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Research Article

Eco-enzyme and mushroom bag-logs waste stimulate production and nutrients content of celery microgreen (*Apium graveolens* L.)

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ABSTRACT

Celery microgreen is celery harvested at a young stage, which is a suitable production model to support urban farming. The study aimed to investigate the potential use of eco-enzyme and oyster mushroom media waste (bag-logs waste) on the growth of celery as microgreen. The present study employed a fully randomized factorial design comprising two factors. The first factor was the dosage of eco-enzyme (E): 0.5, 15, and 25 mL L^{-1} of water, while the second factor was the dosage of bag-log waste (L): 0.50, 100, and 150 g/tray. The variables that were assessed included wet weight, fresh economic weight, longest root length, root volume, moisture content, vitamin C, Mg, and Ca levels. The data were subjected to ANOVA analysis and subsequently followed by the application of the HSD test at a significance level of 5%. The findings indicated that there was a substantial interaction between the eco-enzyme and bag-log waste in all observed parameters. The best treatment was the combination of eco-enzyme at a concentration of 25 mL L^{-1} and bag-log waste at a rate of 150 g/tray. The eco-enzyme treatment exhibited a significant impact on all observed parameters, with the most effective treatment being the application of 25 mL L^{-1}. The bag-log waste application affected all measured parameters with 150 g/tray yielding the most favorable results. Therefore, eco-enzymes and bag-log waste have the potential as growing media for celery microgreen cultivation.

Keywords: celery, healthy food, organic farming, urban farming, zero waste

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INTRODUCTION

Urban farming refers to the practice of utilizing limited spaces in residential areas for agricultural purposes, with the aim of promoting community-based initiatives that enhance food security for families (Andini et al., 2021). Among the several strategies employed to facilitate urban farming, the cultivation of microgreens has emerged as a noteworthy approach (Kesawarni, 2020).

Microgreens are harvested-young stage of vegetables or grain sprouts that are cultivated as functional food crops with the objective to promote global food diversification, facilitate adaptation to urbanization and climate change, and enhance health outcomes (Rauniyar & Karki, 2023). These microgreens possess a higher concentration of bioactive compounds, including pigments, enzymes, and vitamins, compared to their mature counterparts, along with other phytochemical compounds (Saleh et al., 2022). This phenomenon occurs due to the lack of utilization of the current chemicals for differentiation by other plant organs (Samuoliene et al., 2016). According to Weber (2016), microgreens exhibit a higher degree of environmental sustainability in comparison to conventional farming practices due to their reduced reliance on fertilizers, pesticides, and other chemical inputs.

In terms of cultivation, microgreens exhibit superior suitability for indoor cultivation due to their ability to thrive without the need for direct exposure to sunlight. Celery has been identified as a viable plant species for microgreen cultivation (Kalal et al., 2021). Celery microgreen is commonly utilized to enhance the visual appeal, flavor, and consistency of a diverse range of culinary preparations, including salads, soups, sandwiches, juices, and as a garnish for various main courses that are intended for consumption. Celery exhibits several significant functional features, including anti-rheumatic, antispasmodic, diuretic, hypotensive, and anti-inflammatory effects (Azizah & Darsono, 2023; Mashine et al., 2023; Simamora et al., 2021; Sohrabi et al., 2021). According to Xiao et al. (2019), the extensive range of advantages and applications associated with celery highlights the substantial potential for business ventures in microgreen celery production.

Enhancing the quality of celery microgreens can be achieved by implementing a fertilizer application. The utilization of environmentally sustainable and proper fertilizer applications, such as organic systems, is strongly encouraged. One potential alternative fertilizer for such purpose is eco-enzyme as proposed by Babalar et al. (2023). Eco-enzyme is a solution containing acetic acid (H_3COOH), which has antibacterial capabilities that can effectively combat germs, viruses, and bacteria. The enzymes contain lipase, trypsin, and amylase, have the ability to hold the proliferation of pathogenic microorganisms. Eco-enzymes possess hydrolytic enzymes that exert a substantial impact on soil health, hence serving as plant growth boosters (Mar'ah & Farma, 2021). Eco-enzymes also include nitrogen in the form of nitrate (NO_3), which serves as a readily absorbable nutrient for plants (Natasya et al., 2023).

