Plant Height, Number Of Leaves, And Flowers Of Tomato (*Solanum lycopersicum* L) After The Application Of Eco-Enzyme From Nutmeg Leaf Waste

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Abstrak

Eco-enzyme merupakan pupuk cair hasil dari fermentasi limbah organik seperti ampas buah dan sayuran, gula dan air dalam proses pembuatannya pun lumayan lama sekitar 3 bulan. Larutan *eco-enzyme* berwarna coklat gelap dan memiliki aroma fermentasi asam manis yang kuat *eco-enzyme* mengandung berbagai jenis enzim seperti protease, lipase, dan amilase yang sangat bermanfaat bagi tanaman dan mengandung banyak mikroorganisme. Jenis penelitian ini adalah kuantitatif dengan pendekatan eksperimen lapangan, yang dilaksanakan pada tanggal 19 Agustus-27 November 2024 yang berlokasi di samping gedung Student Center IAIN Ambon. Objek penelitian ini adalah tanaman tomat buah yang diberi konsentrasi *eco-enzyme* yang berbeda. Rancangan penelitian yang digunakan rancangan acak kelompok yang terdiri dari 5 perlakuan dan 4 kelompok sehingga jumlah unit pengamatan sebanyak 20 unit. Hasil penelitian menunjukan bahwa pemberian *eco-enzyme* dengan konsentrasi yang berbeda (100%, 80%, 60%, 40%, 20%) signifikan terhadap pertambahan tinggi tanaman, jumlah daun dan jumlah bunga. Pada pemberian konsentrasi *eco-enzyme* 20% rata-rata pertambahan tinggi tanaman 53.25 cm, rata-rata pertambahan jumlah daun 13 helai, rata-rata pertambahan jumlah bunga 3.25 kuntum. Uji beda tiap perlakuan dengan menggunakan HSD-Tukey tersebut terlihat bahwa pada perlakuan Konsentrasi *eco-enzyme* 20% (K5) lebih baik dari perlakuan yang lainnya.

Kata kunci: *tomat buah, eco-enzyme, limbah daun, tanaman pala*

Abstract

Eco-enzyme is a liquid fertilizer resulting from the fermentation of organic waste such as fruit and vegetable pulp, sugar and water in the manufacturing process which is quite long, around 3 months. The eco-enzyme solution is dark brown and has a strong sweet and sour fermentation aroma. Eco-enzyme contain various types of enzymes such as protease, lipase, and amylase which are very beneficial for plants and contain many microorganisms. This type of research is quantitative with a field experiment approach, which was carried out on August 19-November 27, 2024 which is located next to the IAIN Ambon Student Center building. The object of this research is tomato fruit plants that are given different concentrations of eco-enzyme. The research design used is a randomized block design consisting of 5 treatments and 4 groups so that the number of observation units is 20 units. The results showed that the provision of eco-enzyme with different concentrations (100%, 80%, 60%, 40%, 20%) was significant to the increase in plant height, number of leaves and number of flowers. In the provision of eco-enzyme concentration of 20%, the average increase in plant height was 53.25 cm, the average increase in the number of leaves was 13 strands, the average increase in the number of flowers was 3.25 buds. The difference test for each treatment using HSD-Tukey showed that the treatment of eco-enzyme concentration 20% (K5) was better than the other treatments.

Keywords: fruit tomato, eco-enzyme, leaf waste, nutmeg plant

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important horticultural commodities, both economically and nutritionally (Lismeri et al., 2019). Tomatoes are rich in vitamin C, lycopene, and other antioxidants, which provide significant health benefits (Prabowo et al., 2020). Furthermore, tomatoes play an essential role in the food processing industry, including in the production of sauces, soups, and juices, which increases the demand for this commodity (Widowati, 2019). However, one of the main challenges in tomato cultivation is improving plant growth, including the height of the plant, number of leaves, and flowers, in order to enhance the potential yield of the fruit.

Increasing agricultural yields is closely tied to the management of resources used, one of which is fertilization. Fertilization is a technique used to improve soil fertility and enhance plant growth (Rahayu et al., 2019). Typically, chemical fertilizers are widely used by farmers to boost crop production. However, excessive use of chemical fertilizers can lead to soil degradation, water pollution, and other negative environmental impacts (Sutrisno & Hadi, 2018). Therefore, the use of organic fertilizers, which are more environmentally friendly, has gained increasing attention. One type of organic fertilizer that has recently been of interest is eco-enzyme.

