
Effects of Eco-Enzyme Concentrations and Growing Media on the Growth Performance of Pakcoy Microgreens (*Brassica rapa chinensis* L.)

Adellia Novianti, I Gusti Bagus Udayana, I Nengah Muliarta, Made Sri Yuliantini, Ni Luh Putu Sulis Dewi Damayanti, Ni Kadek Desy Andya Dewi^{1*}

¹ Study Program of Agrotechnology, Faculty of Agriculture, Science and Technology, Warmadewa University.

*Corresponding author. Email: desyandya@warmadewa.ac.id

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Abstract

Microgreens are young vegetable seedlings valued for their high nutritional content and rapid growth cycle. Pakcoy microgreens (*Brassica rapa chinensis* L.) have strong potential for sustainable urban agriculture. This study aimed to evaluate the effects of different eco-enzyme concentrations and growing media on the growth performance of pakcoy microgreens. The experiment was conducted using a factorial completely randomized design with two factors: eco-enzyme concentration and growing media type. Several growth parameters were observed, including plant height, number of leaves, fresh weight, and overall growth vigor. The results showed that both eco-enzyme concentration and growing media not significantly influenced the growth of pakcoy microgreens. Higher eco-enzyme concentrations generally promoted better vegetative growth, particularly when combined with suitable growing media. The interaction between eco-enzyme application and growing media played an important role in optimizing microgreen growth performance. These findings indicate that eco-enzyme can be utilized as an environmentally friendly input to enhance pakcoy microgreen production. The use of appropriate growing media further improves growth outcomes, supporting sustainable and efficient microgreen cultivation systems. This study provides practical insights for small-scale growers and urban farmers seeking to improve microgreen productivity using eco-friendly alternatives.

Keywords:

Microgreens; Pakcoy; Eco-Enzyme; Growing Media; Plant Growth.

1. Introduction

The adoption of healthier lifestyles has increased public awareness of the importance of consuming fresh and nutritious vegetables. Food products are no longer valued solely for their basic nutritional function but also for their role in improving overall health quality [1]. This shift has encouraged the development of functional foods, one of which is microgreens. Microgreens are young, immature vegetables harvested at the cotyledon stage, with or without the emergence of the first true leaves. Due to their high nutritional value and short cultivation cycle, microgreens have gained increasing popularity worldwide [2].

Microgreens are easy to cultivate and require minimal space, making them particularly suitable for urban agriculture systems [3]. Microgreens harvested 7–14 days after sowing at a height of 3–10 cm and are often reported to contain higher concentrations of vitamins, antioxidants, and minerals than their mature counterparts. The elevated nutritional content of

microgreens is associated with intense metabolic activity during early growth stages, when catabolic and anabolic processes occur rapidly [4].

Among leafy vegetables, pakcoy (*Brassica rapa chinensis* L.) is a suitable species for microgreen production. Pakcoy belongs to the Brassicaceae family and is characterized by compact growth, thick leaves, and a high nutritional profile. It contains essential nutrients such as vitamins A and C, carbohydrates, proteins, and minerals that contribute to immune system support and antioxidant activity [5]. Vitamin A plays an important role in maintaining eye health, while vitamin C functions as a primary antioxidant that helps protect cells from oxidative stress [6].

Adequate nutrient supply is critical in microgreen cultivation to ensure optimal growth and productivity. Nutrient deficiencies at early growth stages may disrupt physiological processes and reduce biomass accumulation [7]. Liquid organic fertilizers have been increasingly recommended as sustainable nutrient sources for microgreen production due to their rapid nutrient availability and environmentally friendly nature [8]. One promising organic input is eco-enzyme, which is produced through anaerobic fermentation of fruit and vegetable waste. Eco-enzyme contains various enzymes and bioactive compounds, including amylase, protease, and secondary metabolites, which may enhance nutrient availability and plant growth. Previous studies have reported positive effects of eco-enzyme application on plant morphological traits and growth performance [9].

In addition to nutrient inputs, growing media play a crucial role in microgreen cultivation by providing physical support, water, oxygen, and nutrients for root development. Commonly used media such as cocopeat and compost possess favorable properties, including high porosity and water-holding capacity, and are widely applied in microgreen production systems [10]. Therefore, this study aimed to evaluate the effects of different growing media types and eco-enzyme concentrations on the growth and nutritional quality of pakcoy microgreens.

2. Material and Methods

2.1. Research Location and Time

The experiment was conducted in a greenhouse at the Faculty of Agriculture, Science and Technology, Warmadewa University, Denpasar, Indonesia, from August to September 2024. The greenhouse provided controlled environmental conditions, including protection from excessive rainfall and direct environmental disturbances. Temperature and relative humidity were maintained under natural greenhouse conditions suitable for microgreen cultivation. The vitamin C, protein and carbohydrate content were conducted in Laboratory in Faculty of Agriculture, Science and Technology, Warmadewa University.