On the other side, bag-log of oyster mushroom planting substrate is abundant in some regions like Riau Province after the success of intensification of mushroom production. The bag-log waste is usually dumped by cultivators of mushrooms or simply used as fertilizers on the farm. The bag-log media is composed of 68.5% sawdust, 13.5% fine rice bran, 0.5% gypsum ($CaSO_4$), 3.5% lime ($CaCO_3$), and 0.5% triple superphosphate (TSP). The utilization of bag-log waste has potential benefits and affordable media for promoting plant growth in celery microgreen. This is attributed to the presence of nitrogen (N) components in the form of ammonium or nitrate, as well as N-organic compounds (Fiana et al., 2022).

Recently, sustainable production in agriculture has become an important issue. Many efforts have been made to cope with such issues including the manipulation of growing media in plant cultivation. Abul-Soud et al. (2019) study deep water culture (DWC) and straightforward soilless cultivation method that has the potential to significantly contribute to the ecological production of green vegetables, including lettuce and celery. The findings of the study conducted by Deepa & Malladadavar (2020) showed that the utilization of a growing medium consisting of cocopeat and 15 mL of eco-enzyme resulted in the highest levels of chlorophyll content and the lowest bacterial contamination of wheatgrass microgreen. In general, media with high sterility and low fungal or bacterial contamination is desirable. Furthermore, the findings of a study conducted by Mar'ah and Farma (2021) indicated that the application of eco-enzyme derived from discarded papaya and pineapple skin has a positive impact on the growth of ground kale (*Ipomoea reptans*), including an increase in plant height, number of leaves, and fresh weight of spinach.

According to the findings of Wulandari & Hartatik (2022), the application of bag-log waste has a positive effect on plant height, leaf count, blossom count, root length, as well as dry and fresh weight of chickpeas (*Phaseolus vulgaris* L.). Moreover, the findings of Sinaga et al. (2015) demonstrated that the utilization of compost derived from bag-log waste applied at a rate of 100 g per polybag stimulates chili growth. Thus, the study aimed to investigate the potential use of eco-enzyme and oyster mushroom media waste (bag-logs waste) on the growth of celery as microgreen.

MATERIALS AND METHODS

Research site

The present study was conducted at the Greenhouse of the Faculty of Agriculture and the basic chemistry laboratory of Universitas Islam Riau, Riau Province, Indonesia. The four-month research was started from February 2023 to May 2023.

Research materials

Eco-enzyme is a liquid substance that is derived through the process of fermenting organic waste generated in domestic kitchens. Eco-enzyme is made from the peels of fruits and unprocessed remnants of vegetables, such as onion skins, plus brown sugar, and water, in a proportionate ratio of 1:3:10. The mixture was incubated in a sealed container. After three months, the liquid was filtered and ready to use as an eco-enzyme.

The ingredients employed in this investigation encompassed celery seed of the Amigo cultivar, topsoil, eco-enzyme, oyster mushroom media waste, aquades, 0.01 N iodine, 1% amilum, and potassium iodide (KI). The equipment utilized in this research comprised analytical balances, rulers, hand payers, research banners, plant tray weighing 1,000 g, plywood measuring 4.80 meters, saws, nails, scissors, mortar, paper labels, glass beakers, Erlemneyer flasks, cups, ovens, blenders, measuring cups, volume pipettes, droppers, a set of titration tools, as well as stationery and a camera.

Research design

The research study had a completely randomized design with two factorial factors. The initial element examined in this study was eco-enzyme (E), which consisted of four treatment levels: E0: Without eco-enzyme; E1: Concentration eco-enzyme 5 mL L^{-1} of water; E2: Concentration eco-enzyme 15 mL L^{-1} of water; and E3: Concentration eco-enzyme 25 mL L^{-1} of water. The second factor investigated was oyster mushroom media waste (L), also with four treatment levels: L0: Without bag-log waste; L1: Bag-log waste 50 g/tray; L2: Bag-log waste 100 g/tray; and L3: Bag-log waste 150 g/tray.

