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Effectiveness of Eco-Enzyme Fertilizer in Enhancing the Growth of Kailan (*Brassica oleracea* var. *alboglabra*)

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ABSTRACT: Kailan (*Brassica oleracea* var. *alboglabra*) is a leafy vegetable with high economic value whose productivity is strongly influenced by nutrient availability and growing media conditions. Eco-enzyme fertilizer has emerged as a promising environmentally friendly organic fertilizer that may enhance plant growth through the improvement of nutrient availability and biological activity in the growing medium. This study aimed to evaluate the effectiveness of different eco-enzyme fertilizer concentrations in improving the growth of kailan. The research was conducted at the experimental field in Titigalar Hamlet, Baturiti District, Tabanan Regency, Bali, Indonesia. The experiment was arranged in a randomized complete block design (RCBD) with one factor consisting of four eco-enzyme fertilizer concentrations: 0, 50, 100, and 150 mL L^{-1} of water. Each treatment was replicated three times, resulting in 12 experimental units. The observed variables included plant height, number of leaves, leaf area, and leaf chlorophyll content. Data were analyzed using analysis of variance (ANOVA), followed by Tukey's Honestly Significant Difference (HSD) test at the 5% significance level. The results showed that eco-enzyme fertilizer application had a highly significant effect on all observed growth parameters, including plant height, number of leaves, leaf area, and leaf chlorophyll content. Increasing eco-enzyme concentrations enhanced vegetative growth compared with the untreated control. The application of eco-enzyme at 100 mL L^{-1} produced the most favorable vegetative growth, as indicated by superior plant height, leaf number, leaf area, and chlorophyll content. These findings demonstrate that eco-enzyme fertilizer is effective in promoting kailan growth and has considerable potential as an environmentally friendly organic fertilizer to support sustainable kailan cultivation.

KEYWORDS: co-enzyme, kailan, plant growth, organic fertilizer.

INTRODUCTION

Kailan (*Brassica oleracea* var. *alboglabra*) is one of the most important leafy vegetables belonging to the family Brassicaceae and is widely cultivated in many Asian countries because of its high nutritional value and economic importance (Knez et al., 2024). The crop is highly appreciated by consumers due to its tender texture, distinctive flavor, and rich nutritional composition, including vitamins A, C, and K, calcium, iron, dietary fiber, and various antioxidant compounds that contribute to human health. Increasing consumer awareness of healthy diets has led to a continuous rise in the demand for kailan from households, restaurants, hotels, and modern retail markets, making the crop an attractive commodity for commercial vegetable production (Wang et al., 2025).

Despite its promising market potential, kailan productivity in Indonesia remains below its attainable yield. According to Statistics Indonesia (BPS, 2023), the productivity of Brassicaceae leafy vegetables has not yet reached its genetic potential under farmers' cultivation practices. One of the major constraints is the continuous decline in soil fertility caused by the excessive and prolonged use of inorganic fertilizers without adequate incorporation of organic amendments. Long-term dependence on chemical fertilizers may reduce soil organic matter, suppress beneficial soil microorganisms, deteriorate soil biological activity, and ultimately decrease nutrient use efficiency by plants (Sulaminingsih, 2024; Sari, 2024). Consequently, improving soil quality through environmentally sustainable nutrient management has become an important strategy for enhancing kailan productivity.

The application of organic fertilizers has gained increasing attention as an alternative approach for improving crop growth while maintaining soil health. Unlike inorganic fertilizers that mainly supply mineral nutrients, organic fertilizers contribute to improving soil physical, chemical, and biological properties, thereby creating a more favorable environment for plant growth. Among the various organic inputs currently being developed, eco-enzyme fertilizer has emerged as a promising and environmentally friendly organic liquid fertilizer.

