rice. Glutinous corn possesses unique characteristics, including 100% amylopectin starch, and an attractive appearance unlike any other type of corn. The glutinous corn boasts sufficient nutritional and fiber content to be a staple food substitute for rice, making it a popular choice and a key ingredient in industry. Glutinous corn can be used for food diversification, such as making sticky corn into milk, pudding, and ice cream. Corn starch can be processed into fillers, thickeners, and biscuits (Gangga and Wangiyana, 2024).

Low nutrient and organic matter content, low moisture content, and pH that is too low or too high can cause the absorption of nutrients and water to be hampered, which will result in the photosynthesis process not being optimal, as well as very high aluminum saturation, which is toxic to plants. The optimization of infertile land is improved through the application of effective cultivation technologies, including fertilization. Fertilization can stimulate increased growth and quality of glutinous corn.

Fertilizer is key to soil fertility because it contains one or more nutrients to replace those absorbed by plants. The types of fertilizer that can be used are organic and inorganic fertilizers (Lamakoma et al., 2019). Organic fertilizers can be applied in solid or liquid form. Liquid organic fertilizers are the result of the fermentation of plant residues, which ultimately turn into liquid. The use of liquid organic fertilizer can trigger increased plant growth and quality (Koto et al., 2022). One type of liquid organic fertilizer that can be used is eco-enzyme. Eco-enzyme is a multifunctional solution that can be used as a fertilizer, plant growth hormone, pesticide, insecticide, wastewater treatment, and antimicrobial agent (Gu et al., 2021). Eco-enzymes are made from organic waste (fruit and vegetable waste) and sugar through an anaerobic fermentation process. Eco-enzyme production involves mixing water, sugar, and vegetable or fruit waste. Fruit waste is a waste material that is usually disposed of by open dumping (waste is thrown away in a final disposal site without any treatment), without further processing, which can cause environmental pollution (disturbance) and unpleasant odors.

One of the potentials that can be seen from fruit waste is as an eco-enzyme because fruit waste contains enzymes that can help break down nutrients in the soil, so that it can increase the availability of nutrients such as nitrogen (N), phosphorus (P), potassium (K), vitamins, calcium (Ca), iron (Fe), sodium (Na), and magnesium (Mg) (Lubis et al., 2022) and potential to become an activator that can speed up the composting process (Muliarta et al., 2023). Based on the results of the research by Halim et al. (2025), eco-enzymes at low doses have had a good effect on the number of leaves in red onion plants.

MATERIALS AND METHOD

The research was conducted at the Field Laboratory of Experimental Garden 2, Faculty of Agriculture, Halu Oleo University, from August to November 2025.

Research Procedures

Land Preparation**:** The land used in this study was first cleared of weeds and other debris, such as trash and tree branches, that could interfere with the research process. Next, the soil was prepared by loosening the surface of the soil using a hoe, followed by the creation of experimental plots. Each experimental plot measured 3 m x 2.5 m.

Base Fertilization**:** The base fertilizer used in this study was ground goat manure that had been fermented for 3 weeks. The fertilizer dosage was 3 kg/plot or 7.5 tons ha^{-1}. Base fertilization was applied 2 weeks before planting by spreading it evenly over the surface of the experimental plots, then mixing and turning it into the soil using a hoe.

Planting**:** Planting begins by digging holes approximately 5 cm deep and planting at a spacing of 70 cm x 40 cm apart. Two glutinous corn seeds are placed in each hole and covered with soil. Planting is done in the morning, after watering, to facilitate seed germination.

Experimental Design

The research was conducted using a Randomized Block Design (RBD) with eco-enzyme treatment (E). The treatment consisted of 5 levels, namely without eco-enzyme 0 mL + 1000 mL air (E0), 10 mL eco-enzyme + 190 mL water (E1), 20 mL eco-enzyme + 980 mL water (E2), 30 mL eco-enzyme + 970 mL water (E3), 40 mL eco-enzyme + 960 mL water (E4). Each treatment was repeated four times to obtain 20 experimental units.