Eco-enzyme is an organic liquid fertilizer produced through the fermentation of organic materials such as vegetable, fruit, and leaf waste, which is rich in enzymes and microorganisms (Kusumawati et al., 2021). Eco-enzyme helps improve soil quality, increase nutrient availability, and enhance the activity of soil microorganisms that support plant growth (Sari, 2017). The use of eco-enzyme made from easily available organic materials, such as nutmeg leaf waste, could be a low-cost and effective fertilizer alternative, as well as help reduce unprocessed organic waste (Sari et al., 2020).

Nutmeg leaf waste, which is often discarded without being utilized, can serve as a valuable source for eco-enzyme production (Purbosari et al., 2021). Nutmeg leaves contain active compounds such as essential oils, flavonoids, and phenolic compounds, which have the potential to enhance plant growth (Yuliana, 2019). The fermentation process of nutmeg leaves to produce eco-enzyme is believed to increase the concentration of beneficial microbes and other organic components that can support plant metabolism (Rukmini, 2023). Previous studies have shown that the application of eco-enzyme can improve the number of leaves, flowers, and yield in various types of plants, such as vegetables and fruits (Ika et al., 2017).

However, despite the widespread use of eco-enzyme in various plants, research on its effect on tomato plant growth, particularly using nutmeg leaf waste as the base material, is still very limited (Sanjaya & Putra, 2022). This study aims to explore the impact of eco-enzyme derived from nutmeg leaf waste on the height of the plant, the number of leaves, and flowers in tomato plants. The findings of this study are expected to provide valuable information for improving tomato production in a more sustainable and environmentally friendly manner.

Eco-enzyme has the potential to be an effective solution for increasing tomato plant production, given its active compounds that can stimulate root growth and improve nutrient absorption by the plant (Purwaningsih & Sumarmi, 2023). Therefore, it is essential to conduct further studies on the effects of eco-enzyme from nutmeg leaf waste on aspects of tomato plant growth, specifically regarding plant height, leaf number, and flowers. The results of this study are expected to offer an environmentally friendly alternative to fertilization that can be widely applied in tomato cultivation.

METHOD

This study employs an experimental design with a Completely Randomized Design (CRD). This design was selected because it allows for controlled testing of the effects of eco-enzyme derived from nutmeg leaf waste on the height of the plant, number of leaves, and flowers in tomato plants (Sugiyono, 2017). The study was conducted in a greenhouse to control environmental factors such as temperature, humidity, and light, which are crucial for supporting tomato plant growth (Rasyid, 2024).

The research was conducted in the greenhouse of the Biology Education Study Program, located next to the Student Center building at IAIN Ambon, from May to July 2025. The duration of the study was 3 months, with observations made weekly throughout the growth period of the plants. The materials used in this study include:

1. Tomato Plants (*Solanum lycopersicum* L.) of the Tymoti variety, 14 days old after sowing (Sari et al., 2020).
2. Eco-enzyme made from nutmeg leaf waste. The eco-enzyme was produced through the fermentation of nutmeg leaves mixed with water and brown sugar for 90 days or 3 months (Ika et al., 2017).
3. Basic Fertilizer (compost, manure) for initial fertilization (Setiawan, 2020).
4. Clean water for irrigation.

The tools used in this study include: a plant height measuring tool (ruler or measuring tape), a micrometer for measuring the plant stem diameter, paper and pen for data recording, a scale for weighing the plants (if needed), and a camera for documentation. The variables in this study include the independent variable, which is the application of eco-enzyme made from nutmeg leaf waste at different concentrations, and the dependent variables, which include plant height (cm) measured from the soil surface to the top of the leaves, the number of leaves per plant, which is counted weekly, and the number of flowers per plant, which is counted weekly.