The tray had a volume capacity of 1,000 g. The media is basically derived from topsoil, in the case of without bag-log waste. The baglog waste was applied once at one week before planting. The experimental unit consisted of six planting pots, with an additional four planting pots designated for use as samples. Consequently, a total of 16 treatment combinations were formed, each replicated three times. This resulted in a total of 48 experimental units, which were distributed over 288 planting trays.

The celery seeds were sown directly on a tray. The eco-enzyme was applied three times: 7, 14, and 21 days after planting (DAP). The method of application involved spraying the eco-enzyme in the vicinity of the plant roots.

The harvesting of celery microgreens typically occurs 30 days after germination, during the emergence of a pair of juvenile leaves. The harvesting was done including the stem portion close to the media surface (about 2 mm from the media surface).

The variables evaluated included fresh weight, marketable fresh weight, longest root length, root volume, water content, vitamin C content, Mg and Ca content. The determination of Vitamin C content was conducted through the utilization of the titration method, whilst the quantification of Mg and Ca used AAS (Atomic Absorption Spectrophotometer). The observations and data collecting was conducted at the harvest age, specifically 30 days post-harvest.

Data analysis

The collected data was subsequently analyzed using ANOVA with the R Studio application for data processing. Further examination of statistically significant variations at a 5% significance level. If the calculated F was greater than the F table then the analysis proceeded with Tukey's honestly significant difference (HSD) test at the 5% level.

RESULTS AND DISCUSSION

Fresh weight

The fresh weight of celery microgreens from different treatments is presented in Table 1. The treatment combination that yielded the highest plant wet weight of 63.16 g was identified as E3L3. According to Rambey et al. (2018), it was found that the concentration of potassium in bag-log waste was significantly elevated, reaching a level of 45%. The presence of potassium in plants is crucial for enhancing their moist weight due to its critical role in the process of photosynthesis. Furthermore, the application of eco-enzymes has been found to enhance the metabolic processes in celery plants. Specifically, the presence of nitrogen in the form of nitrate (NO_3) within eco-enzymes serves as a crucial component for protein synthesis. Additionally, enzymes have a pivotal function in promoting the division of meristem tissue, as well as stimulating the growth of roots and the development of leaves (Saifuddin, 2010).

Table 1. Average fresh weight (g) of celery microgreen treated with eco-enzyme and bag-log waste.

Eco-enzyme	Bag-log waste (g/tray)				Average (g)
(mL L^{-1} air)	0 g (L0)	50 g (L1)	100 g (L2)	150 g (L3)	
0 (E0)	41.91d	44.33d	45.33cd	47.75cd	44.83b
5 (E1)	42.58d	44.66cd	42.66d	49.00cd	44.72b
15 (E2)	43.91d	47.16cd	47.91cd	46.91cd	46.47b
25 (E3)	49.16cd	51.75bc	56.91ab	63.16a	55.25a
Average	44.39c	46.97bc	48.20b	51.7a	
CV = 5.12%		HSD E&L = 2.17		HSD ExL = 7.44	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the honestly significant difference test (HSD) at the 5 % level. HSD E&L is for each main factor while HSD ExL is for interaction.

Marketable fresh weight

The findings from the examination of the economic fresh weight of celery microgreens, followed by the application of the honestly significant difference (HSD) test at a significance level of 5%, indicated that the use of eco-enzyme and oyster mushroom media waste significantly influenced the economic fresh weight characteristics of the plants. Figure 1 and Table 2 present the average outcomes of the economic fresh weight measurements conducted on microgreens of celery plants, after subsequent testing using the HSD method at a significance threshold of 5%.

a b

Figure1. Comparison of marketable fresh weight celery microgreen, (a). E0L0 30 g/tray, (b). E3L3 77 g/tray.

Table 2. Average marketable fresh weight of celery microgreen treated with eco-enzyme and bag-log waste (g).