Observation Variables

Observations were conducted on three randomly selected plant samples per plot. The variables observed in this study were:

1. Plant height (cm), measured from the base of the stem to the tip of the tallest plant, was measured at 14, 21, 28, 35, and 42 days after planting (DAP).
2. Stem diameter (mm), measured at the centre of the stem, was measured at 14, 21, 28, 35, and 42 DAP.
3. Number of leaves (leaflets), counted on fully opened leaves, was measured at 14, 21, 28, 35, and 42 DAP.
4. Total leaf area (cm^2). Leaf area measurements were conducted on three leaf samples: the upper, middle, and lower leaves. Leaf length was measured from the base to the tip, and leaf width was measured at the widest point in the middle of the leaf; the result was multiplied by a constant (0.73) (Susilo, 2015). Observations were carried out at the ages of 7, 14, 21, 28, and 42 DAP using the formula: LDT = n $\sum_{n=1}^{n} PLk$

Notes: LDT = total leaf area (cm^2), n = number of leaves, i = 1,2,3, …n, P = leaf length (cm), L = leaf width (cm), k = Leaf area constant value (0,73).

5. Number of stem segments (stems), counted as fully formed nodes on the corn plant stem. The number of stem segments was calculated at 42 days after planting.
6. Length of the stem segment (cm), measured from the lowest node to the highest node on the corn plant stem. The node length was calculated at 42 days after planting.
7. Dry weight of the stalk (g), measured by placing the plant stems and leaves in label envelopes, then drying them in an oven at 80 °C for 2 x 24 hours.
8. Dry weight of the roots (g), measured by placing the plant roots in label envelopes, then drying them in an oven at 80 °C for 48 hours.
9. Total dry weight.

Data Analysis

Observation data were analyzed using analysis of variance (ANOVA). If the calculated F value was greater than the table F

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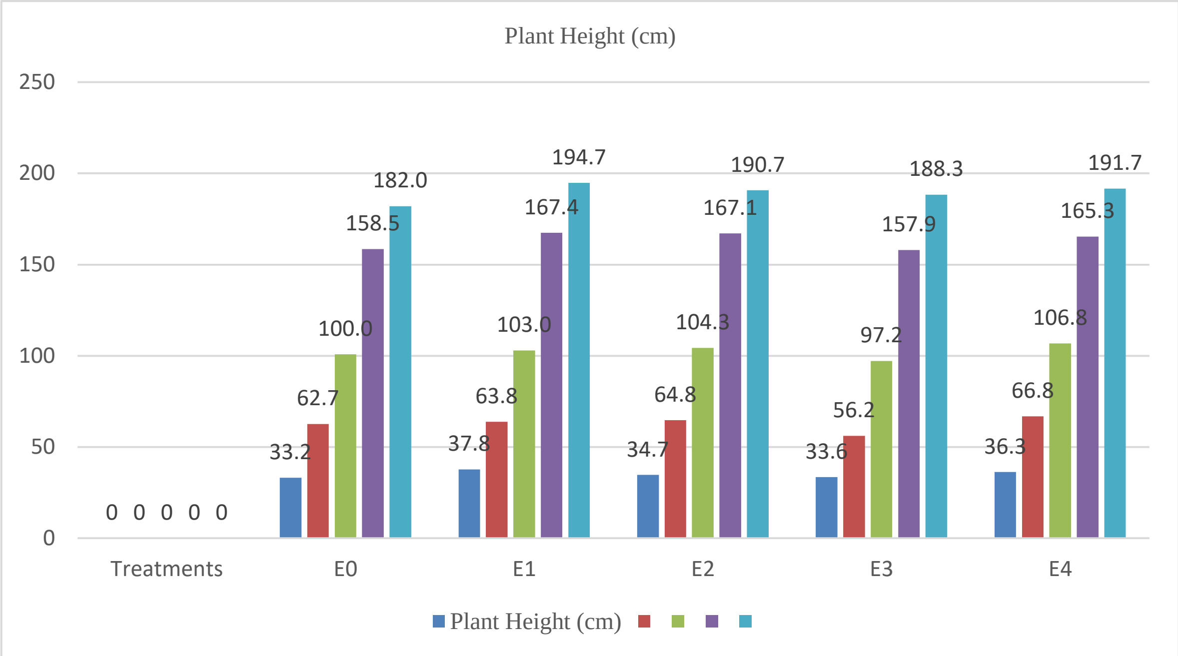
value, Duncan's Multiple Range Test (DMRT) was continued at a 95% confidence level.

