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Optimizing Eco-enzyme Dosage on Kale (*Brassica oleracea*) Growth and Production

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Abstract

Kale, a member of the cabbage family, is currently witnessing an increase in popularity; however, this heightened interest is not reflected in production levels, primarily due to the excessive application of inorganic fertilizers. To mitigate this challenge, implementing organic fertilizers, such as eco-enzymes, may enhance kale yield. A research study was carried out at the experimental field of the Faculty of Agriculture at Muhammadiyah University of Jakarta from June to October 2022. The study employed a Randomized Block Design (RAK) with six varying doses of eco enzymes, ranging from a control group to 50 mL per plant. Each treatment was replicated four times, with three plants allocated to each experimental unit. The parameters assessed included the number of leaves, leaf length, leaf width, gross weight, consumption weight, and root length. Data analysis, utilizing variance (F test) and the DMRT test at a 5% significance level, indicated that varying doses of eco enzymes had a significant impact on plant height, leaf length, gross weight, and consumption weight while showing no significant effect on the number of leaves, leaf width, and root length of the kale plants.

Keywords: Growth, Kale, Liquid Organic Fertilizer, Production, Vegetable Plants

1. Introduction

The plant *Brassica oleracea* var., commonly known as Kale. Acephala, a vegetable plant, is a Brassicaceae or cabbage family member. Kale production is substantial, amounting to approximately 2000 plants per day, primarily driven by the strong demand from local and nonlocal markets (Laki 2021). The consumption of Kale has been associated with improved human health, such as a decreased risk of specific cancers and cardiovascular diseases. According to Acikgoz (2011), Kale contains antioxidants such as vitamin E, C, and carotenoids. Dalmadi (2010) stated that Kale is a rich source of various vitamins, including vitamin A, vitamin B1, vitamin B2, vitamin B3, and vitamin C. Additionally, Kale contains isothiocyanates, specifically sulforaphane, which have been found to exhibit anti-cancer properties.

The substantial consumer demand and consumption of Kale in the market is not proportionate to the level of kale production by Indonesian vegetable farmers. Over an extended period of time, the overuse of inorganic fertilizers by vegetable farmers in Indonesia has contributed to decreased kale production by depleting soil fertility and nutrient levels. One method for preserving nutrient availability is to utilize organic fertilizers.

Organic fertilizer is derived from processing organic waste materials, including animal excrement, refuse, plant debris, sawdust, and activated sludge, with its quality being contingent upon the specific processing methods employed (Yulipriyanto, 2010). One notable source of organic fertilizer is eco enzyme, a solution composed of complex organic compounds generated through the fermentation of organic waste, sugar, and water. The resulting eco-enzyme liquid is characterized by its dark hue and a sour or fresh scent. Eco-enzyme serves multiple functions, including acting as a general cleaner, a fertilizer for plants, a repellent for plant pests, and a tool for environmental conservation, as it can neutralize various pollutants in the surrounding ecosystem (Khairunnisa, 2021). Incorporating eco-enzyme into the planting medium has enhanced plant nutrient availability (Rochyani et al., 2020). Furthermore, studies have indicated that applying eco-enzyme can boost the hydroponic production of mustard greens (Wiryono, 2021). The use of eco enzyme as a liquid organic fertilizer has demonstrated a significant positive impact on the growth of pak choi mustard plants (Salsabila and Winarsih, 2023), although it appears to have no substantial effect on the

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growth and yield of shallots (Lubis et al., 2022). Applying eco-enzyme to kale plants is anticipated to yield high-quality Kale with increased production levels. This research aims to investigate the influence of eco-enzyme application on the growth and yield of kale plants.

