



## RESEARCH ARTICLE

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# Increasing the Production of Chili Peppers (*Capsicum frutescens*) with Application of Mycorrhiza *Glomus Moseae* and *Gigaspora* on Sea Sand Media

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## Abstract

Utilizing coastal areas for agricultural purposes has not yet been widely adopted. The saline conditions and sandy soils typical of coastal regions make it difficult for plants to thrive. Chili peppers are a horticultural commodity with high economic value and are widely cultivated by farmers across various regions of Indonesia. Geographically and ecologically, Indonesia's coastal areas hold significant potential for agricultural development, fisheries, tourism, marine energy, and biodiversity conservation. Approximately 22% of Indonesia's total land area is coastal, making these regions highly strategic for local resource-based economic development. The total coastal area is estimated at over 327,000 km<sup>2</sup>. Besides household use, cayenne pepper also serves as a raw material in the food and beverage industry. However, saline stress conditions can be toxic to plants. Salinity stress disrupts many aspects of plant physiology, including a decreased photosynthesis rate, cell damage due to sodium ion (Na<sup>+</sup>) accumulation, and reduced crop quality. This study employed a 4 × 3 randomized block factorial design (RBD) with three replications, yielding 12 treatment combinations across two treatment factors. The results showed that mycorrhizal application significantly affected plant height at 15, 30, and 45 days after sowing (DAS), as well as fresh weight at 110 DAS, but had no significant effect on other parameters. Among all observations, the *Glomus mosseae* mycorrhizal type consistently outperformed other mycorrhizal types in enhancing cayenne pepper growth. This study recommends further research on the use of organic materials as planting models suitable for coastal areas. Reason: The text was revised to improve clarity, coherence, and technical accuracy. Redundant phrases were removed, and terminology was standardized (e.g., "days after sowing" instead of "HST"). Sentence structure was enhanced for readability, and scientific names were corrected for proper formatting. Additionally, the flow of ideas was improved to connect better the background, methodology, results, and recommendations.

**Keywords:** Coastal Utilization, *Glomus moseae*, Salinity, Stress, Suboptimal Land

## 1. Introduction

Utilizing coastal areas for agriculture has not yet been widely adopted. Coastal areas with saline conditions and sandy soil make it difficult for plants to thrive. (Maulana & Pratiwi, n.d. 2024) . Coastal farmers have not utilized coastal areas for agricultural purposes due to the difficult soil conditions and salinity stress that can poison plants. Salinity stress disrupts many aspects of plant physiology, including reduced photosynthesis rates, cell damage from sodium ion (Na<sup>+</sup>) accumulation, and decreased crop quality. (Maulana, Pratiwi, et al., 2024) . Physiologically,

high salinity can cause osmotic stress, making it difficult for plants to absorb water and inhibiting plant growth and development. Salinity can also increase the production of reactive oxygen species (ROS), which cause oxidative stress in plants. One way to reduce the negative impact of salinity is to use mycorrhizae, which can increase plant resistance to stress by boosting antioxidant enzyme activity and improving root systems (Maulana et al., 2025).

Chili peppers are a horticultural crop with high economic value each year and play a crucial role in supporting food security and farmer welfare (Maulana,

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Safriani, et al., 2024). However, one of the main challenges in chili pepper cultivation is salinity stress, especially in coastal sandy soils. Salinity can impair plant physiological functions, including photosynthesis and transpiration, and lead to the accumulation of harmful ions in plant tissues (6). With the decreasing availability of fertile agricultural land, managing marginal land, such as saline soils, presents both a challenge and an opportunity to improve agricultural sustainability in Indonesia (Maulana & Noer, 2025).

The success of chili pepper cultivation depends heavily on selecting varieties suited to environmental conditions and production objectives (Kusuma, 2016). Various types of chili pepper mycorrhizae have been developed to increase productivity, resistance to pests and diseases, and tolerance to extreme environmental conditions such as drought and salinity stress. (Eureka Anugrah et al., 2022) . Selecting the right variety is a key factor in efficient cayenne pepper production in various agricultural ecosystems. Each variety also has genetic differences that can affect growth and yield, as well as varying adaptability. (Maulana, Zuhra, et al., 2024) . Each type of mycorrhizae produces different results depending on how intensive and proper cultivation practices are implemented. Variety is a very important factor in determining plant growth and yield, along with environmental factors (Fawziah, 2021). Selecting superior plant varieties is also an important technology for achieving high yields of cayenne pepper (Herlina, 2009).