RESULTS AND DISCUSSION

Plant Height

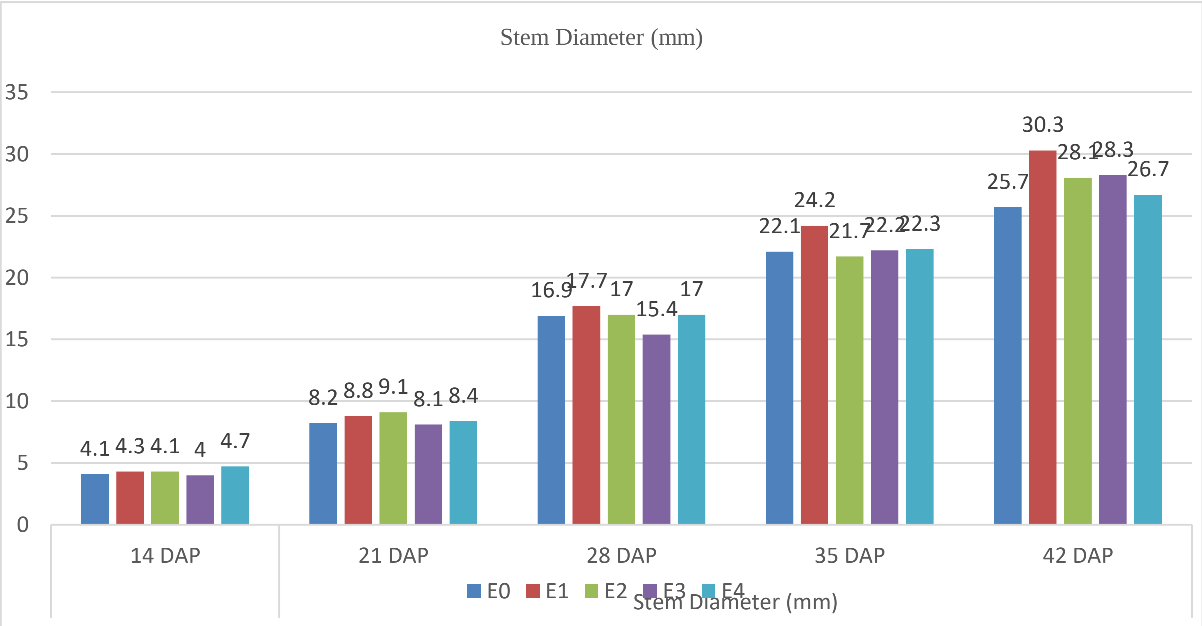
The results of the study on the effect of fruit waste eco-enzyme concentrations on the height of glutinous corn plants at 14, 21, 28, 35, and 42 DAP are presented in Graph 1. Graph 1 shows that plant height increased over the observation period. Plant height values across all treatments were relatively similar. Treatments E1 and E2 tended to show slightly higher plant height values than the other treatments, especially at the end of the observation period. According to Zhu et al. (2020), eco-enzymes contain various nutrients, microorganisms, active enzymes, and secondary metabolites, so that the application of eco-enzymes can also increase soil and environmental fertility and have an impact on plant growth.



Graph 1. Plant height at various eco-enzyme concentrations

Stem Diameter

The results of the study on the effect of fruit waste eco-enzyme concentration on the diameter of glutinous corn stalks at the ages of 14, 21, 28, 35, and 42 DAP are presented in Graph 2.



Graph 2. Stem diameter at various eco-enzyme concentrations

Graph 2 shows that the stem diameter of glutinous corn plants increased with increasing plant age, from 14 to 42 DAP in all treatments. At each observation time, treatments with different eco-enzyme concentrations showed no significant differences. Although there was a slight variation in values between treatments, the growth pattern was relatively similar. The highest stem diameter at 42 DAP was seen in treatment E1 as 30.3 mm, but the difference was not significant compared to the other treatments.

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Number of Leaves

Table 1. Number of Leaves of Glutinous Corn at Various Eco-enzyme Concentrations

Treatments	Number of leaves (sheet)				
	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
0 mL eco-enzyme + 1000 mL water (E0)	4.7	6.0	7.5	8.4	10.7
10 mL eco-enzyme + 190 mL water (E1)	4.8	6.0	7.6	9.1	11.2
20 mL eco-enzyme + 980 mL water (E2)	4.8	6.0	7.6	9.5	11.6
30 mL eco-enzyme + 970 mL water (E3)	4.5	6.1	6.8	8.6	10.7
40 mL eco-enzyme + 960 mL water (E4)	4.8	6.3	7.4	9.1	11.0
DMRT 95%			2= 0.46		
			3= 0.48		
			4= 0.49		
			5= 0.50		

