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Evaluation Of Mycorrhizal And Moringa Leaf Fertilizer On The Chili's Vegetative

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ABSTRACT

This study aims to test the effect of mycorrhizae and organic moringa leaf fertilizer on the vegetative growth of chili plants. The study was conducted at the agricultural laboratory of KH.A. Wahab Hasbullah University (UNWAHA) in June – October 2025. It was done through an experimental method. The study used a Completely Randomized Design (CRD), using 4 treatments with 5 replications each. The treatments used were Ap0 (control, without additional fertilizer), Ap1 (75% soil + 25% moringa leaf compost), Ap2 (75% soil + 25% mycorrhizal bioagent fertilizer), and Ap3 (75% soil + a combination of 12% moringa leaf compost and 12% mycorrhizal bioagent fertilizer). Data analysis used Duncan's Multiple Range Mean Difference Test (DMRT) with a 5% level. The observation time was 7, 14, 21, and 28 days after planting. The result were The application of mycorrhiza, Moringa leaf fertilizer, and the consortium of both had a height of chili plants ranging from 21 cm at 28 day after planting (DAP) are higher than the control which was around 18 cm. The control treatment produced a lower number of leaves, namely 8.4 compared to the other three treatments with an average of 12 strands. The wet root weight of chili plants 30 DAP in the control was 2 grams, lower than the administration of mycorrhiza (4.2 grams), Moringa leaf fertilizer (4.2 grams), and the consortium of both (3.8 grams). The cross-section of the roots of chili plants in the three treatments was thicker than the control.
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***Keywords**: Mycorrhizae; Moringa leaf fertlizer; Capsicum sp.; vegetative growth.*

INTRODUCTION

Chili (Capsicum annum L.) is a commercially important commodity in horticultural agriculture (Setyadi, 2020). However, production has begun to decline in recent years. In 2024, production was only 3,840,040.55 quintals (BPS, 2025), a decrease compared to 3,950,407.75 quintals in 2023 (BPS, 2024). This decline is due to factors influencing in production, including water availability and quality, cultivation techniques, and climate change (Imaniasita et al., 2020). Furthermore, using inorganic chemical fertilizers and molasses extensively, burning crop residues on land, and short periods of fallowing is still done by farmer. The current climate, characterized by extreme weather patterns with unpredictable duration, creates a significant urgency for soil biological degradation. According to Bogati & Walczak (2022), soil under drought stress negatively impacts soil microbial community structure, enzymatic activity, and overall soil fertility. Efforts to mitigate these factors are needed to maintain soil biological quality and increase crop production. Based on current conditions and trends, soil management through the implementation of organic fertilizers and soil conservation techniques is essential to mitigate soil degradation, which impacts plant growth. Therefore, innovation in chili cultivation practices is needed without relying heavily on chemical fertilizers.

Mycorrhiza is a fungus that forms a symbiotic relationship with plant roots and helps increase the efficiency of nutrient absorption, especially phosphorus and other nutrients (Susanti, *et al.*, 2018). It is not only plays a role in increasing nutrient availability but can also increase plant resistance to environmental stress, such as drought and soil pathogens (Smith, 2009). Biofertilizers containing these biological agents can stimulate soybean plant roots to absorb nutrients in the soil. Susanti, *et al.* (2018) reported that mycorrhiza helps improve marginal soil conditions. The symbiosis both of them, mycorrhiza is fulfilled with carbohydrates from plants, while plants can increase the ability to absorb water and soil nutrients with the help of mycorrhiza (Susanti, *et al.*, 2018). The application of Mycorrhiza sp. biofertilizer to soybean plants in lithosol soil media has a significant effect on increasing plant height, length and number of root nodules compared to without fertilizer application (Susanti, *et al.*, 2024). One of the innovations developing in this system is the use of consortia between soil microorganisms, such as mycorrhizae, with nutrient-rich natural ingredients such as Moringa oleifera leaf extract. Research related to Moringa leaves shows that the application of these plants can increase vegetative growth of plants such as leaves and stems, as well as increase chlorophyll content, which in turn can increase the rate of photosynthesis and crop yields. The application of Moringa leaf extract can also improve plant morphological structure (Yasmeen *et al.*, 2013). Another study (Madina & Koesriharti, 2023) also reported that the application of 9% concentration of Moringa leaf extract in 1000 ml of sterile water could increased plant length and number of leaves in *Brassica rapa*. The advantages of mycorrhizae and Moringa leaves are expected to be a product that enhances plant growth through a consortium of both. Based on this, a study was conducted aimed at testing the mycorrhizal and organic Moringa leaf fertilizer on the vegetative growth of chili plants on a laboratory scale.