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Eco-enzyme is produced through the fermentation of organic household waste, particularly fruit and vegetable residues, mixed with molasses or brown sugar and water in specific proportions. During the fermentation process, various beneficial compounds are generated, including organic acids, enzymes, amino acids, vitamins, minerals, and diverse populations of beneficial microorganisms (Nurlatifah et al., 2022). These bioactive compounds may enhance nutrient availability, stimulate microbial activity in the rhizosphere, improve nutrient cycling, and promote plant growth through increased physiological activity. Furthermore, the utilization of eco-enzyme contributes to the recycling of organic waste into value-added agricultural products, supporting the principles of circular economy and sustainable agriculture.

Several studies have demonstrated the potential of eco-enzyme as an organic fertilizer in horticultural crop production. Salsabila et al. (2024) reported that eco-enzyme application significantly enhanced soil microbial activity, resulting in improved nutrient uptake efficiency by plants. Similarly, Polii et al. (2024) found that eco-enzyme positively affected the vegetative growth of horticultural crops by enhancing physiological processes associated with photosynthesis and nutrient assimilation. In addition, naturally occurring plant growth-promoting substances and bioactive compounds present in eco-enzyme are believed to stimulate cell division and cell elongation, thereby accelerating plant growth and development.

Although eco-enzyme has shown promising results in several horticultural crops, information regarding its application in kailan cultivation remains limited, particularly concerning the optimum concentration required to maximize plant growth. Different concentrations of eco-enzyme may induce different physiological responses because insufficient concentrations may fail to provide adequate stimulation, whereas excessive concentrations may alter nutrient balance or osmotic conditions, thereby reducing plant performance. Determining the most effective concentration is therefore essential to optimize the benefits of eco-enzyme while avoiding undesirable effects on plant growth.

The utilization of eco-enzyme is also consistent with the concept of sustainable agriculture, which emphasizes the efficient use of renewable resources and the reduction of environmental pollution. Recycling household organic waste into eco-enzyme not only decreases the volume of organic waste disposed of in landfills but also reduces dependence on synthetic fertilizers and promotes environmentally friendly crop production systems (FAO, 2021). Consequently, eco-enzyme has considerable potential to become an affordable, sustainable, and locally available organic fertilizer for vegetable cultivation.

Therefore, this study aimed to evaluate the effectiveness of different eco-enzyme fertilizer concentrations in improving the growth of kailan (*Brassica oleracea* var. *alboglabra*) under field conditions. The study further sought to identify the concentration that provides the most favorable vegetative growth based on plant height, leaf number, leaf area, and leaf chlorophyll content. The findings are expected to provide scientific evidence supporting the utilization of eco-enzyme as an environmentally friendly organic fertilizer and to contribute to the development of sustainable kailan production systems.

RESEARCH METHOD

Research Design

This study employed a Completely Randomized Design (CRD) with a single factor to evaluate the effectiveness of different eco-enzyme fertilizer concentrations on the growth of kailan (*Brassica oleracea* var. *alboglabra*).

The treatment factor consisted of four eco-enzyme fertilizer concentrations:

a. E0 = 0 mL L^{-1} of water (control)
b. E1 = 50 mL L^{-1} of water
c. E2 = 100 mL L^{-1} of water
d. E3 = 150 mL L^{-1} of water

Each treatment was replicated three times, resulting in 12 experimental units. Each experimental unit consisted of a plot of kailan plants that received the corresponding eco-enzyme concentration throughout the experimental period.

Research Location and Time

The experiment was conducted from January to February 2026 at the experimental field located in Titigalar Hamlet, Baturiti District, Tabanan Regency, Bali, Indonesia. The study was carried out under open-field conditions representative of vegetable production systems in the highland areas of Bali.

Plant Materials and Equipment

The plant materials consisted of kailan (*Brassica oleracea* var. *alboglabra*) seeds, eco-enzyme solution, soil as the planting medium, water, silver-black plastic mulch (MPHP), and botanical pesticides when required for pest and disease management.

The equipment used included hoes, hand sprayers, rulers, digital balances, a SPAD chlorophyll meter, a leaf area meter, cameras, and computers equipped with Microsoft Excel and IBM SPSS Statistics for data processing and statistical analysis.