Table 1 shows that the highest number of leaves on glutinous corn plants at 28 DAP was obtained in the eco-enzyme 10 mL + 990 mL water (E1) and eco-enzyme 20 mL + 980 mL water (E2) treatments, each with 7.6 leaves, which were not significantly different from the E0 and E4 treatments. This is thought to be because the concentrations of 10 mL + 995 mL water (E1) and eco-enzyme 20 mL + 980 mL water (E2) provide an optimal balance between nutrient availability and enzymatic activity in the soil. This shows how the application of eco-enzymes can have a positive impact on plant development and increase the number of leaves (Nelvia et al., 2024). Nitrogen nutrients can be accessed at more precise doses of eco-enzyme concentrations that affect the development and number of plant leaves (Safitri et al., 2021).

Total Leaf Area

Table 2. Total Leaf Area of Glutinous Corn at Various Eco-enzyme Concentrations

Treatments	Total Leaf Area (cm^2)				
	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
0 mL eco-enzyme + 1000 mL water (E0)	127.5	627.0	1711.1	3355.1 c	4314.1 b
10 mL eco-enzyme + 190 mL water (E1)	137.7	639.0	1780.5	4100.4 ab	5278.5 a
20 mL eco-enzyme + 980 mL water (E2)	139.1	635.2	1843.7	4619.1 a	5748.4 a
30 mL eco-enzyme + 970 mL water (E3)	112.5	608.2	1630.7	3916.5 bc	5120.0 ab
40 mL eco-enzyme + 960 mL water (E4)	118.3	652.6	1636.8	3835.0 bc	5003.8 ab
DMRT 95%				2= 640.42	2= 768.38
				3= 672.44	3= 806.79
				4= 689.51	4= 827.28
				5= 704.46	5= 845.21

Notes: Numbers followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at a 95% confidence level

Table 2 shows that the highest total leaf area of glutinous corn plants at 35 DAP was obtained at a concentration of 20 mL + 980 mL water (E2) with a value of 4619.1 cm2, which was not significantly different from treatment E1 but significantly different from treatments E3, E4, and E0. The highest leaf area at 42 DAP was obtained at the treatment of 10 mL + 190 mL water (E1) with a value of 5278.5 cm^2 and 20 mL + 980 mL water (E2) with a value of 5748.4 cm^2, but was not significantly different from treatments E0, E3, and E4. This occurs because the number of leaves and tillers is high. Wider leaves allow for increased light absorption and photosynthetic efficiency. The potassium content in eco-enzymes can strengthen leaf tissue and widen the leaf surface (Simanjuntak et al., 2021). Potassium also helps regulate stomata and the transport of water and nutrients within plant cells. Eco-enzymes are able to provide essential micronutrients and growth hormones that support leaf development.

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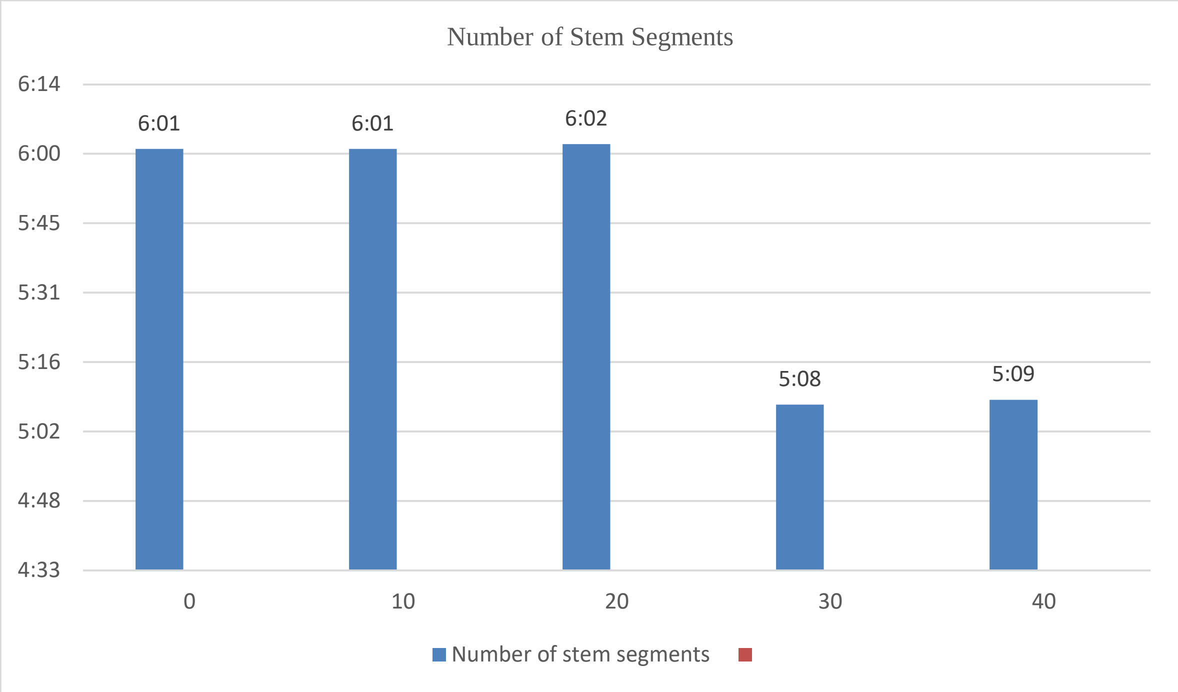
Number of Stem Segments