2.2 Research Design

This study employed a factorial Completely Randomized Design (CRD) consisting of two experimental factors with three replications. The first factor was eco-enzyme concentration, which consisted of three levels: 30 mL eco-enzyme diluted in 970 mL of water (E1), 50 mL eco-enzyme diluted in 950 mL of water (E2), and 70 mL eco-enzyme diluted in 930 mL of water (E3). The second factor was the type of growing media, consisting of cocopeat (M1) and compost (M2). Each treatment combination was randomly assigned to experimental units to minimize environmental bias within the greenhouse. The factorial arrangement resulted in six treatment combinations, with a total of eighteen experimental units. Each experimental unit consisted of one planting tray containing pakcoy microgreens cultivated under uniform greenhouse conditions. Each eco-enzyme

concentration was combined with each growing media type, resulting in six treatment combinations.

2.3 Research Procedure and Variables

Prior to planting, cocopeat was soaked and rinsed to remove tannin content, then dried before use. Both growing media were placed evenly into planting trays. Pakcoy seeds were evenly sown on the surface of the media and watered to maintain moisture. Eco-enzyme solutions were applied by foliar spraying every two days starting from the second day after planting until harvest. The eco-enzyme used in this study was obtained commercially from a local supplier. The product was derived from the fermentation of organic materials, primarily fruit and vegetable waste, and was used according to the recommended dilution for agricultural application. The microgreens were harvested at 10 days after planting when cotyledons and the first true leaves had fully developed. The observed variables included plant height, number of leaves, fresh weight, carbohydrate content, protein content, and vitamin C content of pakcoy microgreens [11].

2.4 Data Analysis

All collected data were subjected to analysis of variance (ANOVA) to determine the effects of eco-enzyme concentration, growing media type, and their interaction on the observed variables. When significant differences were detected, mean separation was performed using the Least Significant Difference (LSD) test at a 5% significance level. Statistical analyses were conducted using appropriate statistical software [12].

3. Result and Discussion

3.1 Result

Based on the analysis of variance, the application of different eco-enzyme concentrations did not result in significant differences in any of the observed variables, including fresh weight, plant height, number of leaves, carbohydrate content, protein content, and vitamin C content (Table 1). This indicates that variations in eco-enzyme concentration did not markedly influence plant growth or nutritional characteristics under the conditions of this study. Similarly, the type of growing medium showed no significant effect on all measured parameters. Plants grown in different media exhibited comparable growth performance and biochemical composition, suggesting that each medium provided a relatively similar environment for plant development. Moreover, no significant interaction between eco-enzyme concentration and growing medium type was detected for any variable. This implies that the effect of eco-enzyme application was consistent across all types of growing media. Overall, these findings indicate that both eco-enzyme concentration and growing medium type did not individually or interactively affect plant growth and nutrient content in this experiment.

Table 1 Significance of the effects of different eco-enzyme concentrations and growing media types on all observed variables.

Variable	Eco-enzym (E)	Medium Type (M)	Interaction (ExM)
Fresh Weight (g)	ns	ns	ns
Plant Heigh (cm)	ns	ns	ns
Number of Leaves	ns	ns	ns
Carbohidra	ns	ns	ns
Protein	ns	ns	ns
Vitamin C	ns	ns	ns

Note: ns indicates non-significant effects ($P \geq 0.05$); ** indicates highly significant effects ($P < 0.01$); * indicates significant effects ($P < 0.05$)

The average plant height of pakcoy microgreens measured at 7 and 14 days after planting (DAP) showed no significant differences among eco-enzyme concentrations (Table 2). Although a gradual increase in plant height was observed with increasing eco-enzyme concentration, ranging from 3.500 to 3.900 cm at 7 DAP and from 6.000 to 7.000 cm at 14 DAP, these differences were not statistically significant. Similarly, fresh weight values were comparable across eco-enzyme treatments. Microgreens treated with 70 ml eco-enzyme tended to have a higher fresh weight (10.823 g) compared to lower concentrations; however, this increase did not differ significantly from the other treatments. The number of leaves remained uniform across all eco-enzyme levels, with an average of two leaves per plant. Regarding growing media, plants grown on cocopeat and compost exhibited similar plant height at both observation times and did not differ significantly. Fresh weight tended to be higher in compost media (12.097 g) compared to cocopeat (7.679 g), yet this difference was not statistically significant. Leaf number was consistent across media types, indicating uniform early vegetative development of pakcoy microgreens under both growing conditions.

Table 2 Average plant height (cm), Fresh Weight and Number of leave of pakcoy microgreens at after sowing under different eco-enzyme concentrations and growing media types.