The study was conducted through the following steps:

1. Preparation of Plants and Growing Media
   a. Tomato seedlings, 14 days old after sowing, were prepared and transplanted into pots or beds of uniform size (Basugi, 2018).
   b. Growing media consisting of a mixture of soil, compost, and manure was prepared for planting the tomato seedlings (Palifiana et al., 2022).
2. Eco-enzyme Production
   a. Selected nutmeg leaves were washed clean and chopped into small pieces.
   b. The nutmeg leaves were mixed with water and brown sugar in a closed container for 90 days or 3 months for fermentation. The resulting eco-enzyme will be used as a liquid fertilizer in this study (Adnan et al., 2021).
3. Treatment Distribution
   a. The tomato plants were divided into several treatment groups as follows:
      K1: Plants treated with eco-enzyme at a concentration of 100%.
      K2: Plants treated with eco-enzyme at a concentration of 80%.
      K3: Plants treated with eco-enzyme at a concentration of 60%.
      K4: Plants treated with eco-enzyme at a concentration of 40%.
      K5: Plants treated with eco-enzyme at a concentration of 20%.
   b. Each treatment was replicated four times, resulting in a total of 5 treatments × 4 replicates = 20 experimental plants.
4. Application of Treatments
   a. Eco-enzyme was applied as a liquid fertilizer once a week to each treatment group according to the specified concentration, with the application time set at 08:00 WIT.

b. Irrigation was done regularly, and basic fertilization was carried out using organic fertilizer to ensure the plants received adequate nutrition (Fitria et al., 2021).

5. Observations
   a. Plant height was measured weekly from the soil surface to the highest leaf tip using a ruler.
   b. The number of leaves was counted once when the flowers formed by counting the leaves on each plant.
   c. The number of flowers was counted weekly by recording the number of flowers that appeared on each plant.

The data obtained will be analyzed using Analysis of Variance (ANOVA) to test the differences between the effects of the treatments on each variable (plant height, number of leaves, and number of flowers). If significant differences are found, further post hoc testing will be conducted to determine which treatments differ significantly. This study was conducted with attention to research ethics involving plants and the environment. All procedures were carefully carried out to minimize damage to the plants and the surrounding environment (Apriani, 2024).

FINDS AND DISCUSSION

In this study, eco-enzyme was used as an additional external nutrient by varying its concentration and measuring the growth of tomato plants, which included plant height (cm), number of leaves (leaflets), and number of flowers (buds).

Plant Height (cm) of Tomato

Plant height is a common growth parameter used to assess the effect of a treatment on test plants. Plant height represents the vegetative growth of the plant, which includes size increase, and is measured using a ruler with centimeter scale. The tomato plant height data were measured over 71 days, with measurements taken weekly. The measurement results and data analysis are presented in Table 1 below:

Table 1. Plant Height (cm) Increase of Tomato Plants for Each Group After 71 Days of Treatment

Treatment	Group 1	Group 2	Group 3	Group 4	Total (cm)	Average (cm)
K1	15	29.5	6.8	27	78.3	19.575
K2	24	10	22	29.5	85.5	21.375
K3	35	37	22	28	122	30.5
K4	48.5	36	29	42	155.5	38.875
K5	58.5	48	50	56.5	213	53.25

Note: K1: 100%; K2: 80%; K3: 60%; K4: 40%; K5: 20%; 1, 2, 3, and 4 are the groups for each treatment

Based on Table 1, it is evident that the application of eco-enzyme at a concentration of 100% resulted in an average height increase of 19.575 cm, 80% concentration resulted in 21.375 cm, 60% concentration resulted in 30.5 cm, 40% concentration resulted in 38.875 cm, and 20% concentration resulted in 53.25 cm. The highest plant height increase was observed with the 20% eco-enzyme concentration. To clarify the data from Table 1, a diagram showing the average plant height increase is presented below:

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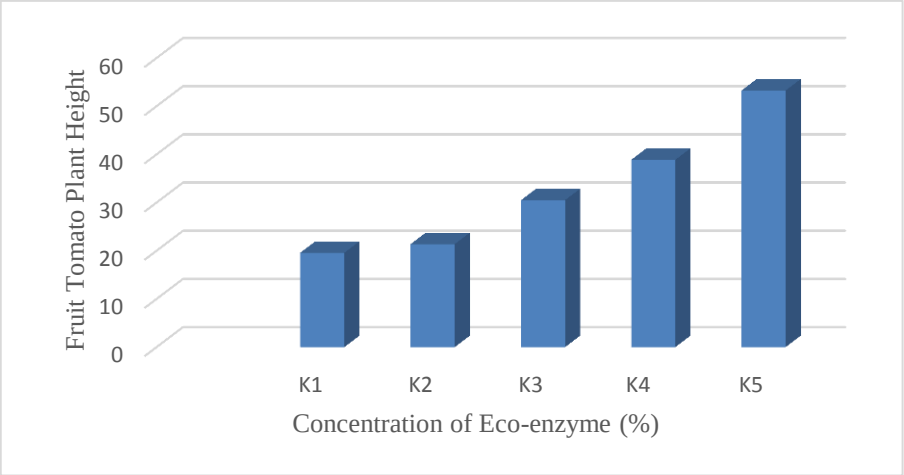