2. Material and Methods

The study took place at the Agrotechnology Experimental Garden of the Faculty of Agriculture, Muhammadiyah University of Jakarta, situated at coordinates Latitude -6.297550040024173, Longitude 106.7671802970177, and an elevation of 25 meters above sea level, during the period of June to October 2022. The equipment utilized included hoes, measuring cups, meters, water hoses, scales, digital scales, stationery, and documentation tools. The components utilized for this research encompassed lowland kale seeds, organic planting medium, rice husks subjected to combustion, soil, furadan 3G, decis pesticide containing deltamethrin as its active ingredient at a concentration of 25 g/ℓ, eco-enzyme, polybags, and labels.

The research employed a Randomized Block Design (RBD) featuring six varying doses of eco-enzyme, designated as P0 control, 10 mL plant -1 , 20 mL plant -1 , 30 mL plant -1, 40 mL plant -1, and 50 mL plant -1. The experiment was conducted with each treatment being repeated 4 times, resulting in 24 experimental units. Three plants made up each experimental unit, resulting in a total of 72 plants observed.

The research involved the preparation of seeding media within seeding trays, followed by the sowing of kale seeds, which were allowed to grow for two weeks post-sowing (mss). Healthy seedlings, aged two mss, were subsequently transplanted into polybags measuring 35 cm x 40 cm, utilizing a soil mixture composed of burnt rice husks and cow manure in a 1:1:1 ratio. Eco-enzyme was administered to the plants following the designated treatment, occurring weekly from the time of transplantation until the kale plants reached 48 days after planting (dap). The care regimen for the Kale included regular watering and pest management tailored to the specific conditions observed in the field. Harvesting of the Kale took place when the plants were 42 dap.

The variables monitored during the vegetative phase encompassed the number of leaves, leaf length, and leaf width, recorded weekly from one week after planting (wst) until harvest. In the generative phase, the parameters assessed included gross weight, consumption weight, and root length, all measured at harvest time. The collected observation data were subjected to analysis of variance (F test), with subsequent testing performed using the DMRT at a significance level of 5%. The analysis was conducted utilizing R Statistic R 1386 4.0.1 software.

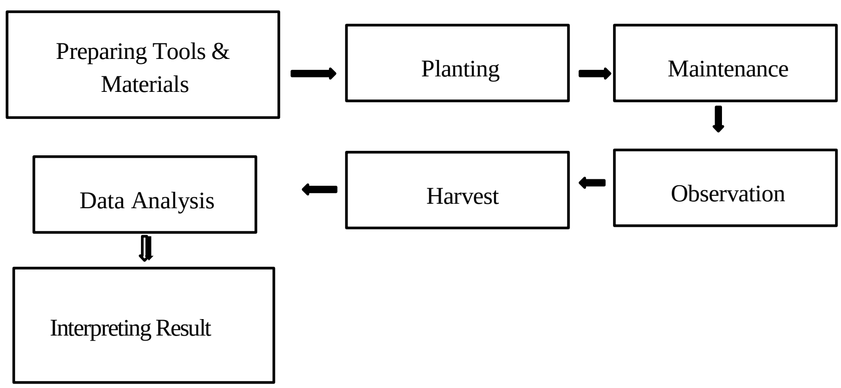

Figure 1. Research flow diagram

3. Results and Discussion

3.1. Plant Height

The results of the analysis of variance demonstrated that the administration of various doses of eco-enzyme exerted a significant effect on the height of kale plants at the ages of 5 and 6 months after sowing (DAP), yet no significant effect was observed at the ages of 1 to 4 DAP (days after planting). The height of kale plants can be found in Table 1.

Table 1 indicates that the tallest kale plants at 1 month after sowing (DAP) were observed in the P4 treatment, measuring 3.62 cm; however, this height was not significantly different from those in other treatments. At 2 DAP, 3 DAP, and 4 DAP, the P5 treatment yielded the highest plant heights of 3.77 cm, 4.87 cm, and 6.41 cm, respectively, with no significant differences noted among the treatments. For 5 DAP and 6 DAP, the P5 treatment again produced the tallest plants, reaching 9.34 cm and 13.46 cm, significantly different from the P3 treatment but not from the other treatments. These findings align with the research by Salsabila and Winarsih (2023), which suggests that the application of eco-enzymes can significantly enhance the height of pak choy mustard plants.