One approach to overcoming salinity stress in cayenne pepper plants is to use mycorrhizal fungi. (PERMANASARI et al., 2016) . Mycorrhiza is a fungus that forms a mutualistic symbiosis with plant roots and can increase nutrient absorption, especially phosphorus, as well as plant resistance to environmental stress, including salinity. (Djam et al., 2024) . Mycorrhiza works by expanding the plant's root system, increasing the roots' ability to absorb water and nutrients, and helping plants cope with poor environmental conditions (Resdiar et al., 2021). There are also studies showing that administering mycorrhizal doses increases vegetative growth and chili production in ordinary latosol soil, without a specific focus on saline sea sand (Madusari et al., 2018).

This study aims to determine and analyze the effect of various types of mycorrhizae, namely *Glomus* sp., *Gigaspora* sp., a mixture of both, and a control without mycorrhizae, on the growth and yield of cayenne pepper plants (*Capsicum frutescens* L.) cultivated on high-salinity sea sand media in coastal areas. Through this study, the plant response to mycorrhizae treatment in the vegetative and generative phases was evaluated, which included parameters of plant height, number of leaves, stem diameter, fresh weight of shoots, fresh weight of roots, number of fruits, and fruit weight per plant at harvest age of 90–110 HST. This study also aims to identify the most effective type of mycorrhizae in increasing plant tolerance

to salinity stress and increasing the productivity of cayenne pepper on marginal coastal land. In addition, this study is expected to provide a scientific basis for the development of mycorrhizae-based biotechnology as a strategy for utilizing sea sand land, enabling coastal areas to be more effectively utilized for the cultivation of high-value horticultural crops.

## 2. Material and Methods

### 2.1. Place and Time of Research

The research was 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 coordinates recorded for this complex is 5°11'52" North Latitude and 96°43'8" East Longitude. The altitude of this place is estimated to be around 20 meters above sea level (MDPL), Kota Juang, and the Laboratory of the Faculty of Agriculture, University of Medan, 5°11'47.0 "N 96°42'30.0" E (approximately 5.1964, 96.7083) from June to November 2025.

### 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 mycorrhizal 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 for placing the experimental polybags.

### 2.3. Research methods

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

The first factor is the type of Mycorrhiza (M), with 4 levels: Control, *Glomus* sp. Mycorrhiza 10g, *Gigaspora* sp. Mycorrhiza 10g and Mixture 10g.

### 2.4. Research Implementation

#### 2.4.1. Preparation of Planting Media

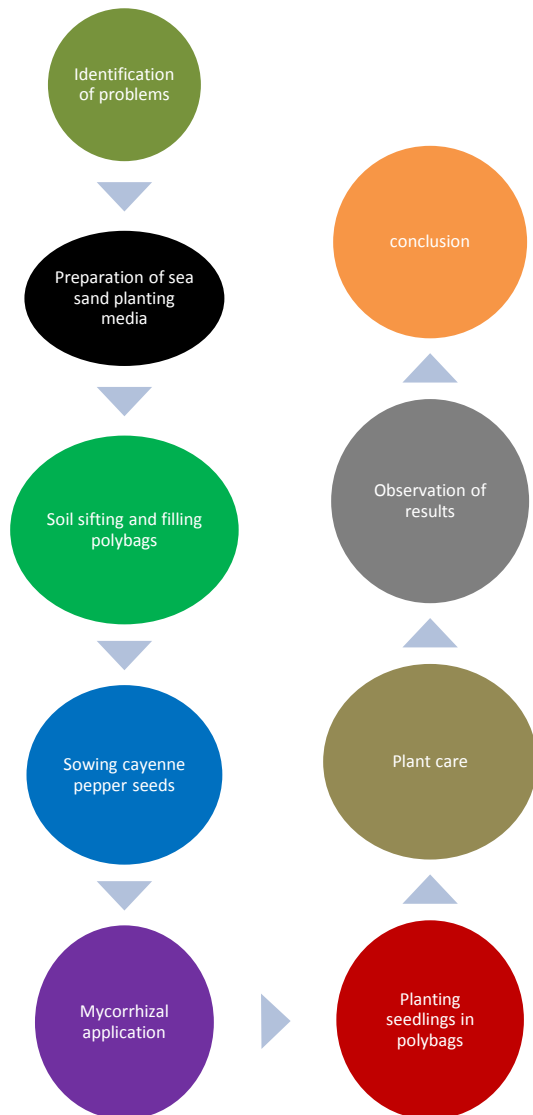
Soil was taken from the topsoil layer to a depth of 0–25 cm. It was then sieved using a 2 mm sieve. The soil was placed into 15 kg polybags and arranged according to the treatment plan.