Figure 1. Average Plant Height Increase (cm) of Tomato Plants for Each Treatment

Based on Figure 1, it can be seen that the lower the concentration of eco-enzyme applied to the tomato plants, the better the height increase. The 20% eco-enzyme concentration treatment performed the best compared to others. To analyze the effect of eco-enzyme concentration on the height increase of tomato plants, an ANOVA test was performed using SPSS version 25 for Windows, and the results are presented in Table 2 below:

Table 2. One-Way ANOVA Test of the Effect of Eco-enzyme Concentration on Plant Height (cm) Increase of Tomato Plants

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3063.173	4	765.793	11.893	0.000
Within Groups	965.892	15	64.393		
Total	4029.065	19			

Note: If Sig value < 0.05, there is an effect of the treatment on the measurement parameter. If Sig value > 0.05, there is no effect of the treatment on the measurement parameter.

Based on Table 2, the Sig value is 0.000, which is less than 0.05, so it can be concluded that there is an effect of the eco-enzyme concentration on the plant height (cm) increase of the tomato plants. To determine the differences between treatments, a Tukey HSD test was conducted, and the data is presented in Table 3 below:

Table 3. Tukey HSD Test Results for Plant Height

Tukey HSDa	Concentration	N	Subset for alpha = 0.05
	1	4	19.57500a
	2	4	21.37500ab
	3	4	30.50000ab
	4	4	38.87500b
	5	4	53.25000c
Sig.			0.346

Note: Numbers in the same subset are not significantly different.

Based on Table 3, it can be seen that treatments K1, K2, and K3 did not differ significantly, but they did differ significantly from treatments K4 and K5. However, treatments K4 and K5 did not differ significantly.

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Number of Leaves (Leaflets) of Tomato Plants

The number of leaves is also a vegetative growth parameter that includes the increase in the number of leaves, counted directly. The leaf count was performed every week for 71 days. The results of the measurements and data analysis are presented in Table 4 below:

Table 4. Number of Leaves Increase of Tomato Plants for Each Group After 71 Days of Treatment

Treatment	Group 1	Group 2	Group 3	Group 4	Total (leaves)	Average (leaves)
K1	5	7	3	9	24	6
K2	5	4	9	9	27	6.75
K3	8	10	8	9	35	8.75
K4	12	9	8	7	36	9
K5	15	10	12	15	52	13

Note: K1: 100%; K2: 80%; K3: 60%; K4: 40%; K5: 20%; 1, 2, 3, and 4 are the groups for each treatment

Based on Table 4, it can be seen that the application of eco-enzyme with 100% concentration resulted in an average leaf increase of 6 leaves, 80% concentration resulted in 6.75 leaves, 60% concentration resulted in 8.75 leaves, 40% concentration resulted in 9 leaves, and 20% concentration resulted in 13 leaves. The best increase in the number of leaves was obtained at the 20% eco-enzyme concentration. To clarify the data from Table 4, a diagram showing the average leaf increase is presented below:

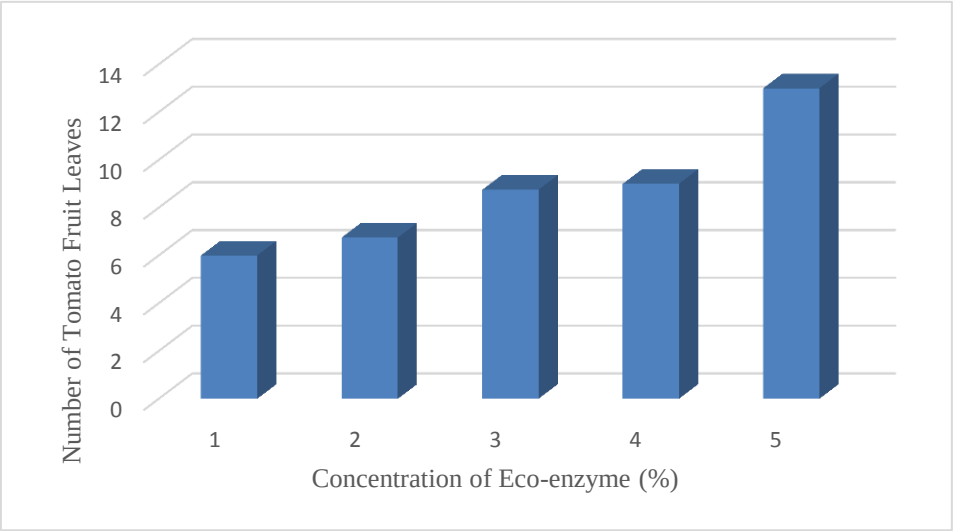

Figure 2. Average Increase in the Number of Leaves (Leaflets) of Tomato Plants for Each Treatment

Based on the figure, it is evident that the lower the concentration of eco-enzyme applied to the tomato plants, the greater the increase in the number of leaves. The 20% eco-enzyme concentration performed the best compared to others. To determine the effect of eco-enzyme concentration on the number of leaves of tomato plants, an ANOVA test was performed using SPSS version 25 for Windows, and the results are presented in Table 5 below:

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Table 5. One-Way ANOVA Test of the Effect of Eco-enzyme Concentration on the Increase in Number of Leaves (Leaflets) of Tomato Plants

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	118.700	4	29.675	5.896	0.005
Within Groups	75.500	15	5.033		
Total	194.200	19			

Note: If Sig value < 0.05, there is an effect of the treatment on the measurement parameter. If Sig value > 0.05, there is no effect of the treatment on the measurement parameter.

Based on Table 5, the Sig value is 0.005, which is less than 0.05, indicating that the eco-enzyme concentration has an effect on the increase in the number of leaves (leaflets) of tomato plants. To determine the differences between treatments, a Tukey HSD test was performed, and the data is presented in Table 6 below:

Table 6. Tukey HSD Test Results for Number of Leaves

Tukey HSDa	Concentration	N	Subset for alpha = 0.05
	1	4	6.00a
	2	4	6.75ab
	3	4	8.75ab
	4	4	9.00ab
	5	4	13.00b
Sig.			0.363

Note: Numbers in the same subset are not significantly different.

Based on Table 6, it can be seen that treatments K1, K2, K3, and K4 did not differ significantly. However, treatments K3, K4, and K5 did not differ significantly, while K1 and K2 differed significantly from K5.

Number of Flowers (Buds) of Tomato Plants

The number of flowers is a vegetative growth parameter closely related to reproduction. Flowers are the reproductive organs of plants, playing a key role in fruit formation. The number of flowers was directly counted. The first flowers appeared in week 7. The measurement results and data analysis are presented in Table 7 below:

Table 7. Number of Flowers Increase of Tomato Plants for Each Group After 71 Days of Treatment

Treatment	Group 1	Group 2	Group 3	Group 4	Total (buds)	Average (buds)
K1	0	0	0	0	0	0
K2	0	0	0	0	0	0
K3	0	1	0	0	1	0.25
K4	2	0	0	2	4	1
K5	6	2	0	5	13	3.25

Note: K1: 100%; K2: 80%; K3: 60%; K4: 40%; K5: 20%; 1, 2, 3, and 4 are the groups for each treatment

Based on Table 7, it is observed that the application of eco-enzyme with 100% and 80% concentrations showed no increase in flower numbers, while the 60% concentration showed an average of 0.25 flowers, the 40% concentration showed 1 flower, and the 20% concentration showed an average of 3.25 flowers. The best increase in flower number was obtained at the 20% eco-enzyme concentration.