The most substantial growth in kale plant height was associated with the 50 mL plant-1 eco-enzyme treatment. This outcome is likely due to the adequacy of the eco-enzyme dosage in supporting kale plant development. Eco-enzymes are known to contain essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and organic carbon (C), as reported by Ritomga and Anhar (2022). According to Tando (2019), nitrogen is crucial in protein synthesis and promotes vegetative growth, particularly in height. Plants tend to utilize nitrogen more for shoot development than root growth, influencing overall height. Furthermore, Pramitasari et al. (2016) noted that applying nitrogen, phosphorus, and potassium can enhance vegetative growth, including plant height.

Table 1. Effect of eco-enzymes on kale plant height at the age of 1 DAP to 6 DAP

Treatment	Plant Height (cm)					
	1 DAP	2 DAP	3 DAP	4 DAP	5 DAP	6 DAP
P0	3.07 ± 0.81 a	3.26 ± 2.42 a	3.84 ± 1.12 a	5.68 ± 1.72 a	7.18 ± 2.01 ab	10.71 ± 3.03 ab
P1	2.48 ± 0.74 a	3.03 ± 2.21 a	3.25 ± 0.47 a	5.18 ± 1.18 a	7.22 ± 2.11 ab	10.96 ± 3.08 ab
P2	2.90 ± 0.77 a	3.14 ± 2.35 a	3.76 ± 1.09 a	5.93 ± 1.80 a	7.38 ± 2.24 ab	11.47 ± 3.13 ab
P3	3.16 ± 0.82 a	3.63 ± 2.46 a	3.63 ± 1.04 a	5.46 ± 1.63 a	6.86 ± 1.78 b	8.96 ± 2.81 b
P4	3.62 ± 0.84 a	3.06 ± 2.24 a	3.84 ± 1.14 a	5.60 ± 1.77 a	6.77 ± 2.12 b	10.68 ± 2.95 ab
P5	3.53 ± 0.79 a	3.77 ± 2.49 a	4.87 ± 1.17 a	6.41 ± 1.83 a	9.34 ± 2.24 a	13.46 ± 3.48 a

Notes: numbers followed by the same letter in the same column are not significantly different based on the DMRT test at the 5% level.

3.2. Number of Leaves

The analysis of variance demonstrates that the administration of diverse doses of eco-enzyme No exerts a substantial influence on the quantity of leaf kale plants at the ages of 1 DAP to 6 DAP. The numerical values corresponding to the number of kale plant leaves are presented in Table 2.

Table 2. Effect of eco-enzymes on the number of Kale leaves at the age of 1 DAP to 6 DAP

Treatment	Number of leaves (blades)					
	1 DAP	2 DAP	3 DAP	4 DAP	5 DAP	6 DAP
P0	4.3 ± 1.04 a	5.4 ± 1.29 a	5.8 ± 1.58 a	6.5 ± 2.50 a	8.1 ± 2.62 a	10.50 ± 2.60 a
P1	3.8 ± 0.38 a	5.1 ± 1.27 a	5.1 ± 0.89 a	6.8 ± 2.51 a	7.8 ± 2.50 a	11.17 ± 2.68 a
P2	4.2 ± 1.02 a	4.8 ± 1.16 a	5.5 ± 1.57 a	7.4 ± 2.66 a	8.6 ± 2.66 a	11.83 ± 2.77 a
P3	4.1 ± 0.98 a	5.0 ± 1.22 a	5.2 ± 1.42 a	5.8 ± 2.34 a	6.6 ± 2.39 a	8.08 ± 2.48 a
P4	4.2 ± 1.01 a	4.5 ± 0.60 a	5.7 ± 1.53 a	6.9 ± 2.58 a	7.9 ± 2.51 a	11.08 ± 2.71 a
P5	3.8 ± 0.93 a	5.0 ± 1.25 a	5.5 ± 1.49 a	7.0 ± 2.62 a	8.0 ± 2.57 a	11.08 ± 2.72 a

Description: numbers followed by the same letter in the same column are not significantly different based on the DMRT test at the 5% level.