The effect of the eco-enzyme concentration on the number of internodes of glutinous corn plants at the ages of 14, 21, 28, 35, and 42 DAP is presented in Graph 3.

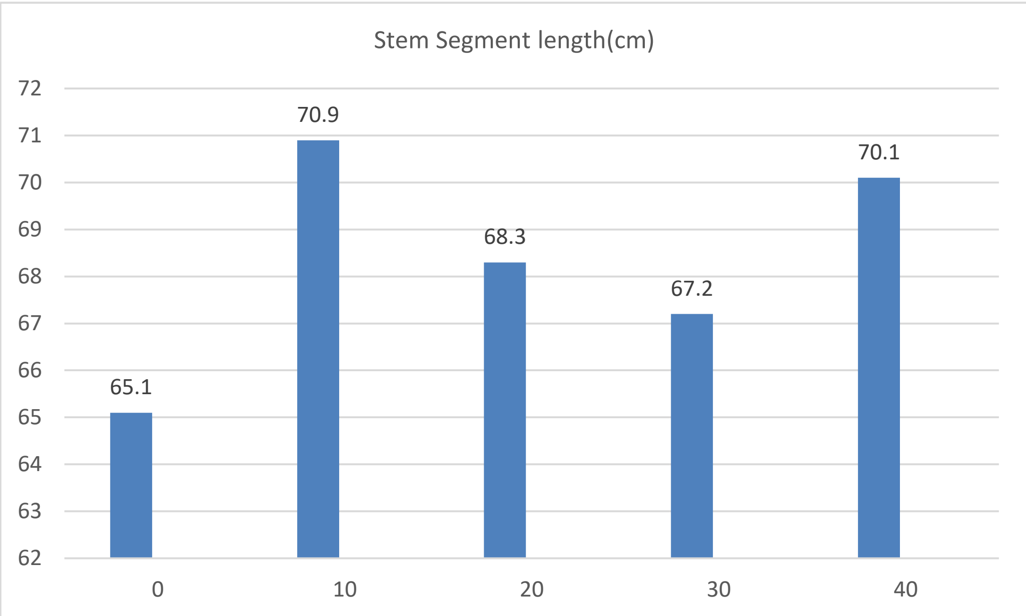


Graph 3. Number of segments at various eco-enzyme concentrations

Graph 3 shows that the number of stem segments in glutinous corn plants at various eco-enzyme concentrations was relatively insignificant, with an average range of 5.8–6.2 internodes, with the highest values in the E2 treatment and the lowest in the E3 treatment. In general, increasing eco-enzyme concentrations did not show a consistent pattern of increase or decrease in the number of stem segments.

Stem Segment Length

The results of the study on the effect of fruit waste eco-enzyme concentration on the length of stem segments of glutinous corn plants at the ages 14, 21, 28, 35, and 42 DAP are presented in Graph 4.



Graph 4. Stem segment length at various eco-enzyme concentrations

Graph 4 shows that the stem length of glutinous corn plants fluctuated at various eco-enzyme concentrations. The highest stem segment length was found in treatment E1 at 70.9 cm, followed by treatment E4 at 70.1 cm, and the lowest stem segment length was found in treatment E0 at 65.1 cm. Although there was variation between treatments, the pattern of changes in stem segment length did not show a consistent trend with increasing eco-enzyme concentration.