Data Sources

The study utilized both primary and secondary data. Primary data were obtained directly from field observations of kailan growth throughout the experimental period. Secondary data were collected from scientific journals, books, government publications, and other relevant literature related to eco-enzyme application, organic fertilization, and kailan cultivation.

Experimental Procedure

The experiment consisted of five consecutive stages.

1. **Seedling Preparation**

Kailan seeds were sown in a nursery until healthy and uniform seedlings were obtained. Seedlings with similar vigor were selected for transplanting into the experimental plots.

2. **Land Preparation and Planting**

The experimental field was cleaned, tilled, and prepared according to the Completely Randomized Design (CRD) layout. Planting beds were established and covered with silver-black plastic mulch (MPHP). Uniform seedlings were transplanted into the prepared plots.

3. **Eco-enzyme Application**

Eco-enzyme fertilizer was applied according to the assigned treatment concentrations (0, 50, 100, and 150 mL L^{-1} of water). Applications were performed at seven-day intervals using a hand sprayer throughout the experimental period.

4. **Crop Maintenance**

All treatments received identical crop management practices, including irrigation, manual weed control, and pest and disease management using environmentally friendly methods whenever necessary.

5. **Data Collection**

Plant growth observations were conducted periodically at 14, 21, 28, and 35 days after transplanting (DAT) to evaluate the effects of eco-enzyme fertilizer on vegetative growth.

Observation Variables

Growth observations were performed throughout the vegetative stage.

The measured variables included:

a. Plant height (cm)
b. Number of leaves
c. Leaf area (cm^2)
d. Leaf chlorophyll content (SPAD)

Plant height was measured from the base of the stem to the highest growing point. Leaf number was determined by counting fully expanded leaves. Leaf area was measured using a leaf area meter, whereas leaf chlorophyll content was determined non-destructively using a SPAD chlorophyll meter.

Data Analysis

Quantitative data were analyzed using Analysis of Variance (ANOVA) based on the Completely Randomized Design (CRD) to determine the effects of eco-enzyme fertilizer concentration on kailan growth.

Whenever significant differences among treatments were detected at the 5% probability level, mean separation was performed using Tukey's Honestly Significant Difference (HSD) test at the 5% significance level.

All statistical analyses were performed using IBM SPSS Statistics, while tables and figures were prepared using Microsoft Excel. The results were subsequently interpreted and discussed according to the objectives of the study.

RESULTS

Significance of the Effect of Eco-Enzyme Fertilizer on the Growth of Kailan Plants

The effect of applying eco-enzyme fertilizer on the growth of kailan plants was evaluated based on the parameters of plant height, number of leaves, leaf area, and leaf chlorophyll content. The results of the analysis of variance (ANOVA) showed that the concentration of eco-enzyme fertilizer had a highly significant effect ($p < 0.01$) on all of the growth parameters observed. These results indicate that the application of eco-enzyme fertilizer was able to significantly increase the vegetative growth of kailan plants compared with the treatment without eco-enzyme application.

The increase in plant height, number of leaves, leaf area, and leaf chlorophyll content is thought to be related to the enzymes, beneficial microorganisms, bioactive compounds, and nutrients contained in the eco-enzyme. These components play a role in increasing soil biological activity, accelerating the decomposition of organic matter, increasing nutrient availability, and optimizing

the physiological processes of the plant. Better nutrient availability promotes cell division and elongation, more optimal leaf formation, expansion of leaf area, and increased chlorophyll synthesis, which plays an important role in the photosynthesis process.

Overall, the results of the study show that eco-enzyme fertilizer is effective in promoting the growth of kailan plants. This effectiveness is reflected in the increase in plant height, number of leaves, leaf area, and leaf chlorophyll content in plants given eco-enzyme fertilizer compared with plants without eco-enzyme application.