Table 2 presents data indicating that the P0 treatment yielded the highest count of kale leaves, specifically 4.3 leaves at 1 week after planting (WAP), 5.4 leaves at 2 WAP, and 5.8 leaves at 3 WAP. These counts were not found to be statistically different from those of the other treatments. The P2 treatment yielded the greatest number of kale leaves between 4 and 6 weeks after planting (WAP), with 7.4 leaves, 8.6 leaves, and 11.83 leaves. However, these numbers did not show significant differences compared to other treatments' results. The eco-enzyme treatment of 20 mL per plant yielded the highest yield of kale leaves. These findings do not align with those of Moi et al. According to a study published in 2015, increasing the concentration of liquid organic fertilizer application results in more leaves on the plant.

The growth and development of leaves are associated with the formation and division of cells and the elongation of cells. These mechanisms are activated by substances such as proteins and carbohydrates. Including nitrogen in creating proteins plays a significant role in producing chlorophyll, a crucial component in photosynthesis. This ultimately stimulates the development and expansion of leaves (Pramushinta and Yulian., 2020)

3.3. Leaf Length

The analysis of variance results indicates that applying different doses of eco-enzyme significantly affects the length of kale leaves between 4 DAP and 6 DAP. However, no significant influence was observed from 1 DAP to 3 DAP. A detailed overview of the kale leaf lengths can be found in Table 3.

Table 3. Influence eco-enzyme to long Kale leaves at the age of 1 DAP to 6 DAP

Treatment	Leaf Length (cm)					
	1 DAP	2 DAP	3 DAP	4 DAP	5 DAP	6 DAP
P0	1.73 ± 0.42 a	2.80 ± 1.16 a	4.66 ± 2.13 a	6.68 ± 2.82 ab	7.84 ± 2.69 ab	12.72 ± 4.43 ab
P1	1.38 ± 0.37 a	2.14 ± 0.48 a	3.86 ± 1.94 a	5.55 ± 2.65 b	8.11 ± 2.83 ab	12.11 ± 4.22 ab
P2	1.58 ± 0.41 a	2.51 ± 1.12 a	4.12 ± 2.10 a	6.78 ± 2.78 ab	8.17 ± 2.77 ab	12.83 ± 4.48 ab
P3	1.45 ± 0.39 a	2.15 ± 1.01 a	3.53 ± 1.66 a	5.18 ± 2.53 b	7.18 ± 2.57 b	10.74 ± 4.03 b
P4	1.43 ± 0.06 a	2.18 ± 1.10 a	4.12 ± 2.04 a	6.28 ± 2.73 ab	8.45 ± 2.86 ab	12.23 ± 4.34 ab
P5	1.50 ± 0.41a	2.79 ± 1.14 a	4.61 ± 2.17 a	8.37 ± 2.83 a	9.83 ± 2.91 a	14.10 ± 7.14 a

Notes: numbers followed by the same letter in the same column are not significantly different based on the DMRT test at the 5% level.

Table 3 indicates that the P0 treatment yielded the longest kale leaf lengths at 1 DAP to 3 DAP, measuring 1.73 cm, 2.80 cm, and 4.66 cm, although these measurements were not significantly different from those of other treatments. At 4 DAP, the P5 treatment produced the longest kale leaf length of 8.37 cm, significantly greater than the lengths observed in the P1 and P3 treatments, yet not significantly different from those in the P0, P2, and P4 treatments. For the ages of 5 DAP and 6 DAP, the P5 treatment again resulted in the longest leaf lengths of 9.83 cm and 14.10 cm, respectively, showing significant differences only when compared to the P3 treatment while remaining statistically similar to the other treatments. These findings corroborate the research by Nurfadilah et al. (2024), which highlighted the positive impact of eco-enzyme nutrition on the length of horenzo spinach leaves.