Eco-enzyme (mL L^{-1} air)	Bag-log waste (g/tray)				Average
	0 (L0)	50 (L1)	100 (L2)	150 (L3)	
0 (E0)	34.91f	37.33ef	38.33ef	40.75def	37.83c
5 (E1)	37.58ef	39.66ef	37.66ef	44.00cde	39.72c
15 (E2)	39.91def	43.16cde	43.91cde	42.91cde	42.47b
25 (E3)	47.16cd	49.75bc	54.90ab	61.16a	53.25a
Average	39.89c	42.47bc	43.70b	47.20 a	
CV = 5.65%		HSD E&L = 2.71		HSD ExL = 7.44	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the honestly significant difference test (HSD) at the 5 % level.

Table 2 presents the primary interaction and impact of eco-enzyme and bag-log waste. The treatment that yielded the highest economic fresh weight was the eco-enzyme treatment with a concentration of 25 mL L^{-1} water (E3) and the use of 150 g of ba-log waste per tray (L3). This particular treatment resulted in a marketable fresh weight of 61.16 g. Here, the utilization of organic fertilizers in plant cultivation has been found to yield several benefits, including enhanced nutrient content in the soil, improved soil structure, and stimulation of soil microorganisms. Adequate application of organic fertilizers has been observed to promote photosynthesis in plants, thereby optimizing physiological processes and maximizing plant productivity.

According to Salim (2023), the utilization of Eco-enzyme and bag-log waste has a significant impact on the growth and development of celery microgreens, particularly in the production of leaves. The role of nitrogen in plants is to promote the development of foliage and stems. Consequently, plants that exhibit stem and leaf growth benefit from nitrogen, as it is assimilated by plant roots in the form of NO_3- and NH_4+. According to Panataria et al. (2022) the application of liquid organic fertilizer including nitrogen-containing eco-enzymes and protein-breaking enzymes during the process of fertilization has the potential to enhance root development and augment phosphorus levels in plants.

Longest root length

Table 3 demonstrates a noteworthy correlation between the primary interaction and impact of eco-enzyme and oyster mushroom media waste on the mean length of the longest root observed in celery microgreen plants. The eco-enzyme treatment with a concentration of 25 mL L^{-1} water (E3) and the addition of 150 g of oyster mushroom baglog waste per tray (L3) exhibited the highest recorded root length of 6.36 cm. This result was found to be statistically similar to the E3L2 treatment, but significantly different from all other treatments. The treatment that exhibited the shortest root length was E0L0, which refers to the absence of eco-enzyme and oyster mushroom media waste addition. The recorded root length for this treatment was 2.19 cm.

Table 3. Average longest root length (cm)of celery microgreen treated with eco-enzyme and bag-log waste.

Eco-enzyme (mL L^{-1} air)	Bag-log waste (g/tray)				Average
	0 (L0)	50 (L1)	100 (L2)	150 (L3)	
0 (E0)	2.19f	2.66ef	3.00ef	3.00ef	2.71c
5 (E1)	2.80ef	2.97ef	3.04e	3.13e	2.98c
15 (E2)	3.27e	3.47de	4.24cd	4.49c	3.87b
25 (E3)	4.67c	5.54b	6.04ab	6.36a	5.65a
Average	3.23c	3.66b	4.00a	4.25a	
CV = 7.14 %		HSD E&L = 0.30		HSD ExL = 0.83	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the honestly significant difference test (HSD) at the 5 % level.

The study conducted by Jaya et al. (2020) revealed that the provision of suitable nutrients has had a positive impact on root development, thereby affecting the absorption of water and nutrients. The observed rise in levels can also be ascribed to the existence of organic matter within eco-enzymes, which possess the ability to augment the composition of the planting substrate. Eco-enzymes exert influence on the availability of soil N, overall N content, and K levels. The concentration N in bag-log media was 0.6%, and P was 0.7%. Indrayani et al. (2021) established a favorable association between the number of plant roots and the efficiency of nitrogen nutrient absorption. Moreover, plants that possess a greater quantity of roots tend to demonstrate enhanced quality.

Root volume

Table 4 displays the outcomes of the further tests conducted on root volume, specifically employing the HSD test at a significance threshold of 5%. The results indicate that both the interaction effect and the main effect of administering eco-enzyme and using bag-log waste have a substantial impact on the root volume.