Table 1. Significance of the Effect of Eco-Enzyme Fertilizer on the Growth of Kailan Plants (Brassica oleracea var. alboglabra)

Parameter	Eco-Enzyme Fertilizer
Plant height	**
Number of leaves	**
Leaf area	**
Leaf chlorophyll content	**

Notes: *** = Highly significant effect (p < 0.01); * = Significant effect (p < 0.05); ns = Not significant.*

Effect of Treatment on Plant Height (cm)

The effect of eco-enzyme fertilizer application on the growth of kailan plants was evaluated through observation of plant height as one of the main indicators of vegetative growth. The results of the Honestly Significant Difference (HSD) test at the 5% significance level are presented in Table 2.

Table 2. Effect of Eco-Enzyme Fertilizer Concentration on the Height of Kailan Plants

Treatment	Plant Height (cm)
Without eco-enzyme	7.00 b
Eco-enzyme 50 mL L^{-1}	31.78 a
Eco-enzyme 100 mL L^{-1}	36.56 a
Eco-enzyme 150 mL L^{-1}	29.89 a
HSD 5%	9.33

Notes: *Values followed by the same letter within the same column are not significantly different based on the HSD test at the 5% level.*

The results of the analysis of variance showed that the concentration of eco-enzyme fertilizer had a highly significant effect ($P < 0.01$) on the height of kailan plants.

The data in Table 5.2 show that the treatment without eco-enzyme produced the lowest plant height, namely 7.00 cm, which was significantly different from all of the eco-enzyme treatments. The 100 mL L^{-1} eco-enzyme treatment produced the greatest plant height, namely 36.56 cm, although statistically it was not significantly different from the 50 mL L^{-1} (31.78 cm) and 150 mL L^{-1} (29.89 cm) treatments. These results indicate that eco-enzyme application was able to significantly increase the height of kailan plants compared with the treatment without eco-enzyme application. The increase in plant height is thought to be related to the enzymes, beneficial microorganisms, bioactive compounds, and nutrients contained in the eco-enzyme. These components are able to increase soil biological activity, accelerate the decomposition of organic matter, and increase nutrient availability, particularly nitrogen. Adequate nitrogen availability plays a role in chlorophyll formation, protein synthesis, and cell division and elongation, so that the vegetative growth of the plant proceeds more optimally.

Effect of Treatment on Number of Leaves, Leaf Area, and Leaf Chlorophyll Content

The effect of eco-enzyme fertilizer application on the number of leaves, leaf area, and leaf chlorophyll content of kailan plants is presented in Table 3.

Table 3. Effect of Eco-Enzyme Fertilizer Concentration on the Number of Leaves, Leaf Area, and Leaf Chlorophyll Content of Kailan Plants

Treatment	Number of Leaves (leaves)	Leaf Area (cm^2)	Leaf Chlorophyll Content
Without eco-enzyme	1.89 b	1.44 b	8.62 b
Eco-enzyme 50 mL L^{-1}	5.56 a	9.78 a	32.08 a
Eco-enzyme 100 mL L^{-1}	5.67 a	10.56 a	38.61 a
Eco-enzyme 150 mL L^{-1}	5.56 a	10.50 a	34.61 a
HSD 5%	1.54	3.66	8.68

Notes: *Values followed by the same letter within the same column are not significantly different based on the HSD test at the 5% level.*

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1. Number of Leaves (leaves)

The results of the analysis of variance showed that the concentration of eco-enzyme fertilizer had a highly significant effect ($P < 0.01$) on the number of leaves of kailan plants. Based on the results of the HSD test at the 5% level, the 100 mL L^{-1} eco-enzyme treatment produced the highest number of leaves, namely 5.67 leaves, which was not significantly different from the 50 mL L^{-1} (5.56 leaves) and 150 mL L^{-1} (5.56 leaves) treatments, but was significantly different from the treatment without eco-enzyme, which produced only 1.89 leaves. These results indicate that eco-enzyme application was able to increase leaf formation, resulting in better vegetative growth of the plant.