#### 2.4.2. Mycorrhizal Application Treatment

Each polybag was inoculated with mycorrhizae for its species, and a control (without mycorrhizae) was included. The mycorrhizae were placed in the planting holes around the root zone at a depth of 2–3 cm, depending on the treatment per plant, before the seeds were planted in the

polybags. The holes containing the mycorrhizae were then covered with soil. Mycorrhizae were applied once at the time of seed planting.

**2.4.3. Research flowchart**



**Figure 1.** Research flow diagram

**2.5. Observation Variables**

**2.5.1. Number of fruits per plant (fruits)**

Observations were made at harvest time at 90, 95, 100, 105, and 110 days after planting by counting the total number of red chilies.

**2.5.2. Fruit weight per plant (g)**

Fruit weight was measured at harvest time, at the ages of 90, 95, 100, 105, and 110 HST, by weighing the chilies per plant on an analytical scale.

**2.5.3. Wet weight of shoots per plant (g)**

After 110 days of planting, the plant is weighed, then

dismantled, cleaned of roots with water, aired for a while, and weighed again 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 is removed, and weighed using an analytical balance.

**2.6. Data Analysis**

Data analysis was performed in Microsoft Excel Professional Plus 2019 (Version 16.0.10396.20017), and manual data collection was conducted.

**3. Results and Discussion**

**3.1. Number of Fruits**

The results of the F test in the analysis of variance showed that the type of mycorrhizae had a very significant effect on the number of fruits 110 days after planting. The average number of fruits 110 days after planting for various types of mycorrhizae is shown in Table 1.

**Table 1.** Average number of fruits at 110 HST in various mycorrhizal treatments.

Mycorrhizal type (10 g/plant)	Number of Fruits
Control	3.64 b ±0.45
<i>Glomus</i>	9.55 a ±0.45
<i>Gigaspora</i>	8.7 1b ±0.45
Mixture	5.10 b ±0.45
BNJ <sub>0.05</sub>	1.43

Description: Number of samples 12 with 3 replications

Table 1 shows that the average number of fruits per plant tends to be higher in the *Glomus mycorrhizal species* (9.55) and statistically, there was no significant difference between mixed mycorrhiza and the control (3.64).

This aligns with research showing that mixed mycorrhizal species (*Glomus* and *Gigaspora*) typically exhibit good adaptability and growth in polluted and tropical environments. (Alfiyah, 2015). This finding is consistent with research showing that plants with mycorrhizal associations exhibit higher nutrient absorption of N and P. (Permanasari et al., 2016) because mycorrhizae will encourage the development of hyphae in plant roots. Mycorrhizae increase the absorption of P and N, which are important nutrients for flower and fruit formation. This effect is also correlated with increased levels of growth hormones, such as cytokinins and auxins, which stimulate the plant's generative processes.

**3.2. Fruit Weight per Plant (g)**

The results of the F test in the analysis of variance showed that the mycorrhizal type treatment had no significant effect on fruit weight per plant at 110 days after planting. The average fruit weight per plant across various mycorrhizal treatments is shown in Table 2. Table 2 shows that the average fruit weight per plant tends to be higher in the *Glomus mycorrhizal type* (50.11) and the lowest is in

the control (8.13).