According to the data presented in Table 4, it is evident that the eco-enzyme treatment combination of 25 mL L^{-1} water and 150 g bag-log waste (E3L3) exhibits the highest root volume of 9.75 cm^3. This value is not significantly different from the root volumes observed in the E3L2 and E3L1 treatments. However, it is significantly different from the root volumes observed in the other treatments. In the lowest treatment combination, the root volume was observed to be highest in E0L0, with an average of 4.00 cm^3. This value was not found to be substantially different from the root volumes observed in the E1L0, E1L1, and E2L0 treatments. However, it was found to be considerably different from the root volumes observed in the remaining treatments.

Table 4. Average volume (cm^3) of microgreen roots of celery plants treated with eco-enzyme and bag-log waste.

Eco-enzyme (mL L^{-1} air)	Bag-log waste (g/tray)				Average
	0 (L0)	50 (L1)	100 (L2)	150 (L3)	
0 (E0)	4.00f	4.25ef	4.33ef	4.33ef	4.22c
5 (E1)	4.25ef	4.16f	4.50ef	5.25def	4.54c
15 (E2)	4.25ef	5.00ef	5.5de	6.33cd	5.27b
25 (E3)	6.50cd	7.25bc	8.33b	9.75a	7.95a
Average	4.75c	5.16c	5.66b	6.41a	
CV = 7.59 %		HSD E&L = 0.46		HSD ExL = 1.27	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the honestly significant difference test (HSD) at the 5 % level.

According to the findings of Tan et al. (2020), it was demonstrated that eco-enzymes serve as a source of nitrogen (N) for plants, specifically in the form of nitrates. Consequently, plants are relieved of the need to further convert these nitrates. The nitrogen element is involved in the promotion of root development by supplying essential nitrogen elements that contribute to the formation of a robust root system. The element N is involved in facilitating the process of carbohydrate-to-protein conversion, hence influencing the growth and development of celery microgreen roots through mechanisms such as division, elongation, and enlargement (Sreenivasan, 2020).

The utilization of bag-log waste can contribute to the enhancement of nutrient N availability, hence promoting root enlargement. Additionally, the substantial potassium content present in this waste material can serve as a stimulant for the growth of micro-green celery roots. Potassium is involved in various physiological processes within plants, including its participation in photosynthetic enzymes, glucose translocation, and CO_2 absorption at the stomata of leaves (Novitasari et al., 2020). Cozma et al. (2022) and stated that celery, a root vegetable, has been highly regarded since ancient times for its abundance of antioxidants and important vitamins, making it a valuable component of a healthy diet with potential therapeutic benefits. Considered a valuable source of vitamins, antioxidants, colors, tastes, organic acids, and tanning compounds, this cuisine is also rich in essential minerals such as Na, K, Ca, Mg, P, Fe, Zn, and Cu. Therefore, Ozcan et al. (2023) found that the leaves of celery exhibited the highest concentration of microelements, followed in a declining order by the head of celery, outside of celery body, interior of celery body, and root. Due to these properties, it is regarded as a medicinal food.

Water content

The results of observing the water content of microgreens in celery plants after HSD test at the 5% level can be seen in Table 5. Table 5 demonstrates that the interaction between eco-enzyme and bag-log waste has a statistically significant impact on the water content of celery microgreen plants. Specifically, the treatment involving eco-enzyme at a concentration of 25 mL L^{-1} water (E3) and oyster mushroom media waste at 150 g (L3) resulted in the highest water content parameter, measuring 19.58%. This value is significantly different from the water content observed in other treatments. In contrast, the treatment combination lacking eco-enzyme (E0) and bag-log waste (L0) exhibited the lowest recorded water content, measuring 4.83%.