METHOD

The research was conducted in the agricultural laboratory of KH.A. Wahab Hasbullah University (UNWAHA) from June to October 2025. The materials used in this study were 14-day-old Panah Merah brand large chili seedlings, air-dried moringa leaves, lithosol soil collected from the Kesamben District, mycorrhizal bioagent fertilizer propagated by the UNWAHA Faculty of Agriculture, EM4 decomposer solution, well/ground water. The equipment used included a Neubauer Improve type hemacytometer, petri dishes, a binocular microscope, a hand counter, a 1 ml syringe, a bucket, a soil stirrer, a 250 ml beaker glass, a 100 ml measuring cylinder, a stirrer, observation sheets, writing utensils, a height/length measuring device, a digital scale, and a plastic cover.

Moringa Leaf Compost

Dry moringa leaves, organic fertilizer made from goat manure, a decomposer solution, and water as a solvent were prepared. The mixing process involved coarsely blending the moringa leaves with the soil, then pouring in the decomposer solution and stirring thoroughly. The ratio of the ingredients was 3:3, with 100ml of decomposer solution per liter of water. The composting process then began, placing the mixture in a bucket and covering it. Stirring was carried out periodically to maintain air circulation, once a week. The composting process lasted for three weeks. After the composting process was complete, the moringa leaf compost was harvested.

Preparing Mycorrhizal Bio-Agent Fertilizer

The spore density of the Mycorrhizal media was measured using a hemacytometer. A Neubauer Improve type hemacytometer was prepared and placed on the microscope stage. The hemacytometer was covered with a cover slip. Observations were then made at 100x magnification. A 0.2ml dilution of the mycorrhizal bio-agent fertilizer was taken using a 1ml syringe. The spore suspension was slowly dripped onto the counting field through both channels on the top and bottom, until the counting field was filled with the suspension capillary action. The suspension was then allowed to stand for one minute to stabilize.

Next, the spore density in the counting box (a + b + c + d + e) was calculated at 400x magnification using a hand counter. The spores were checked by counting each counting box. The spores counted were located on the boundary line of the counting box, only counted on the left and top sides of the counting box. The calculation was then repeated on the second counting field (Susanti *et al.*, 2019). The formula for the number of spores/ml is as follows:

$$S = \frac{X}{L \times t \times d} \times 10^3 \qquad (1)$$

Description:
S = the conidium density/ml
X = the average number of conidia in boxes a, b, c, d, and e
L = the area of the counting box (0.2 mm²) (0.04 mm² x 5 boxes)

t = the depth of the counting field (0.1 mm)
d = the dilution factor
10^3 = the calculated suspension volume (1 ml = 10^3 mm^3)

The research was conducted through two methods, experimental and modified quantitative descriptive (Wiswasta *et al*., 2017). Quantitative data were obtained based on variable observation measurements. The study used a Completely Randomized Design (CRD), using 4 treatments with 5 replications. The treatments were Ap0 (control, without additional fertilizer), Ap1 (75% soil + 25% moringa leaf compost), Ap2 (75% soil + 25% mycorrhizal bioagent fertilizer), and Ap3 (75% soil + a combination of 12% moringa leaf compost and 12% mycorrhizal bioagent fertilizer). Caring and maintenance were carried out by watering twice a day, without the application of pesticides and inorganic fertilizers. Further data analysis used Duncan's Multiple Range Mean Difference Test (DMRT) with a 5% level (Sastrosupadi, 1995). The observation time was 7, 14, 21, and 28 days after planting. The parameters focused on were plant height, number of leaves, wet root weight, and cross-section of chili plant roots.

RESULT AND DISCUSSION

Based on the calculation of mycorrhizal spore density (Figure 1B), it was found to be around 45/gram. The results of the test of mycorrhizal and organic moringa leaf fertilizer on the vegetative growth of chili peppers (Capsicum sp.) are shown in the table below:

Table 1. Results of the Test of Mycorrhizal and Organic Moringa Leaf Fertilizer on the Vegetative Growth of Chili Peppers (*Capsicum* sp.)