**Table 2.** Average fruit weight per plant at 110 days after planting in various mycorrhizal treatments.

Mycorrhizal type (10 g/plant)	Fruit Weight Per Plant
Control	8.13 a $\pm$ 1.53
<i>Glomus</i>	50.11 b $\pm$ 1.53
<i>Gigaspora</i>	35.40 b $\pm$ 1.53
Mixture	41.45 b $\pm$ 1.53
BNJ <sub>0.05</sub>	5.21

Description: Number of samples 12 with 3 replications

*Glomus mosseae* and mixed mycorrhiza have a high level of adaptation to polluted areas with various types of mycorrhiza (Gloria et al., 2016). The results of this study indicate that mycorrhiza significantly affected stem diameter at 30 days after planting and fruit number at 110 days after planting. This significantly affected the growth of chili plants. The best mycorrhiza concentration was found at a dose of 10 grams. This is in line with Kusuma (2016), who stated that Mycorrhiza has many advantages compared to control plants; therefore, the use of Mycorrhiza doses can increase production in both quantity and quality, as well as the level of resistance to plant pest attacks and the response to fertilization.

A mixture of two types of mycorrhizae can adapt better to tropical and polluted soil conditions, and form more numerous and extensive hyphae than a single type of mycorrhizae. This leads to increased nutrient absorption, particularly of K and P, which are important for fruit formation and growth.

### 3.3. Wet Weight of Planting Stalks (g)

The results of the F test in the analysis of variance showed that the type of mycorrhizae had a very significant effect on the fresh weight of the berangkasan at 110 days after planting. The average fresh weight of the berangkasan across various mycorrhizal treatments is shown in Table 3.

**Table 3.** Average fresh weight of seedlings at 110 HST in various mycorrhizal treatment types.

Mycorrhizal type (10 g/plant)	Fruit Weight Per Plant
Control	34.11 a $\pm$ 3.06
<i>Glomus</i>	37.53 a $\pm$ 3.06
<i>Gigaspora</i>	95.33 c $\pm$ 3.06
Mixture	61.61 ab $\pm$ 3.06
BNJ <sub>0.05</sub>	11.08

Description: Number of samples 12 with 3 replications

Table 3 shows that the average wet weight of chili plant shoots tends to be heavier in the *gigaspora* mycorrhizal type (95, 33), although it is not significantly different from the other mycorrhizal treatments.

This aligns with the research (Fawziah, 2021). Previously, the growth and yield of chili plants, including wet plant weight, dry plant weight, fruit weight per plant, number of fruits, yield potential, and root colonization, were determined at a mycorrhizal dose of 10g/plant.

The results of this study indicate that the application of mycorrhizae to high-salinity sea sand media resulted in a quantitative increase in the growth and yield of cayenne peppers, compared with previous studies. In terms of fruit number, the *Glomus* type of mycorrhizae was able to increase production by up to 162% compared to the control (9.55 fruits vs. 3.64 fruits), while the study (Hadianur, Syafruddin, 2017) only reported an increase of 77% in non-saline soil. A much greater increase was also seen in the fruit weight per plant parameter, where the use of *Glomus* resulted in an increase of up to 516% compared to the control (50.11 g vs. 8.13 g), far exceeding the research (PERMANASARI et al., 2016), which only recorded an increase of 77%. In terms of fresh weight of the bed, *Gigaspora* mycorrhiza increased plant biomass by 179% compared to the control (95.33 g vs. 34.11 g), higher than the 120% increase reported (Fawziah, 2021) in ordinary soil media. A similar finding was observed in root wet weight, where *Gigaspora* mycorrhizae increased root biomass by up to 148%, whereas research by Resdiar et al. (2021) recorded only an increase of around 105%.

### 3.4. Wet Weight of Plant Roots (g).

The F test in the analysis of variance showed that the type of mycorrhizae had no significant effect on shoot fresh weight at 110 days after planting. The average root weight per plant across various mycorrhizal treatments is shown in Table 4.