The application of 50 mL of eco-enzyme per plant was associated with the longest leaf lengths, likely due to the adequate nutrient content provided by the eco-enzyme, which supports the growth of kale leaves. Eco-enzyme is rich in nitrogen in nitrate (NO3-), readily absorbed by plants, enhancing nutrient mobility and efficiency (Aziz & Kurnia, 2015). Additionally, eco-enzyme contain enzymes such as α-amylase, maltase, and proteolytic enzymes, which facilitate the breakdown of starches in food reserves into glucose, serving as an energy source for plant growth (Ginting et al., 2021). This process is essential for the effective metabolism and photosynthesis of plants.

Prasetya (2015) noted that efficient plant metabolism accelerates the synthesis of amino acids and proteins, thereby promoting the formation of new cells in the roots, stems, and leaves. Furthermore, Rahayu et al. (2021) emphasized that the nitrate form of nitrogen in eco-enzymes contributes to protein synthesis, while the enzymes present stimulate the division of meristematic tissue and enhance both root and leaf development.

3.4. Leaf Width

The results of the variance analysis demonstrate that administering diverse doses of eco-enzyme No exerts a substantial influence on the development of broad Kale leaves from 1 to 6 months after sowing (DAP). The width of kale leaves is delineated in Table 4.

Table 4. Effect of eco-enzymes on kale leaf width at the age of 1 DAP to 6 DAP

Treatment	Leaf Width (cm)					
	1 DAP	2 DAP	3 DAP	4 DAP	5 DAP	6 DAP
P0	1.38 ± 0.40 a	2.23 ± 1.02 a	3.73 ± 1.82 a	4.78 ± 2.03 a	7.36 ± 2.96 a	10.12 ± 13.78 a
P1	1.17 ± 0.33 a	1.57 ± 0.34 a	2.90 ± 1.71 a	4.16 ± 1.88 a	6.48 ± 2.82 a	10.17 ± 14.17 a
P2	1.28 ± 0.38 a	1.82 ± 0.99 a	3.17 ± 1.73 a	4.98 ± 2.07 a	6.88 ± 2.91 a	10.71 ± 14.44 a
P3	1.24 ± 0.37a	1.60 ± 0.96 a	2.80 ± 1.64 a	3.95 ± 1.56 a	5.98 ± 2.60 a	9.00 ± 13.14 a
P4	1.20 ± 0.35 a	1.63 ± 0.92 a	3.39 ± 1.76 a	4.74 ± 1.96 a	7.43 ± 3.00 a	12.08 ± 14.63 a
P5	1.22 ± 0.36 a	1.92 ± 1.01 a	3.72 ± 1.80 a	5.34 ± 2.09 a	8.19 ± 3.20 a	12.33 ± 15.02 a

Description: numbers followed by the same letter in the same column are not significantly different based on the DMRT test at the 5% level.

Table 4 depicts the maximum width of kale leaves at 1 DAP to 3 DAP, indicating that the P0 treatment produced widths of 1.38 cm, 2.23 cm and 3.73 cm, which were not significantly different from the widths produced by other treatments. The P5 treatment yielded the widest kale leaf width at 4 DAP to 6 DAP, measuring 5.34 cm, 8.19 cm, and 12.33 cm. However, these measurements did not show a statistically significant difference compared to other treatments. These findings are consistent with the results reported by Widarawati et al. A study conducted in 2023 noted that the utilization of eco-enzyme did not produce a notable impact on the leaf area of red spinach.