2. Leaf Area (cm^2)

The results of the analysis of variance showed that the concentration of eco-enzyme fertilizer had a highly significant effect ($P < 0.01$) on the leaf area of kailan plants. The 100 mL L^{-1} eco-enzyme treatment produced the largest leaf area, namely 10.56 cm^2, which was not significantly different from the 150 mL L^{-1} (10.50 cm^2) and 50 mL L^{-1} (9.78 cm^2) treatments, but was significantly different from the treatment without eco-enzyme, which produced a leaf area of only 1.44 cm^2. The increase in leaf area indicates that eco-enzyme application was able to stimulate the development of leaf tissue, thereby increasing the surface area available for photosynthesis.

3. Leaf Chlorophyll Content

The results of the analysis of variance showed that the concentration of eco-enzyme fertilizer had a highly significant effect ($P < 0.01$) on the leaf chlorophyll content of kailan plants. Based on the results of the HSD test at the 5% level, the 100 mL L^{-1} eco-enzyme treatment produced the highest leaf chlorophyll content, namely 38.61, which was not significantly different from the 150 mL L^{-1} (34.61) and 50 mL L^{-1} (32.08) treatments, but was significantly different from the treatment without eco-enzyme, which produced only 8.62.

The increase in chlorophyll content indicates that eco-enzyme application was able to increase the synthesis of the green leaf pigment through increased availability of nitrogen and other essential nutrients. Higher chlorophyll content increases the efficiency of light energy capture and the rate of photosynthesis, thereby supporting the vegetative growth of kailan plants more optimally.

DISCUSSION

This study aimed to examine the effectiveness of eco-enzyme fertilizer application on the growth of kailan plants (*Brassica oleracea* var. *alboglabra*). The growth parameters observed included plant height, number of leaves, leaf area, and leaf chlorophyll content. The results of the analysis of variance showed that the concentration of eco-enzyme fertilizer had a highly significant effect on all of the growth parameters observed. These results indicate that eco-enzyme application was able to increase the vegetative growth of kailan plants compared with the treatment without eco-enzyme application.

The increase in plant height resulting from eco-enzyme application is clearly seen from the rise in plant height from 7.00 cm in the treatment without eco-enzyme to 36.56 cm at the 100 mL L^{-1} concentration. This result is consistent with the study by Fadilah and Fevria (2022) on hydroponically cultivated kailan plants, which reported that eco-enzyme application was able to increase plant growth compared with no eco-enzyme application. Eco-enzyme contains various bioactive compounds, enzymes, beneficial microorganisms, and nutrients resulting from the fermentation of organic waste, which are able to increase the availability of nutrients for plants. Gustia et al. (2025) also reported that increasing eco-enzyme concentration up to a certain level was able to increase the growth of kale plants (*Brassica oleracea*), although at higher concentrations this increase began to level off. A similar pattern was also observed in the present study, in which the 150 mL L^{-1} concentration no longer produced a greater plant height than the 100 mL L^{-1} concentration.

The increase in plant height is thought to be related to the increased availability of nitrogen in the soil resulting from eco-enzyme application. Rachman et al. (2025) reported that eco-enzyme application was able to increase total soil nitrogen content, thereby supporting the growth of green mustard and peanut plants on Inceptisol soil. Nitrogen is an essential element in the formation of proteins, enzymes, and chlorophyll, which play an important role in cell division and elongation. Therefore, increased nitrogen availability accelerates the growth of plant tissue, resulting in a significant increase in plant height.

A similar response was also shown by the number of leaves, leaf area, and leaf chlorophyll content. All of these parameters increased significantly in plants given eco-enzyme compared with those without eco-enzyme, with the highest values generally obtained at the 100 mL L^{-1} concentration. Novianto and Bahri (2023) reported that the application of liquid organic eco-enzyme fertilizer to mustard plants (*Brassica juncea* L.) was able to increase vegetative growth through an increase in the number of leaves and leaf area. The macronutrient, micronutrient, and bioactive compound content of eco-enzyme is thought to be able to stimulate the formation of new leaf tissue, resulting in more optimal development of the plant canopy.