Shoot Dry Weight

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Table 3. Dry Weight of Corn Slabs at Various Eco-enzyme Concentrations

Treatments	Shoot Dry Weight (g)
	70 DAP
0 mL eco-enzyme + 1000 mL water (E0)	51.9 c
10 mL eco-enzyme + 190 mL water (E1)	65.9 b
20 mL eco-enzyme + 980 mL water (E2)	78.0 a
30 mL eco-enzyme + 970 mL water (E3)	71.3 a
40 mL eco-enzyme + 960 mL water (E4)	65.0 b
DMRT 95%	2= 12.50
	3= 13.12
	4= 13.46
	5= 13.75

Notes: Numbers followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at a 95% confidence level

The results of study 3 showed that the highest dry weight of glutinous corn stover at 70 DAP was obtained in the 20 mL + 980 mL water (E2) treatment with a value of 78.0 g, which was not significantly different from treatments E1, E3, and E4, but significantly different from treatment E0. This indicates that the dry weight of plants is closely related to the availability of nutrients, so that plants that get the nutrients they need will grow well.

Dry Root Weight

Table 4. Dry Root Weight of Glutinous Corn Plants at Various Eco-enzyme Concentrations

Treatments	**Dry Root Weight (g)**
	70 DAP
0 mL eco-enzyme + 1000 mL water (E0)	7.00 c
10 mL eco-enzyme + 190 mL water (E1)	10.60 ab
20 mL eco-enzyme + 980 mL water (E2)	11.41 a
30 mL eco-enzyme + 970 mL water (E3)	9.45 ab
40 mL eco-enzyme + 960 mL water (E4)	9.17 b
DMRT 95%	2= 2.00
	3= 2.10
	4= 2.16
	5= 2.20

Notes: Numbers followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at a 95% confidence level

The results of the study in Table 4 show that the highest dry weight of plant roots at 70 DAP was obtained in the 20 mL + 980 mL water treatment (E2) with a value of 11.41 g, which was not significantly different from treatments (E1), (E3), and (E4), but significantly different from treatments without eco-enzyme concentration (E0). Root volume is closely related to the macronutrient nitrogen. Eco-enzymes supply Nitrogen to plants in the form of nitrate so that it does not need to be converted by the plant. Nitrogen plays a role in stimulating root development. Nitrogen plays a role in accelerating the conversion of carbohydrates into proteins, which influences the division, elongation, and enlargement of plant roots.

Total Dry Weight

Table 5. Total Dry Weight of Glutinous Corn Plants at Various Eco-enzyme Concentrations

Treatments	**Total Dry Weight (g)**
	70 DAP
0 mL eco-enzyme + 1000 mL water (E0)	58.93 c
10 mL eco-enzyme + 190 mL water (E1)	76.47 ab
20 mL eco-enzyme + 980 mL water (E2)	89.46 a
30 mL eco-enzyme + 970 mL water (E3)	80.73 ab
40 mL eco-enzyme + 960 mL water (E4)	74.13 b
DMRT 95%	2= 13.19
	3= 13.84
	4= 14.20
	5= 14.50

Notes: Numbers followed by different letters indicate significant differences based on Duncan's Multiple Range Test (DMRT) at a 95% confidence level

The results in Table 5 show that the highest total dry weight of plants at 70 DAP was obtained in the 20 mL + 980 mL water treatment (E2), with a value of 89.46 g. This was not significantly different from treatments (E1), (E3), and (E4), but significantly different from treatments without eco-enzyme concentration (E0). This is thought to be due to the supply of macronutrients such as N, P, and K, which allowed the glutinous corn plants to grow better than in the K0 treatment. The higher the uptake of N, P, and K, the higher the corn production and stalk weight of the plants. There was a positive relationship between nitrogen and potassium levels and the resulting stalk dry weight. This indicates that nitrogen and potassium levels in plants are closely related to the resulting plant dry weight.

CONCLUSION

Based on the research results and discussion above, it can be concluded that the concentration of fruit waste eco-enzyme treatment affected the number of leaves, total leaf area, dry weight of the stalk, dry weight of the roots, and total dry weight of the glutinous corn plants. The eco-enzyme concentration treatment that provided the best effect compared to the other treatments was obtained at an eco-enzyme concentration of 20 mL + 980 mL of water (E2).

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