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Applying Mycorrhiza and *Trichoderma harzianum* to Increase Chilli Plant Production (*Capsicum annum* L)

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Abstract

Red chili production in Indonesia has fluctuated over the past five years, with a decrease to 1.04 million tons in 2015 and 2016, followed by an increase to 1.20 million tons in 2017. This study aimed to determine the effect of administering mycorrhizal fungi on the growth of chili plants. The materials used in this study included 10% KOH, 50% alcohol, dye (Quink Parker), chili seeds of various varieties (Kharisma), mycorrhizal fertilizers (*Glomus sp*. and Gigaspora), and *Trichoderma harzianum* pellets. The tools utilized in this research comprised 15 kg polybags, shovels, measuring tapes, watering cans, analytical scales, soil sieves, hoes, a Nikon Binocular Microscope (model SE 102), petri dishes, sieves, tweezers, glass slides, cover glasses, an oven, a camera, and plastic containers for holding the polybags. The F-test results from the variance analysis indicate that mycorrhizal fungi significantly influence the fruit weight of chili plants at 110 days after planting (DAP) and root infection at 45 DAP. However, there was no significant effect on wet fruit weight, wet root weight, or the number of fruits produced. Additionally, the F-test results demonstrate that Trichoderma has a highly significant effect on the observed variables. Furthermore, the F-test results indicate a significant impact on fruit weight at 110 hours after transplanting (HST) and wet weight at 110 HST.

Keywords: Chili Production, Growth, Mycorrhiza, Red chili, Trichoderma,

1. Introduction

Red chili (*Capsicum annuum* L.) is a horticultural plant that belongs to the Solanaceae family (Weihan et al., 2024). It holds significant economic value and is rich in various nutrients, including protein, fat, carbohydrates, calcium, and vitamins A and C. Consequently, red chili is a commodity that is essential for cooking in many communities (Wahyudin Purba & Padhilah, 2021). In Indonesia, red chili is particularly popular for its spicy flavor and high nutritional content (Tambunan, 2021). A 100-gram serving of chili fruit contains 90.9% water, 31 calories, 1 g of protein, 0.3 g of fat, 7.3 g of carbohydrates, 29 mg of calcium, 24 mg of phosphorus, 4.7 mg of vitamin A, and 18 mg of vitamin C.

Red chili production in Indonesia has experienced fluctuations over the past five years. 2013 production reached 1.01 million tons (Djam et al., 2024). This figure increased to 1.07 million tons in 2014 but declined to 1.04 million tons in 2015 and 2016. In 2017, red chili production rebounded to 1.20 million tons. In Aceh, red chili production in 2017 was only 53,041 tons, according to the Ministry of Agriculture of the Republic of Indonesia in 2018. The consumption of red chili continues to rise annually, driven by the growing population. The decline in quality and the instability of red chili production can be attributed to unpredictable weather, pest infestations, diseases, viruses, and fungi (Syaifullah, 2016). Therefore, cultivating red chili plants necessitates optimal care and suitable environmental conditions.

One of the diseases affecting chili plants is fusarium wilt, caused by the fungus *Fusarium oxysporum* Schlechtendahl et Fr. This pathogen can lead to wilting in both young plants and those that are already productive (Karim et al., 2016). To enhance production, farmers typically prefer chemical fertilizers; however, the long-term use often has detrimental effects on living organisms and

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the surrounding environment (Wirda et al., 2023). Therefore, there is a pressing need for environmentally friendly organic fertilizers (Maulana, Zuhra, et al., 2024)

Mycorrhiza can form a symbiosis with almost all agricultural plants, including horticultural plants. The administration of AMF (arbuscular mycorrhizal fungi) to horticultural plants significantly affects the incubation of Fusarium wilt disease. (Maulana, Safriani, et al., 2024). In the research (Maulana et al., 2024), applying FMA (asbicular mycorrhizal fungi) on chili plants can delay the emergence of yellow curly leaf disease on chilies caused by Begomovirus. Not only that, but mycorrhizal fungi can also increase soil fertility. In the study (Maulana & Erwin Harahap, 2023), Mycorrhizal fungi are a type of fungus that has an essential role in maintaining soil fertility by increasing the uptake of N, P, and K nutrients, increasing water absorption. (Maulana & Noer, 2025) And increase resistance to drought and soil microbial activity. (Maulana et al., 2022).