Treatment	Plant Height (7 DAP)	Plant Height (14 DAP)	Fresh Weigh (g)	Number of Leave
Eco-Enzyme (E)				
E1 (30ml eco-enzyme)	3,500 a	6,000 a	9,387 a	2,000 a
E2 (50ml eco-enzyme)	3,533 a	6,867 a	9,453 a	2,000 a
E3 (70ml eco-enzyme)	3,900 a	7,000 a	10,823 a	2,000 a
Media Tanam (M)				
M1 (Cocopeat)	3,644 a	6,733 a	7,679 a	2,000 a
M2 (Kompos)	3,644 a	6,511 a	12,097 a	2,000 a

Note: Mean values followed by the same letter within the same treatment and column indicate no significant difference at the 5% Least Significant Difference (LSD) test. DAP mean Day After Planting.

Table 3 Carbohydrate, protein, and vitamin C contents of pakcoy microgreens under different eco-enzyme concentrations and growing media.

Treatment	Carbohidrat	Protein	Vitamin C
Eco-Enzyme (E)			
E1 (30ml eco-enzyme)	2,900 a	0,049 a	0,049 a
E2 (50ml eco-enzyme)	3,523 a	0,053 a	0,053 a
E3 (70ml eco-enzyme)	3,422 a	0,050 a	0,050 a
Media Tanam (M)			
M1 (Cocopeat)	3,652 a	0,053 a	0,053 a
M2 (Kompos)	2,911 a	0,049 a	0,049 a

Note: Mean values followed by the same letter within the same treatment and column indicate no significant difference at the 5% Least Significant Difference (LSD) test.

The carbohydrate, protein, and vitamin C contents of pakcoy microgreens were not significantly affected by different eco-enzyme concentrations (Table 3). Carbohydrate content showed a slight increase at the 50 ml eco-enzyme treatment (3.523), followed by a marginal decrease at the higher concentration; however, these variations were not statistically significant. Protein and vitamin C contents also exhibited minimal variation among eco-enzyme treatments,

indicating a relatively stable nutritional composition across all concentration levels. Similarly, the type of growing medium did not significantly influence the nutritional parameters measured. Microgreens grown on cocopeat tended to show higher carbohydrate, protein, and vitamin C contents compared to those grown on compost, but these differences were not significant. The uniformity of protein and vitamin C values across treatments suggests that early-stage pakcoy microgreens maintain consistent biochemical characteristics regardless of growing media.

3.2 Discussion

The present study demonstrated that variations in eco-enzyme concentration and growing media type did not significantly affect growth parameters or nutritional composition of pakcoy microgreens. These findings indicate that, within the tested concentration range and cultivation conditions, eco-enzyme application did not exert a measurable influence on early plant development. Although eco-enzymes are widely promoted as organic inputs containing beneficial microorganisms, enzymes, and organic acids, their agronomic effectiveness remains context-dependent and highly influenced by crop characteristics and growth duration [13].

Microgreens represent a unique production system characterized by a short growth cycle and harvest at an early developmental stage. During this phase, plant growth relies predominantly on endogenous seed reserves rather than external nutrient uptake [14]. This physiological trait may explain the lack of significant response in plant height, fresh weight, and leaf number to eco-enzyme application. Previous studies have similarly reported that nutrient or organic inputs applied during early growth stages often result in limited effects on microgreen biomass accumulation, as metabolic activity is largely regulated by seed-derived resources [15].

Although a gradual numerical increase in plant height and fresh weight was observed at higher eco-enzyme concentrations, these differences were not statistically significant. This suggests that while eco-enzyme application may contribute marginally to plant growth, the magnitude of its effect was insufficient to overcome biological variability within the short cultivation period. Comparable trends have been reported in microgreen studies where organic amendments produced subtle but non-significant improvements in growth parameters [16].

The absence of significant differences between cocopeat and compost growing media further supports the notion that physical growing conditions, rather than nutrient composition, play a more critical role during microgreen cultivation. Cocopeat is known for its favorable physical properties, including high water-holding capacity and good aeration, while compost provides organic matter and nutrients [17]. In this study, both substrates appeared to provide equally suitable conditions for early pakcoy microgreen growth, resulting in comparable plant height, fresh weight, and leaf number. This finding is consistent with previous research indicating that substrate type has a relatively minor effect on microgreen growth when moisture availability and aeration are adequate [17].