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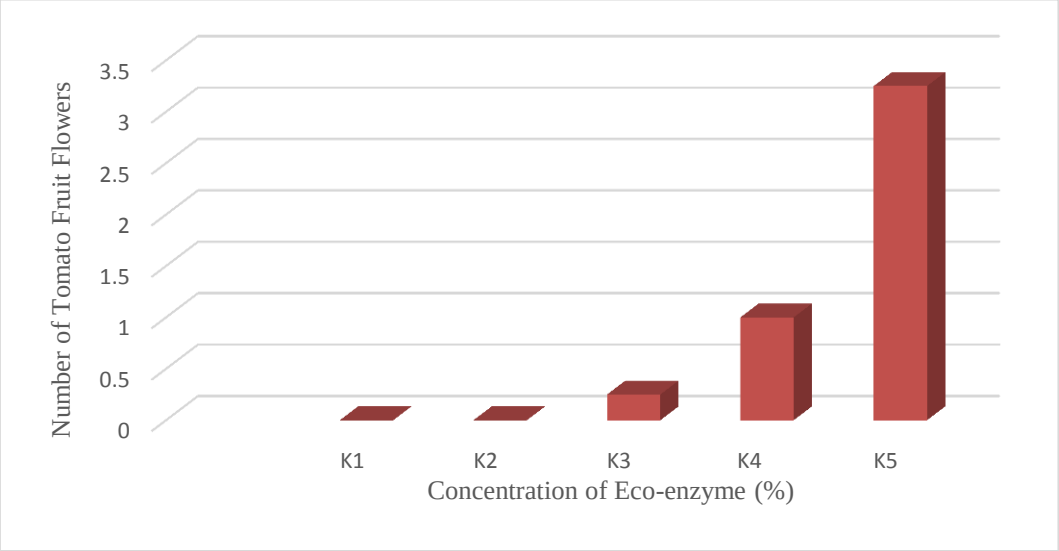

Figure 3. Average Number of Flowers (Buds) of Tomato Plants for Each Treatment

Based on Figure 3, it is seen that the lower the concentration of eco-enzyme applied to the tomato plants, the higher the increase in the number of flowers. The 20% eco-enzyme concentration performed the best compared to other concentrations.

This study aimed to examine the effect of eco-enzyme concentration on the growth of tomato plants, with parameters including plant height, number of leaves, and number of flowers. Each treatment applied different eco-enzyme concentrations, namely 100%, 80%, 60%, 40%, and 20%, which were tested on four groups of tomato plants. Below is the discussion of the results for each parameter, supported by previous studies.

Eco-enzyme is the result of fermenting organic waste such as fruit pulp, vegetables, sugar, and water, containing various essential nutrients for plants (Rukmini P. & Herawati D.A., 2023). According to Hasanah Y (2020), the eco-enzyme derived from decomposed fruit and vegetable waste produces nitrogen, which is beneficial for increasing soil organisms and microorganisms, thereby improving soil fertility and promoting plant growth.

Plant Height of Tomato

The results of the study indicate that the plant height increased as the concentration of eco-enzyme decreased. Based on Table 1 and Figure 1, the 20% eco-enzyme concentration resulted in the most significant increase in plant height, with an average increase of **53.25 cm**. In contrast, the 100% concentration only produced an average increase of **19.575 cm**. This suggests that too much eco-enzyme concentration can inhibit plant growth, possibly due to excessive nutrients that cause stress to the plants (Hastuti, 2022). Generally, this study shows a consistent pattern with previous studies that emphasize the importance of proper dosage when using eco-enzyme (Hasanah, 2020).

Previous research by (Lestari et al., 2019), also showed that using eco-enzyme at high concentrations could result in inhibited plant growth, especially when plants experience excessive nutrients affecting their vegetative growth balance. This finding aligns with the study's results, where the 100% concentration produced poorer growth compared to the 20% concentration, which resulted in the best plant growth. In their research on eco-enzyme in rice plants, also observed that exceeding the optimal eco-enzyme concentration could reduce the growth and yield, indicating that lower concentrations were more beneficial. These findings are relevant to this study, which demonstrates that the 20% eco-enzyme concentration is more conducive to tomato plant growth (Anggraini & Sari, 2022).

Additionally, a study by (Tan & Liang, 2018) also supports this observation, finding that excessive concentrations of eco-enzyme could reduce nutrient effectiveness in plants, as they become less capable of absorbing nutrients optimally. Plants receiving too high a concentration of eco-enzyme experience stress that hinders photosynthesis and ultimately stunts their growth.

The ANOVA Test results shown in Table 2 confirm that there were significant differences between the treatments, with a Sig. value of 0.000, indicating that eco-enzyme concentration significantly affects plant height. The Tukey HSD Test results in Table 3 also show that treatments with 100%, 80%, and 60% concentrations did not differ significantly from each other but were significantly different from the 40% and 20% treatments. Therefore, it can be concluded that using lower eco-enzyme concentrations is more beneficial for supporting tomato plant height growth.