In addition to mycorrhizal fungi, *Trichoderma harzianum* fungi are also used as biological agents to replace chemical pesticides to control OPT (plant pest organisms). (Maulana et al., 2021). The antagonistic fungus *Trichoderma harzianum* is a microorganism that is antagonistic to plant pathogens (disease-causing agents), and its habitat is in the soil. Besides that, it can also live in litter or organic materials to become nutrients that benefit plants. (Anggraeni & Usman, 2015). This fungus is found in many soil types, so its distribution area is vast. In addition to being antagonistic, the fungus *Trichoderma harzianum* (Anggraeni & Usman, 2015). It can grow very quickly, becoming a competitor for other organisms in utilizing nutrients, space and time. (AFIFAH, 2017)

Several previous studies have proven that the antagonistic fungus Trichoderma sp. in ginger isolation can control the pathogen F. oxysporum, which causes rhizome rot disease in ginger and kencur, and can suppress the development of Fusarium wilt disease, ranging from 7.89-56.25%. Trichoderma sp. can inhibit the pathogen C. capsici in vitro with an inhibition percentage of 68.2% during a seven-day incubation period and can also inhibit the pathogens Fusarium sp and S. roflsii with inhibition percentages of 53.9% and 35.5%, respectively, during seven days of incubation. (Soesanto, et al., 2011)

Based on the problems above, it is necessary to research the effectiveness of the type of mycorrhizal fungi and the correct dose of *Trichoderma harzianum* pellets to suppress the growth of fusarium wilt disease and increase chili plant production.

2. Material and Methods

2.1. Place and Time of Research

This research will be conducted at the PEMA Farm Research and Business Center, BTN Kupula Indah Complex, located in Kota Juang District, Bireuen Regency, Aceh Province. One of the recorded coordinates for this complex is 5°11'52" North Latitude and 96°43'8" East Longitude. The height of this place is estimated to be around 20 meters above sea level (MDPL), Kota Juang and the Soil Biology Laboratory of the National Islamic University of Indonesia for 3 months, namely from January to April 2023.

2.2. Materials and tools

The materials used were 10% KOH, 50% alcohol, dye (Quink Parker), chili seeds of varieties (Kharisma), mycorrhizal fertilizer (glomus sp. and Gigaspora) and *Trichoderma harzianum* pellets obtained from the Soil Biology laboratory of Syiah Kuala University.

The tools used in this study were 15 kg polybags, trays, meters, watering cans, analytical scales, soil sieves, hoes, Nikon SE 102 binocular microscopes, petri dishes, sieves, tweezers, slides, cover slips, ovens, cameras and plastic houses as a place to put the experimental polybags.

2.3. Research methods

The design used in this experiment was a 4 × 3 Factorial Randomised Block Design (RAK) with three replications, so that it had 12 treatment combinations consisting of two treatment factors:

The first factor is the type of Mycorrhiza (M), which consists of 4 levels:

M0 = Control
M1 = Mycorrhiza Glomus sp. 10g
M2 = Mycorrhiza Gigaspora sp. 10g
M3 = Mixture 10g

The second factor is the dose of Trichoderma, which consists of 3 levels:

T0 = Control
T1 = Dose 10g
T2 = Dose 20g

From these two factors, 12 treatment combinations were obtained.

2.4. Research Implementation

2.4.1. Preparation of Planting Media

The soil was taken from the topsoil layer with a 0-25 cm depth. Then the soil was sieved using a 2 mm sieve. The soil was put into 15 kg polybags and arranged according to the treatment plan.

2.4.2. Mycorrhizal Application Treatment

Each polybag was given mycorrhiza according to each type and control (without mycorrhiza). Mycorrhiza was placed in the planting hole around the root area at 2-3 cm depth according to the treatment per plant before the seeds were planted in the polybag. Then, the planting hole given to Mycorrhiza was again covered with soil. Mycorrhiza application was carried out once at the time of planting seeds.

2.4.3. *Trichoderma harzianum* Application Treatment

Each polybag was given *Trichoderma harzianum* according to each dose and control (without giving *Trichoderma harzianum*). Trichoderma Harzianun was placed in the planting hole around the root area at a depth of 2-3 cm according to the treatment per plant before the seeds were planted in the polybag. Then, the planting hole given to *Trichoderma harzianum* was covered again with soil. *Trichoderma harzianum* application was carried out once at the time of planting seeds.