Table 5. Average water content (%) of celery microgreen treated with Eco-enzyme and bag-log waste

Eco-enzyme (mL L^{-1} air)	Bag-log waste (g/tray)				Average
	0 (L0)	50 (L1)	100 (L2)	150 (L3)	
0 (E0)	4.83a	4.91a	5.41a	6.33a	5.37a
5 (E1)	7.25ab	8.75b	9.08b	12.83c	9.47b
15(E2)	13.08cd	14.08cd	14.58cde	15.16cde	14.22c
25 (E3)	15.41cde	15.91de	17.33ef	19.58f	17.06d
Average	10.14a	10.91ab	11.60b	13.47c	
CV = 8.58 %		HSD E&L = 1.10		HSD EL = 3.01	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the honestly significant difference test (HSD) at the 5 % level.

The diminished water content observed in celery microgreen plants under the E0L0 or control treatment can be attributed to the lack of essential nutrients. Consequently, these plants solely relied on the nutrients present in the soil, resulting in sluggish and stunted growth. As a consequence, cell formation and plant weight gain were suboptimal (Waterland et al., 2017). This finding aligns with the viewpoint expressed by Pant et al. (2023), who suggest that water content in food is frequently linked to its stability index, particularly during storage. An elevated water content facilitates the proliferation of bacteria, fungi, mold, and yeast, leading to alterations in the composition of the meal.

Vitamin C content

Table 6 presents the outcomes of the analysis conducted on Vitamin C microgreens in celery plants, following additional testing using the Bonferroni-Dunn's test at a significance level of 5%. The results indicate that the utilization of eco-enzyme and bag-log waste has a significant impact on the Vitamin C parameters of celery microgreens, both in terms of interaction and main effects.

Table 6. Average vitamin C (%) content of celery microgreen treated with eco-enzyme and bag-log waste (%).

Eco-enzyme (mL L^{-1} air)	Mushroom media waste (g/plant's tray)				Average
	0 (L0)	50 (L1)	100 (L2)	150 (L3)	
0 (E0)	10.74f	11.23f	11.53f	11.64f	11.28d
5 (E1)	11.69f	12.05f	13.62ef	16.29de	13.41c
15 (E2)	14.15ef	16.57de	18.88d	23.27c	18.22b
25 (E3)	25.13c	31.74b	34.35b	38.82a	32.51a
Average	15.43d	17.9c	19.59b	22.5a	
CV = 5.99 %		HSD E&L = 1.25		HSD EL = 3.44	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the honestly significant difference test (HSD) at the 5 % level.

Table 6 demonstrates a notable correlation between the primary interaction and impact of Eco-enzyme and oyster mushroom media waste on the Vitamin C composition of celery microgreens. The eco-enzyme treatment with a concentration of 25 mL L^{-1} (E3) and 150 g bag-log waste (L3) exhibited the highest Vitamin C content, reaching 38.82%. This value was found to be substantially different from the other treatments. In contrast, the combination lacking eco-enzyme (E0) and bag-log waste (L0) exhibited the lowest Vitamin C content at 10.74%. This value was determined to be statistically similar to the treatments E1L0 and E1L1, but considerably distinct from the remaining treatments.

According to the findings of Reddy et al. (2021), the consumption of a small quantity of celery microgreens can provide a significant amount of vitamin C, hence satisfying the requirement for antioxidant components. Incorporating raw microgreens into one's diet not only ensures freshness but also mitigates the depletion of essential bioactive elements, including vitamins and pigments, which are crucial for maintaining optimal bodily functions. The significant presence of vitamin C in celery microgreens is inherently linked to the utilization of organic growing media, specifically oyster mushroom media waste, as well as the application of liquid organic fertilizer, notably Eco-enzyme. The macro-nutrient that influences the vitamin C content of microgreen celery in organic fertilizers is K. Therefore Kong et al. (2020), stated that there is a positive correlation between the K value and the vitamin C content, indicating that when the K value increases, the vitamin C content also increases.

Li et al. (2010) stated that the presence of substantial interactions between the element P and the levels of Ca and Mg in the growing media. The application of P at a dosage of 124 mg L^{-1} resulted in a considerable increase in various parameters of celery growth, including above-ground fresh weight, total dry biomass, leaf area, as well as the concentrations of P, Ca, and Mg in celery leaves. Contrasting patterns were noted in the root/shoot ratio, leaf chlorophyll, carotenoids, soluble protein, soluble sugar, vitamin C, N, and K content in celery leaves. The celery plants exhibited a notable increase in above-ground fresh weight, total dry biomass, and leaf area when exposed to medium levels of calcium (320 mg L^{-1}) and magnesium (192 mg L^{-1}), as compared to both low levels (160 mg L^{-1} Ca and 96 mg L^{-1} Mg) and high levels (640 mg L^{-1} Ca and 384 mg L^{-1} Mg).