**Table 4.** Average wet weight of 110 HST in various types of mycorrhizal treatments.

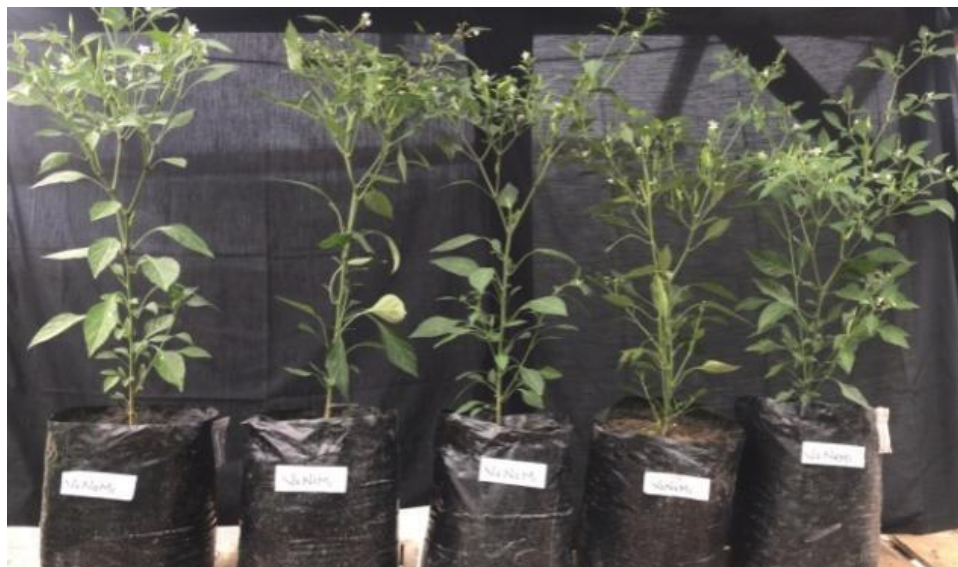
Mycorrhizal type (10 g/plant)	Fruit Weight Per Plant
Control	13.41 ab $\pm$ 1.14
<i>Glomus</i>	11.14 a $\pm$ 1.14
<i>Gigaspora</i>	33.26 d $\pm$ 1.14
Mixture	1.7 bc $\pm$ 1.14
BNJ <sub>0.05</sub>	3.32 $\pm$ 1.14

Description: Number of samples 12 with 3 replications

Table 4 shows that the average wet weight of chili plant roots tends to be heavier in the *Gigaspora* mycorrhizal type (33, 26), while the *Glomus* mycorrhizal type only has a weight (11, 14) and a mixture. The results of the research conducted showed that the mycorrhizal significantly affected the number of fruits at 110 HST, stem diameter at 30 HST, and had a very significant effect 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. The results of this study indicate that mycorrhizae increase the growth and yield of cayenne pepper, with effects quantitatively higher than those reported in previous studies. At 110 days after planting (DAP), *Glomus* mycorrhizae increased production by up to 162% compared to the control, while research by Setiawati et al. (2024) only reported an increase of about 77% in non-saline soils. Stem diameter at 30 days after planting in this study increased by about 45–60%, higher than in the

study by Setiawati et al. (which increased the diameter by only 20–35%). Plant height at 15, 30, and 45 HST increased by 40–75%, greater than the 18–33% increase reported (Setiawati et al., 2024). The number of leaves also showed a much stronger response, increasing by 50–80%, whereas the study by Astiko et al. (nd) reported only a 20–40% increase. Meanwhile, the stem diameter at 15 days after planting was not significantly different, consistent with Kusuma's (2016) report that the effect of mycorrhizae in the early phase was not optimal because root colonization was not yet fully formed. Overall, the mycorrhizal effect in this study was greater than in previous studies, mainly because the saline sea sand

medium induced stress, making the plants more responsive to mycorrhizal colonization. Thus, this study has the novelty of a higher quantitative response in extreme environments compared to previous studies in ordinary soil media. The best growth and yield of chili plants were found with the *Gigaspora mycorrhizal type of 10 g/plant*. This is in line with previous research (Hadianur et al. , 2017) which showed that the growth and yield of chili plants such as parameters such as fresh 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 10 g/plant.



**Figure 2.** Research documentation

Mycorrhizae increase lateral root formation and main root length, as well as root fresh weight, in okra and chili plants. The increase in root weight also indicates that mycorrhizae increase soil microbial activity and improve soil structure.

#### 4. Conclusion

The results showed that the type of mycorrhizae had a highly significant effect on the number of cayenne pepper fruits at 110 days after planting, with *Glomus* sp. being the most effective in increasing yield. Although not all parameters showed significant differences, mycorrhizae still provided significant increases in growth, such as the

number of leaves at 15 days after planting and stem diameter at 30 days after planting, especially at a dose of 10 g per plant. Overall, a dose of 10 g of *Glomus* sp. is recommended as the best choice for increasing cayenne pepper production in sea-sand media or in high-salinity coastal areas.

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