2.4.4. Research flow chart

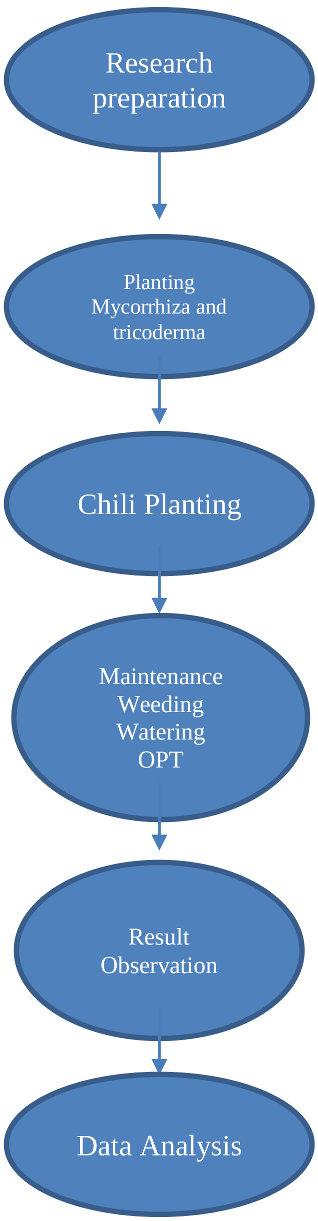

Figure 1. Research flow diagram

2.5. Observation Variables.

2.5.1. Number of fruits per plant (fruits)

Observations were made during harvest at the ages of 90, 95, 100, 105 and 110 HST days after planting by counting the total number of already red chillies.

2.5.2. Fruit weight per plant (g)

Fruit weighing is carried out at harvest time, at the ages of 90, 95, 100, 105 and 110 HST by weighing the weight of the chilies per plant using an analytical scale.

2.5.3. Wet weight of shoots per plant (g)

Observation of the wet weight of the plant after 110 days after planting, the plant is dismantled and then cleaned with water on the roots, aired for a while and then the weight of the plant is measured using an analytical scale.

2.5.4. Wet weight of roots per plant (g)

After 110 days of planting, the roots are cut at the base of the stem, cleaned with water until the sticky soil on the roots is gone, and weighed using an analytical scale.

2.6. Data Analysis

Data analysis was carried out using Microsoft Office applications. Excel Professional Plus 2019, and manual data collection

3. Results and Discussion

3.1. Number of fruits

The results of the F test on the analysis of variance showed that the type of mycorrhiza had a very significant effect on the number of fruits, 110 HST. The average number of fruits 110 HST on various types of mycorrhiza can be seen in Table 1.

Table 1. The average number of fruits at 110 HST in various mycorrhizal type treatments.

Mycorrhizal type (10 g/g/plant)	Number of Fruits
Control	6.88b ±0.45
Glomus	4a ±0.45
Gigaspora	7.11b ±0.45
Mixture	6b ±0.45
BNJ $_{0.05}$	1,569

Table 1 shows that the average number of fruits per plant tends to be higher in the gigaspora mycorrhiza type (7.11) and statistically does not differ significantly between mixed mycorrhiza (6) and control (6.88).

This is in line with research stating that mixed mycorrhiza (Glomus and Gigaspora) usually has good adaptability and growth in polluted and tropical areas. (Alfiyah, 2015). This is in accordance with the research results, which states that high absorption of N and P nutrients is found in plants that are given mycorrhiza. (Permanasari et al., 2016) Because mycorrhiza will encourage the development of hyphae on plant roots. Mycorrhiza increases the absorption of P and N nutrients, which are essential in forming flowers and fruits. This effect is also correlated with an increase in growth hormones such as cytokinins and auxins, which stimulate the generative process of plants.

3.2. Fruit Weight Per Plant (g)

The results of the F test on the analysis of variance showed that the treatment of mycorrhizal types had no significant effect on the weight of fruit per plant at the age of 110 HST. The average weight of fruit per plant in various treatments of mycorrhizal types can be seen in Table 2.

Table 2. The average fruit weight per plant at 110 HST in various mycorrhizal type treatments.

Mycorrhizal type (10 g/g/plant)	Fruit Weight Per Plant
Control	8.66a ±1.53
Glomus	28.18b ±1.53
Gigaspora	26.61b ±1.53
Mixture	31.05b ±1.53
BNJ $_{0.05}$	5,306

Table 2 shows that the average fruit weight per plant tends to be heavier in the mixed mycorrhizal type (31.05), and the lowest data is found in the control (8.66).