Magnesium content

The findings about the Mg concentration (%) in celery microgreens are presented in Figure 2.

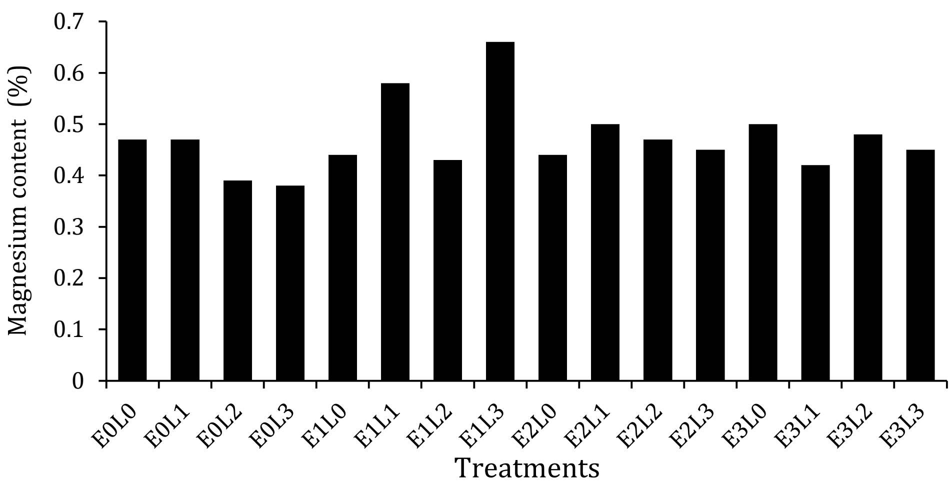

Figure 2. The calcium content of microgreen in each treatment.

Figure 2 illustrates the impact of the combined application of Eco-enzyme and oyster mushroom media waste on the magnesium content of microgreens in celery plants. The combination of eco-enzyme treatment at a concentration of 5 mL L^{-1} water (E1) and 150 g of bag-log waste (L3) exhibited the highest magnesium content, measuring at 0.66%.

This finding was statistically distinct from the magnesium content observed in other treatments. The treatment without eco-enzyme (E0) injection and 150 g (L3) bag-log waste exhibited the lowest magnesium level, measuring 0.38%. There is no significant difference observed between the E0L3 and E3L3 therapies. However, it is important to note that this approach exhibits notable distinctions when compared to alternative therapeutic interventions.

According to Sharma et al. (2020), there exists a strong correlation between the Mg content found in plants and the mineral content present in the soil. Thus, the Mg content of celery microgreens may be influenced by the planting media. There is a positive correlation between the nutrient content of the planting medium and the mineral yield of the plants. The insufficiency of nutrients in the soil can result in a depletion of magnesium levels in the leaves. This observation aligns with the findings of Fitriani et al. (2019), who conducted a study on the Mg content of celery microgreens using nascent leaves. It has been established that young leaves exhibit a higher rate of photosynthesis compared to mature leaves. The magnesium content in leaves exhibits variation, with young leaves often containing lower levels of magnesium compared to mature or old leaves

Calcium content

The findings about the calcium content (%) in celery microgreens, obtained by analysis conducted at the laboratory of central plantation services, are visually shown in Figure 3.