Treatment	7DAP		14DAP		21DAP		28DAP	
	T	D	T	D	T	D	T	D
Ap0	15.4 a	3.8 a	16.8 a	4.8 a	16.8 a	6.4 a	17.8 a	8.4 a
Ap1	14.8 a	4.6 ab	18.6 a	5.4 b	21 b	10.2 b	21.8 b	12 b
Ap2	15.2 a	4.4 ab	16.6 a	5.2 ab	19.2 b	10.2 b	21 b	12 b
Ap3	15.6 a	4.6 ab	17 a	5.4 b	19 b	10 b	20.4 b	11.6 b

Note: DAP = days after planting; T = plant height; D = number of leaves; Ap0 = control; Ap1 = mycorrhizal; Ap2 = moringa leaf compost; Ap3 = mycorrhizal + moringa leaf compost.
Numbers followed by different letters in the same column indicate significant differences based on Duncan's test at the 5% level.

Observations showed that the mycorrhizal and moringa leaf compost consortium treatments responded differently to the vegetative growth of chili pepper plants at each observation time point (7, 14, 21, and 28 DAP). These differences in response indicate that the effectiveness of each treatment is closely related to the plant's ability to utilize nutrients and the support of microorganisms during the vegetative growth phase.
The table above shows that plant heights across all treatments were not significantly different on days 7 and 14 DAP. On day 7, the average height of chili pepper plants was around 15 cm. Similarly, on 14th, the average height was around 17 cm. Observations began to show significant differences at 21 and 28 DAP.
Treatments of Ap1, Ap2, and Ap3 showed a tendency to produce taller plants than the control, especially at 21 and 28 DAP as shown in Table 1. In Ap1 and Ap3, it indicates that mycorrhizae play a role in increasing nutrient absorption, especially phosphorus, which plays an important role in the process of cell division and elongation. The increase in plant height in the Ap3 treatment indicates a synergistic effect between mycorrhizae and moringa leaf compost in supporting the growth of chili plants. The control treatment had a significantly lower average than the other three treatments. There was an average difference between the height of the control plant (Ap0) and the other three treatments (Ap1, Ap2, and Ap3) which was around 4 cm.

Meanwhile, the number of chili plant leaves also showed significant differences between treatments at four observation times. The Ap0 treatment produced a lower number of leaves, approximately 8.4 leaves at 21 and 28 DAP, compared to the other three treatments. The average difference between the three treatments was approximately 4 leaves. The increase in leaf number was related to better nitrogen availability from moringa leaf compost and increased nutrient uptake efficiency due to mycorrhizal associations. Leaves serve as the primary photosynthetic organ, so an increase in leaf number reflects more optimal vegetative growth conditions.

Table 2. Results of the Mycorrhizal and Moringa Leaf Organic Fertilizer Test on Fresh Root Weight of Chili Peppers (Capsicum sp.) at 30 DAP

Treatment	Wet weight of roots (gr)
Ap0	2 a
Ap1	4.2 b
Ap2	4.2 b
Ap3	3.8 ab

Note: DAP = days after planting; Ap0 = control; Ap1 = mycorrhiza; Ap2 = moringa leaf compost; Ap3 = mycorrhiza + moringa leaf compost. Numbers followed by different letters in the same column indicate significant differences based on Duncan's test at the 5% level.

Table 2 shows the wet root weight of chili peppers 30 DAP. The results of the wet root weight measurements showed that Ap1, Ap2, and Ap3 were not significantly different among the three, and were significantly different from Ap0 by a difference of 2 grams. Shakhidar et al. (2024) reported that 40 days after planting, the fresh root weight of chili peppers grown in cocopeat media was approximately 1.93g heavier than the control plant grown in soil alone, which was approximately less than 1g. The results showed that the application of mycorrhiza, moringa leaf compost, and a combination of the two affected the wet root weight of chili plants.

In general, moringa leaf extract (Figure 1A) has a complete range of plant growth-promoting properties due to its high levels of N, P, K, Ca, Fe, essential minerals, amino acids, the cytokinin hormone 'zeatin', auxin, and gibberellin (Madina & Koesriharti, 2023). Nguru *et al.* (2022) reported that a liquid organic fertilizer (POC) mixture of moringa leaves and banana peels at a concentration of 50% + 50% water significantly improved chili plant growth, resulting in a total yield of 39 fruits per plant and a total fresh fruit weight of 57.33 grams per plant.

The relatively high N content in moringa leaves, due to their richness in protein and chlorophyll, is suspected to help increase plant height and leaf number, especially during the vegetative phase of chili peppers up to 28 days after planting.