Eco-enzymes are comprised of micronutrients, such as Zn, Mn, Fe, Ca, Mg, S, and B, which serve as catalysts in the synthesis of proteins and the production of leaf chlorophyll. Protein serves as the primary component in protoplasm, the central site of plant metabolism, and promotes cell division and elongation. According to Faqih et al. (2017), the presence of nitrogen and micronutrients in plants is essential for the synthesis of chlorophyll, leading to an increase in photosynthesis and the production of photosynthate necessary for the growth and development of leaf meristem tissue.

3.5. Gross Weight, Consumption Weight and Root Length

The results of the variance analysis demonstrated that the administration of various doses of eco-enzymes significantly affected the gross weight and consumption weight of Kale, yet no significant effect was observed on the length of kale roots. The detailed findings, including the mean values, standard deviations, and statistical significance, are elucidated in Table 5.

Table 5 illustrates that the highest gross weight of Kale was obtained in treatment P5, with a value of 86.83 g, which differs significantly from treatments P2 and P3 but not significantly from treatments P0, P1, and P4. The highest intake of Kale was observed in treatment P5, totaling 74.58 g, which was significantly different from treatments P2 and P3 but not significantly different from treatments P0, P1, and P4. The treatment P5 resulted in the longest root length of Kale at 35.95 cm. However, this length was not significantly different from that of the other treatments.

The 50 mL plant-1 treatment with eco-enzyme application observed the highest total and maximum consumption weight. According to Handayani et al. (2020), it is believed that the observed outcome is a result of the adequate nitrogen content, which is believed to enhance the growth of kale plants by increasing their height, leaf count, and root development. The gross weight and consumption weight of plants are impacted by variables such as plant height, leaf count, and leaf area. In line with Devina's assertion (2012), it is suggested that an increased quantity of leaves, leaf area, and plant height will lead to heightened photosynthate production, consequently augmenting the overall fresh weight of the plant. Harjoko (2019) noted that plant organs contain varying assimilates and relative water content, leading to plant wet weight appearance disparities. When they are wet, plants' weight is influenced by the dimensions of their organs and the degree of moisture present within the plant parts that the roots have taken up.

Table 5. Effect of eco-enzymes on gross weight, consumption weight and root length of Kale

Treatment	Gross Weight (g)	Consumption Weight (g)	Root Length (g)
P0	68.92 ± 15.04 ab	49.00 ± 12.74 ab	33.61 ± 12.77 a
P1	42.13 ± 13.04 ab	33.50 ± 11.95 ab	26.45 ± 11.27 a
P2	40.79 ± 11.29 b	30.46 ± 10.78 b	36.93 ± 13.70 a
P3	38.75 ± 8.49b	26.00 ± 8.90 b	25.20 ± 9.83 a
P4	60.25 ± 14.24 ab	40.58 ± 13.31 ab	31.29 ± 12.16 a
P5	86.83 ± 15.09 a	74.58 ± 16.17 a	35.98 ± 13.21 a

Description: Numbers followed by the same letter in the same column are not significantly different based on the DMRT test at the 5% level.

The treatment of plants with 50 mL of eco-enzyme resulted in the longest root length observed. This outcome can be attributed to enhancing organic compounds in the eco-enzyme, which promotes increased biological activity that interacts favorably with the soil's physical and chemical characteristics, thereby facilitating improved plant root growth (Saifuddin et al., 2021). Additionally, the nitrate content in eco-enzymes has been shown to encourage root growth and development (Tisdale & Nelson, 2020).

Figure 2. Effect of Eco-enzyme Dose on Kale Production

4. Conclusion

The application of different concentrations of eco-enzyme had a notable impact on the height, length of leaves, overall weight, and edible weight of kale plants. However, there was no substantial impact on the number of leaves, width of leaves, and the length of the roots. Applying Eco-enzyme at a rate of 50 mL per plant resulted in the highest levels of kale growth and production, except for the number of kale leaves.

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