Number of Leaves (Leaflets) of Tomato Plants

Based on Table 4, reducing the concentration of eco-enzyme also had an effect on increasing the number of leaves of tomato plants. The 20% eco-enzyme concentration resulted in an average increase of 13 leaves, whereas the 100% concentration only led to an average of 6 leaves. This indicates that lower concentrations of eco-enzyme facilitate better leaf growth, which is associated with increased photosynthetic capacity.

This result is consistent with the findings of (Salim et al., 2020), which demonstrated that using eco-enzyme on long bean plants at lower concentrations increased the number of leaves because plants were better able to manage the nutrients provided. Similarly, (Meilani et al., 2023) reported similar results in their study on tomato plants, indicating that eco-enzyme application at lower concentrations supports vegetative growth, such as the formation of healthier leaves and stems. These findings strengthen the results of the current study, which shows that lower eco-enzyme concentrations are more beneficial for leaf growth.

In a study by (Listiana et al., 2024) on the effects of eco-enzyme on vegetable plants, it was found that lower concentrations of eco-enzyme accelerated the process of cell division in plants, contributing to the formation of more leaves and larger leaf sizes. This suggests that using eco-enzyme at lower concentrations can stimulate an increase in the number of leaves, which serves as one of the key indicators of successful plant growth.

The ANOVA Test conducted (Table 5) shows a significant effect of eco-enzyme concentration on the increase in the number of leaves, with a Sig. value of 0.005. The Tukey HSD Test results in Table 6 show that treatments with 100% and 80% concentrations did not differ significantly, but there were significant differences between the 20% treatment and the others. These results indicate that lower concentrations are more effective in increasing the number of leaves in tomato plants.

Number of Flowers (Buds) of Tomato Plants

Regarding the number of flowers, which is an indicator of the reproductive growth of plants, the 100% and 80% eco-enzyme concentrations showed no increase in flower numbers (Table 7). On the other hand, the 20% concentration resulted in an average of 3.25 flowers, the highest among the treatments. This indicates that eco-enzyme at lower concentrations better supports the flowering of tomato plants.

The findings from (Koto et al., 2022) support this observation, which showed that lower concentrations of eco-enzyme stimulated optimal flowering in chili plants. In their research on melon plants also found that using eco-enzyme at lower concentrations increased the number of flowers, ultimately affecting fruit yield (Adnan et al., 2021). This suggests that lowering the eco-enzyme concentration enhances flower formation in plants, directly impacting reproductive outcomes.

In a study by (Nangoi et al., 2022) on the effects of eco-enzyme on flowering plants, it was found that lower eco-enzyme concentrations stimulate increased flower formation by enhancing enzymatic activity that supports the flowering process. This strengthens the findings in this study, which show that lower concentrations of eco-enzyme support better flower formation in tomato plants.

Figure 3 shows that the lower the eco-enzyme concentration, the higher the number of flowers formed. The ANOVA Test for flower number (Table 5) reveals that there is a significant effect of the treatment on flower number, with a Sig. value of 0.005. This indicates that lower concentrations of eco-enzyme promote flower formation in tomato plants.

Based on the results of this study, it can be concluded that the application of eco-enzyme at lower concentrations (20%) provides the best results for enhancing both vegetative and reproductive growth of tomato plants. In terms of plant height, number of leaves, and number of flowers, the 20% eco-enzyme concentration showed the most optimal performance. Higher concentrations tend to inhibit plant growth, possibly due to excessive nutrients or an imbalance between the plant's needs and the nutrient content of the eco-enzyme. Therefore, using eco-enzyme at a concentration of 20% can be considered the most effective concentration for supporting tomato plant growth in this study.

This study also highlights the importance of concentration regulation in eco-enzyme application for plant growth, which can be applied in agriculture or horticulture to improve plant yields (Polii et al., 2019). Future research can be conducted to explore the long-term effects of eco-enzyme use on other plants or with additional variables such as different soil types or climates.

CONCLUSION

1. The application of eco-enzyme at different concentrations significantly affects plant height and the number of leaves.
2. The plant height in treatments K1, K2, and K3 did not differ significantly, but they differed significantly from treatments K4 and K5. There was no significant difference between K4 and K5. The number of leaves in treatments K1, K2, K3, and K4 did not differ significantly. K3, K4, and K5 did not differ significantly, while K1 and K2 differed significantly from K5.

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