Nutritional parameters, including carbohydrate, protein, and vitamin C contents, were also not significantly affected by eco-enzyme concentration or growing media type. Carbohydrates provide energy, proteins support growth and tissue formation, and vitamin C acts as an antioxidant. In microgreens, higher levels of these nutrients are expected to improve nutritional quality rather than directly affect growth. Eco-enzyme is a liquid organic product derived from the fermentation of fruit and vegetable waste, containing enzymes, organic acids, and beneficial microorganisms. It is commonly used as a biofertilizer due to its potential to enhance nutrient availability and support plant growth. Previous studies have reported that eco-enzyme application can improve plant growth and productivity through increased microbial activity and nutrient cycling [18]. However, in short-cycle crops such as microgreens, its effect may be limited due to the short growth period. The observed stability in nutritional composition suggests that biochemical traits of pakcoy microgreens are largely governed by genetic factors and intrinsic metabolic regulation rather than external organic inputs at early growth stages [19]. Several studies have demonstrated that microgreen nutritional quality is more strongly influenced by environmental factors such as light intensity, spectral quality, and harvest timing than by substrate composition or nutrient amendments [20].

The lack of interaction effects between eco-enzyme concentration and growing media indicates that eco-enzyme application did not interact synergistically with substrate properties to influence plant growth or nutrient accumulation. This suggests that, within the tested conditions, eco-enzyme did not substantially alter nutrient availability or uptake dynamics in the root zone. Similar non-interactive responses have been observed in controlled-environment studies evaluating organic liquid inputs in microgreen and leafy vegetable production systems [21].

Beyond the observed growth and nutritional parameters, the effectiveness of eco-enzymes is closely associated with microbial activity and biochemical processes in the rhizosphere. Organic liquid inputs such as eco-enzymes are generally reported to exert indirect effects on plant performance through gradual modification of microbial communities, enzymatic activity, and nutrient transformation rather than providing immediately available nutrients. In short-cycle crops like microgreens, however, the limited cultivation period may not allow sufficient time for microbial populations to establish and function optimally. Consequently, the potential benefits of eco-enzymes related to enhanced nutrient mineralization or microbial-mediated nutrient availability may not be fully expressed at the early harvest stage [22].

The effectiveness of eco-enzyme application is also influenced by the method and timing of application relative to plant developmental stages. Previous studies have shown that different application approaches, including soil drenching, foliar spraying, and seed treatment, can result in varying physiological responses depending on root development and nutrient uptake capacity. In microgreen production systems, root structures remain shallow and relatively underdeveloped, which may limit the interaction between applied eco-enzymes and active nutrient absorption sites. This condition may partly explain the absence of significant treatment effects in the present study and highlights the importance of application strategy when evaluating organic biostimulants for microgreen cultivation [23].

In addition, the controlled and relatively uniform environmental conditions commonly used in microgreen production may reduce the expression of treatment-induced differences. Under optimal temperature, moisture, and nutrient conditions, plant growth is less constrained by external limitations, potentially masking subtle effects of organic inputs. Several studies have demonstrated that the positive impacts of biostimulants and organic amendments are more pronounced under stress conditions, such as nutrient limitation or environmental stress, where plants exhibit greater responsiveness to external stimuli. The lack of significant response to eco-enzyme application in this study may therefore reflect favorable growth conditions rather than an absence of biological activity [24].

Genetic and physiological characteristics of pakcoy microgreens may further contribute to their limited responsiveness to external organic inputs during early growth stages. Pokcoy microgreens are known for their efficient utilization of seed reserves, enabling rapid biomass accumulation shortly after germination. This intrinsic physiological efficiency may reduce dependence on exogenous nutrient sources during the early developmental phase. As a result, the influence of eco-enzymes on growth and nutritional attributes may become more evident only at later growth stages or in longer cultivation systems [25].

Taken together, these considerations suggest that the role of eco-enzymes in microgreen production is strongly context-dependent and influenced by crop physiology, cultivation duration, application method, and environmental conditions. While eco-enzymes may offer potential benefits in more complex or prolonged cropping systems, their immediate impact on early-stage pakcoy microgreens appears limited. Further studies incorporating longer growth periods, varied application strategies, and environmental or nutritional stress conditions are warranted to better elucidate the functional role of eco-enzymes in sustainable horticultural production [26].

Future research should explore extended cultivation periods, higher application frequencies, or different application methods to better assess the potential effects of eco-enzyme on plant growth and nutrient accumulation. Additionally, integrating eco-enzyme application with optimized light management or microbial inoculants may provide further insights into its role within sustainable microgreen production systems.

4. Conclusion

The application of different eco-enzyme concentrations and growing media types did not significantly affect the growth or nutritional quality of pakcoy microgreens. All observed parameters, including fresh weight, plant height, number of leaves, carbohydrate content, protein content, and vitamin C content, showed no significant differences among treatments. These results suggest that the short growth cycle of microgreens and the reliance on seed nutrient reserves limit the effectiveness of organic inputs such as eco-enzyme and organic growing media. Although no significant effects were observed, eco-enzyme remains a potential environmentally friendly input for sustainable microgreen cultivation. Further studies are recommended to explore longer cultivation periods, alternative application methods, or higher nutrient availability to enhance microgreen growth and quality.

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