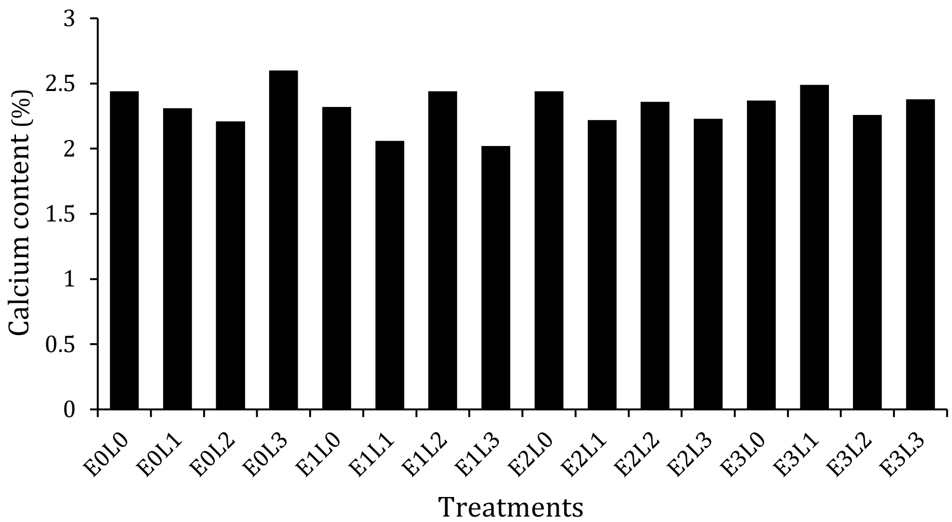

Figure 3. The calcium content of microgreen in each treatment.

Figure 3 shows that among the treatment combinations, the highest Calcium content of microgreens was observed in the treatment combination without eco-enzyme treatment and 150 g bag-log waste (E0L3), with a value of 2.60%. This value was significantly different from the other treatments. Conversely, the lowest Calcium content was found in the treatment combination of Eco-enzyme treatment with 5ml/l water and 150 g bag-log waste (E1L3), with a value of 2.02%. This value was not significantly different from the E1L0 treatment, but significantly different from the other treatments.

The age of the plant has an impact on the concentrations of calcium ions. There is a positive correlation between the plant age and the concentration of Ca in its organs. The calcium yields observed in this study were found to be relatively low. According to Valsikova et al. (2016), a notable disparity was seen in the vitamin C content of parsley and celery when comparing the fresh herbs with those subjected to post-harvest treatments, specifically drying and freezing. Following the processing of herbs in both examined species, it was discovered that the vitamin C content saw a drop. Specifically, in the case of freezing, the vitamin C content was reduced by around 65% for celery and 61% for parsley. Similarly, after the drying process, the vitamin C content decreased by about 86% for celery and 82% for parsley, when compared to the fresh herb. In the case of both selected species, the influence of processing on vitamin C concentration was shown to be more significant than the effect of variation. According to the findings of Kamchan et al. (2004), the bioavailability of calcium in plant meals may be restricted by the presence of inhibitory substances, particularly oxalate, when present at elevated or moderate concentrations.

This might potentially be attributed to the underdevelopment of plant roots, which may have been caused by the compaction of the planting media. The application of bag-log waste 150 g/tray (L3) can consequently compaction of the planting media, the obstruction of calcium nutrient uptake by root interception may have occurred. The elevated temperature conditions within the greenhouse accelerate the transpiration process. However, due to the limited quantity of water that can be transpired, the concentration of dissolved calcium transported through mass flow by transpiration water decreases. Consequently, the concentration of calcium in plant tissue also decreases following the calcium concentration within the greenhouse. The solubility of the substance in water that is transported through transpiration has been observed by (Prasad & Shivay, 2020).

CONCLUSIONS

The interaction between eco-enzyme and bag-log waste was significant on plant fresh weight, marketable fresh weight, longest root length, root volume, water content, vitamin C content, calcium content, and magnesium content. The most effective treatment was the utilization of a combination of eco-enzyme treatment at a concentration of 25 mL per liter of water, together with bag-log waste at a rate of 150 g per planting pot (E3L3). The eco-enzyme demonstrates a significant impact on all observed variables, with the most effective at a concentration of 25 mL L^{-1} (E3). The effect of bag-log waste is statistically significant across all observed parameters, with the most optimal treatment being 150 g (L3). Hence, the utilization of eco-enzymes and mushroom bag-log waste exhibits promising prospects in microgreen cultivation.

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