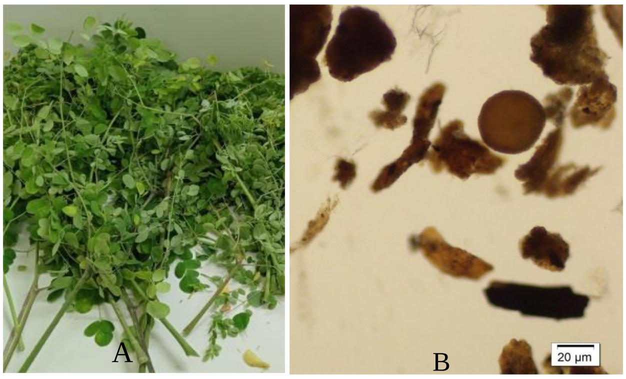

Figure 1. Moringa leaves (A) and mycorrhizal spores taken from a biofertilizer carrier medium at 20µm magnification (B) (Susanti, 2025)

The decomposition process by microorganisms in the organic fertilizer production process using moringa leaves breaks down complex compounds into simpler, ionic forms. This helps the roots obtain and absorb nutrients through root hairs. The zeatin content in moringa leaves can increase the number of root hairs, which is thought to impact nutrient absorption efficiency in chili plants.

The positive effect of mycorrhizal inoculation on plant growth is largely attributed to increased phosphorus (P) uptake. Plant roots that associate with mycorrhizae can increase their ability to absorb phosphorus. This is positively correlated with lateral root formation and elongation, root hair number, and volume. Treatments of Ap1, Ap2, and Ap3 showed a high number of root hairs, resulting in thicker root volume compared to the control (Ap0) (Figure 2). Furthermore, active, mycorrhizal roots tend to retain and accumulate greater amounts of nutrients, contributing to increased plant biomass production (Candrasekaran, 2020).

Figure 2. Cross-section of chili plant roots 30 DAP; Ap0 = control; Ap1 = mycorrhizae; Ap2 = moringa leaf compost; Ap3 = mycorrhizae + moringa leaf compost (Susanti, 2025).

The results of cross-sectional growth of chili roots from Ap1, Ap2, and Ap3 were also thicker than those Ap0. This indicates that applying moringa leaf fertilizer can also increase the number of roots in chili plants. The phosphorus (P) content in moringa leaves is thought to help supply this element for plant root growth. One characteristic of chili plants is their relatively shallow root system and sensitivity to growing medium conditions. This treatment can help optimize root absorption of nutrients.

The Ap3 treatment, a consortium of moringa leaf organic fertilizer and mycorrhizae, showed no significant differences compared to the single treatment. However, the organic moringa leaf fertilizer can help chili plants absorb nutrients, especially under stress conditions that are unfavorable for their growth. Chili plants are susceptible to drought stress and high temperatures. The presence of mycorrhizae can help reduce plant stress, thereby reducing the risk of growth and harvest failure. Therefore, the addition of mycorrhizae, moringa leaf fertilizer, or a combination of both can help plants overcome these root system deficiencies.

The addition of EM4 microbial activator to the fertilizer production process using moringa leaves is intended to significantly accelerate decomposition (Ropi'i, *et al.* 2020)(Kuniawati,*et.al.*, 2021). This can produce finished fertilizer in approximately three weeks. Meanwhile, the mycorrhizal spore density was found to be around 45/gram, with the organic fertilizer carrier suspected of colonizing roots, resulting in significantly different growth compared to the untreated treatment. Kuppusamy & Karunanandham (2012) reported that using sterile vermiculite substrate + 10% soil for the production of arbuscular mycorrhizal inoculum with a spore density of 5 – 6/gram, it was able to colonize 100% of the roots in corn.

CONCLUSIONS

The evaluation results of the application of Mycorrhiza and Moringa leaf compost fertilizer on the vegetative growth of chili plants were significantly different compared to without the provision of both at the age of 21 and 28 DAP. The application of mycorrhiza, Moringa leaf fertilizer, and the consortium of both had a height of chili plants ranging from 21 cm at 28 DAP higher than the control which was around 18 cm. The control treatment produced a lower number of leaves, namely 8.4 compared to the other three treatments with an average of 12 strands. The wet root weight of chili plants 30 DAP in the control was 2 grams, lower than the administration of mycorrhiza (4.2 grams), Moringa leaf fertilizer (4.2 grams), and the consortium of both (3.8 grams). The cross-section of the roots of chili plants in the three treatments was thicker than the control.

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