The number of leaves increased from 1.89 leaves in the treatment without eco-enzyme to 5.67 leaves at the 100 mL L^{-1} concentration, while leaf area increased from 1.44 cm^2 to 10.56 cm^2 at the same concentration. The increase in the number and area of leaves provides a physiological advantage for the plant because it enlarges the surface area available for photosynthesis. The larger the leaf area formed, the greater the plant's capacity to capture light energy to produce the photosynthates required to support vegetative growth.

The increase in leaf chlorophyll content from 8.62 in the treatment without eco-enzyme to 38.61 at the 100 mL L^{-1} concentration indicates that eco-enzyme plays a role in increasing the photosynthetic activity of the plant. Ichsan and Sulhaswardi (2024) reported that eco-enzyme application was able to increase chlorophyll content, number of leaves, and stomatal development in clove plant seedlings. The increase in chlorophyll content is thought to be related to the increased availability of nitrogen, which is the main constituent element of the chlorophyll molecule. Higher chlorophyll content increases the efficiency of light absorption, so that photosynthesis proceeds more optimally and supports the growth of kailan plants.

Physiologically, the eco-enzyme concentration of 100 mL L^{-1} gave the best response for most of the growth parameters. This indicates that at this concentration, the requirement for nutrients and bioactive compounds was at an optimum level to support cell division, leaf formation, chloroplast development, and chlorophyll synthesis. In contrast, increasing the concentration to 150 mL L^{-1} no longer significantly increased any of the growth parameters. This condition indicates that the plant had reached an optimum point in utilizing the nutrients and active compounds contained in the eco-enzyme, so that a further increase in concentration no longer produced a meaningful increase in growth.

Overall, the results of this study show that eco-enzyme fertilizer is effective in increasing the growth of kailan plants, particularly with respect to plant height, number of leaves, leaf area, and leaf chlorophyll content. This effectiveness is thought to be related to the ability of eco-enzyme to increase nutrient availability, improve soil biological activity, and provide bioactive compounds that support the plant's physiological processes. Based on the results of this study, an eco-enzyme concentration of 100 mL L^{-1} is the most effective concentration for increasing the vegetative growth of kailan plants (*Brassica oleracea* var. *alboglabra*).

CONCLUSION

Based on the results of the research and discussion regarding the effectiveness of eco-enzyme fertilizer in increasing the growth of kailan plants (Brassica oleracea var. alboglabra), the following conclusions can be drawn.

1. The application of eco-enzyme fertilizer had a highly significant effect on the growth of kailan plants, including plant height, number of leaves, leaf area, and leaf chlorophyll content.
2. An eco-enzyme concentration of 100 mL L^{-1} was the most effective concentration for increasing the vegetative growth of kailan plants. At this concentration, the highest plant height, number of leaves, leaf area, and leaf chlorophyll content were obtained compared with the other treatments, although these were not significantly different from the 50 mL L^{-1} and 150 mL L^{-1} concentrations.
3. The application of eco-enzyme fertilizer was proven to be effective as a liquid organic fertilizer in supporting the growth of kailan plants through increased nutrient availability, soil biological activity, and physiological processes related to leaf formation, chlorophyll synthesis, and vegetative growth.

ADVICE

Based on the findings of this study, the following recommendations are proposed:

1. Eco-enzyme fertilizer can be recommended as a liquid organic fertilizer for kailan cultivation, as it has been proven to increase plant growth. Based on the results of this study, a concentration of 100 mL L^{-1} is recommended as the most effective concentration for achieving optimal vegetative growth.
2. Further research is recommended to evaluate the effectiveness of eco-enzyme fertilizer on various kailan varieties, environmental conditions, and soil types, so that broader application recommendations can be obtained.
3. Further research also needs to examine the effect of eco-enzyme fertilizer on other growth and productivity parameters, such as plant biomass, yield, product quality, and changes in the physical, chemical, and biological properties of the soil, so that the mechanism of action of eco-enzyme can be understood more comprehensively.