Mixed mycorrhiza (Glomus mosseae and Gigaspora sp) has a high level of adaptation in polluted areas with various types of mycorrhiza (Gloria et al., 2016). The results of this study indicate that Trichoderma significantly affect the stem diameter 30 HST and the Number of Fruits 110 HST. It has a very significant effect on the growth of chili plants. The best *Trichoderma harzianum* is found in a *Trichoderma harzianum* dose of 10 grams. This is in line with the statement that *Trichoderma harzianum* has many advantages compared to control plants; therefore, the use of *Trichoderma harzianum* doses can increase production in both quantity and quality, as well as the level of resistance to attacks by plant pests and the response to fertilization.

A mixture of two types of mycorrhizae can adapt better to tropical and polluted soil conditions, and form more and wider hyphae than single mycorrhizae. This leads to increased absorption of nutrients such as K and P, which are essential in fruit formation and enlargement. *Trichoderma harzianum* and mycorrhiza accelerate growth and improve the quality of fruit of horticultural plants.

3.3. Wet Weight of Planting Stalks (g)

The results of the F test on the analysis of variance showed that the type of mycorrhiza had a very significant effect on the wet weight of the 110 HST shoots. The average wet weight of the shoots in various treatments of mycorrhiza types can be seen in Table 3.

Table 3. Average wet weight of shoots at 110 HST in various mycorrhizal type treatments.

Mycorrhizal type (10 g/g/g/plant)	Fruit Weight Per Plant
Control	55.22a ±3.06
Glomus	56.33a ±3.06
Gigaspora	70.88c ±3.06
Mixture	58.88ab ±3.06
BNJ $_{0.05}$	10.58

Table 3 shows that the average wet weight of chili plant shoots tends to be heavier in the gigaspora mycorrhiza type (70.88). However, statistically, it is not significantly different from the other types of mycorrhiza given.

This is in line with research (Fawziah, 2021) Previously, the growth and yield of chili plants, such as wet plant weight, dry plant weight, fruit weight per plant, number of fruits, yield potential and root colonization in chili plants were found at a mycorrhizal dose of 10g/plant. The level of pathogen attack in the field is also very small, seen from several samples observed, only a few plants were infected with the disease. Symptoms of attack caused by *Trichoderma harzianum* on F. oxysporum are the entanglement of F. oxysporum hyphae by Trichoderma spp hyphae (Herlina, 2009)

Administration can increase plant weight in fresh and dry form in red chili and help reduce disease symptoms by increasing plant physiological resistance. In addition, it was reported that arbuscular mycorrhizae can increase plant growth under saline soil stress conditions by increasing root colonization and upper plant tissue.

3.4. Wet Weight of Plant Roots (g).

The results of the F test on the analysis of variance showed that the type of mycorrhiza had no significant effect on the fresh weight of the 110 HST shoots. The average root weight per plant in various treatments of mycorrhiza types can be seen in Table 4.

Table 4. Average wet weight per batch at 110 HST on various types of mycorrhizal treatments.

Mycorrhizal type (10 g/plant)	Fruit Weight Per Plant
Control	17.33ab ±1.14
Glomus	13.44a ±1.14
Gigaspora	24.66d ±1.14
Mixture	18bc ±1.14
BNJ 0.05	3,961 ±1.14

Table 4 shows that the average wet weight of chili plant roots tends to be heavier in the Gigaspora mycorrhiza type (24.66), while in the Glomus mycorrhiza type it only has a weight of (13.44) and a mixture (18). The results of the study showed that the type of mycorrhiza had a significant effect on the number of fruits at 110 HST, stem diameter at 30 HST, and had a very substantial impact on the height of chili plants at 15, 30 and 45 HST, the number of leaves per plant at 15, 30 and 45 HST, but had no significant effect on stem diameter at 15 HST. Chilli plants' best growth and yield were found in the Gigaspora mycorrhiza type 10 g/g/plant. This is in line with previous research (Hadianur et al., 2017) which showed the growth and yield of chili plants such as wet plant weight parameters, dry plant weight, fruit weight per plant, number of fruits, yield potential and root colonization in chili plants were found at a mycorrhizal dose of 10g/plant.

Mycorrhiza increased lateral root formation, main root length, and root fresh weight in okra and chili plants. The increase in root weight also indicates that mycorrhiza increases soil microbial activity and improves soil structure.

4. Conclusion

The mycorrhizal type significantly impacts the number of fruits per plant at 110 days after sowing. The best growth and yield of chili plants occurred in the presence of Gigaspora sp. mycorrhiza. The application of Trichoderma did not have a significant impact on any of the result parameters. The optimal combination of leaf count per chili plant at 15 HST and stem diameter at 30 HST was observed in Trichoderma with a 10g dosage.

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