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REFERENCES

1) Statistics Indonesia (BPS). (2023). *Indonesian horticultural statistics 2023*. Statistics Indonesia.
2) Fadilah, N., & Fevria, R. (2022). Effect of eco-enzyme application on the growth of kailan (*Brassica oleracea* var. *alboglabra*) cultivated hydroponically. *Jurnal Serambi Biologi, 7*(3), 270–274.
3) Food and Agriculture Organization of the United Nations (FAO). (2021). *Sustainable agriculture development guidelines*. Food and Agriculture Organization of the United Nations.
4) Gustia, H., Wulandari, Y. A., Rosdiana, & Putri, D. (2025). Optimizing eco-enzyme dosage on kale (*Brassica oleracea*) growth and production. *Jurnal Agronomi Tanaman Tropika (JUATIKA), 7*(1), 164–169
5) Ichsan, F. M., & Sulhaswardi. (2024). Effect of eco-enzyme and rice husk biochar on the growth of clove (*Syzygium aromaticum* L.) seedlings grown in Red-Yellow Podzolic soil. *Dinamika Pertanian, 40*(3).
6) Knez, M., Mattas, K., Gurinovic, M., Gkotzamani, A., & Koukounaras, A. (2024). Revealing the power of green leafy vegetables: Cultivating diversity for health, environmental benefits, and sustainability. *Global Food Security, 43*, 100816.
7) Novianto, N., & Bahri, S. (2023). Growth and yield response of mustard (*Brassica juncea* L.) to the application of eco-enzyme liquid organic fertilizer. *Jurnal Agrotek Tropika, 10*(2), 1.
8) Nurlatifah, I., Agustine, D., & Puspasari, E. A. (2021). *Production and characterization of eco-enzyme from fruit peel waste*. Proceedings of the International Conference on Sustainable Science and Technology (ICSST 2021), Tangerang, Indonesia.
9) Polii, M. G. M., Tumewu, P., Supit, P. C. H., Loho, A. E., Managanta, A. A., & Sompotan, S. (2025). Effect of Organic Fertilizer Formulation and Eco-Enzyme Application Timing on the Growth and Yield of Cherry Tomato. International Journal of Multicultural and Multireligious Understanding, 12(1), 765-770.
10) Rachman, I. A., Umasugi, B., Aji, K., Hakim, N. F. A., Sofyan, A., & Hasan, A. D. A. (2025). Effect of eco-enzyme application on soil nutrient and plant productivity of green mustard–peanut in Inceptisol. *Kultivasi, 24*(2), 196–205.
11) Salsabila, A. Z., Agustrina, R., Arifiyanto, A., Sumardi, & Saputri, D. A. (2024). Effectiveness of eco-enzyme produced from young Manado kepok banana (*Musa paradisiaca* var. *formatypica*) peel waste as an antimicrobial agent. *BIOSFER: Jurnal Biologi & Pendidikan Biologi, 9*(1), 1134–1145.
12) Sari, W. (2024). *The impact of inorganic fertilizer use on soil fertility across different rice field ages in Ponrang District, Luwu Regency* (Undergraduate thesis). Hasanuddin University, Makassar.
13) Sulaminingsih. (2024). Evaluation of the effectiveness of organic and inorganic fertilizers on rice growth. *Jurnal Review Pendidikan dan Pengajaran, 7*(3).
14) Wang, Y., Miao, H., Zhang, F., Sun, B., & Wang, Q. (2025). Seasonal variation in nutritional substances in varieties of leafy Chinese kale (*Brassica oleracea* var. *alboglabra*): A pilot trial. *Agronomy, 15*(3), 671.