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RESEARCH ARTICLE

Application of Mycorrhizal Fungi and Application of Organic Matter in Coastal Sandy Soil Media with Copy Grip on the Growth of Cayenne Pepper

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ABSTRACT

The use of coastal areas as agricultural areas has not yet been applied in the general community. Coastal areas with saline conditions and sandy soils make it difficult for plants to live optimally. Biological agent input that can tolerate saline stress on coastal soil using Mycorrhizal fungi so that plants are able to survive and be productive on coastal land that is classified as saline. The use of mycorrhizal fungi and the addition of organic matter to a land with a sandy texture is considered to be able to change the physical properties of the soil and help plant roots to bind the media more strongly. This is because mycorrhizal biofertilizers and organic matter are considered to be able to improve the physical, chemical, and biological properties of the soil. This study aims to determine the influence of organic matter application and the application of mycorrhizal types and the interaction between these two factors on the growth and yield of chili plants in saline soil. The design used in this experiment was a Randomized Design of Factorial Pattern Groups (RAK) 4 × 3 with 3 replicates, so that it had 12 treatment combinations consisting of above 2 treatment factors. The first factor is the type of Mycorrhiza (M) which consists of 4 levels: M0 = Control, M1 = 5 g/plant, M2 = Glomus Moseae and M3 = Acaulusspora.The second factor is the type of organic matter (O) consisting of 3 levels, namely O0 = Control, O1 = 10 tons/ha, O2 = 20 tons/ha. The results of this study are that the type of mycorrhiza has a very real effect on the height of plants aged 15 HST, 30 HST, 45 HST, has a very real effect on the number of leaves aged 30 HST and 45 HST and root infections aged 45 HST, has a real effect on the diameter of the stem at the age of 15 HST, The growth and yield of chili plants are best found in the mycorrhiza type Glomus Moseae 10g. Organic matter had a significant effect on plant height of 15, 30 and 45 HST, stem diameter of 15, 30 and 45 HST and Number of Leaves 15, 30 and 45 HST.

INTRODUCTION

The use of coastal areas as agricultural areas has not yet been applied in the general community. Coastal areas with saline conditions and sandy soils make it difficult for plants to live optimally. Farmers in coastal villages have not used coastal areas as agricultural land because of the soil medium that is difficult to plant and also in saline conditions that can poison plants (Barus & Rauf, 2021). Saline soil is a soil that contains a lot of salt where many plants have not been able to adapt, providing other inputs is a solution in suppressing saline stress for plants (Yan et al., 2013). The main cause of low soil fertility and stress in plants is the high salt content in the soil (Masganti et al., 2022). With the help of mycorrhizae, plant growth is getting better and also shows an increase in growth or development in the soil with a grip.

Biological Agents that can tolerate saline stress on coastal soils by using Mycorrhizal Fungi so that plants are able to survive and be productive on coastal lands that are classified as saline. Another effort that can be made to overcome salinity stress in plants is by FMA inocnation. FMA applications can overcome salinity stress through various mechanisms such as increasing nutrient uptake, producing plant growth hormone, and changing the physiological and biochemical properties of host plants. The function of arbuscule mycorrhiza (FMA) is a symbiotic root symbiont with the majority of higher plants and is generally found in terrestrial ecosystems (Doudi et al., 2019). This symbiosis can benefit plants through several ways, including increasing nutrient uptake, especially P (Rohmnaurriza, 2020).

Mycorrhizal mushrooms have hyphae that spread widely into the soil, further than the distance that the root hairs can reach. With this hyphae, it can help absorb P nutrients around the roots of the hair or those far from the root hair. Mycorrhizal root areas will be more active in absorbing nutrients for a long period of time compared to non-mycorrhizal roots (Rivana et al., 2016). Organic compounds play an important role in the soil, namely as a source of nutrients for microbes, and can also create physical and biochemical conditions of the soil so that it is optimal for plants. The existence of organic compounds has been shown to be positively correlated with microbial enzyme activity, water binding power and preventing evaporation during dry air (Idhan & Nursjamsi, 2016).

The use of FMA as a biological agent in agriculture and forestry can improve plant growth, productivity and quality without damaging the soil ecosystem. In addition, the FMA application can help rehabilitate critical lands and increase crop productivity on marginal lands, including saline soils. The role of mycorrhiza in saline soils includes helping plant growth in terms of improving plant nutrition by increasing nutrient uptake, especially phosphorus, as a biological protector and helping to increase plant resistance to drought (Hadijah, 2014). Another effort that can be made to overcome salinity stress in plants is by FMA inocnation. FMA applications can overcome salinity stress through various mechanisms such as increasing nutrient uptake, producing plant growth hormone, and changing the physiological and biochemical properties of host plants. FMA inoculation can also improve the physiological processes of the host plant such as increasing the nutrient absorption capacity by the plant by increasing the hydraulic pressure of the roots and maintaining the osmotic pressure and carbohydrate composition (Ardiansyah et al., 2014) Plants can be tolerant to NaCl because it has the ability to resist the toxic effects of NaCl and nutrient imbalance.

Tolerance to K deficiency can be possessed by plants that are able to utilize Na to replace some of the needed K. The development of salt-tolerant crops or soil desalination with excessive salt leaching, although successful, is not economical for sustainable agriculture. In this case, biological processes such as the application of mycorrhiza to alleviate salt stress and the use of tree species that are sufficiently salt tolerant are better options. Reclamation of saline land with multipurpose trees from Multy Purpose Tree Species (MPTS) such as Sesbania and Acacia sp. which is a legum tree that is quite salt tolerant, usually used to overcome salt stress problems. However, these trees usually show a great dependence on mycorrhiza.

METHODOLOGY

This research will be carried out in 1 year of activities with the following procedures:

Application of Mycorrhizal Fungi and Application of Organic Matter to Coastal Sandy Soil Media with Copy Grip on the Growth and Yield of Cayenne Pepper (Capsiccum frustescens L) was carried out on the coast of Kuala Raja Village, Kuala District, Bireuen Regency, Center for Research and Business of Agricultural Sciences of the National Islamic University of Indonesia, Aceh Agricultural Technology Assessment Laboratory, Horticulture Laboratory, Soil Microbiology Laboratory and Soil Biology Laboratory of the Faculty of Agriculture Syiah Kuala University, Darussalam Banda Aceh.

The design used in this experiment was a Randomized Design of Factorial Pattern Groups (RAK) 4 × 3 with 3 replicates, so that it had 12 treatment combinations consisting of above 2 treatment factors. The first factor is the type of Mycorrhiza (M) which consists of 4 levels: M0 = Control, M1 = 5 g/plant, M2 = Glomus Moseae and M3 = Acaulusspora.The second factor is the type of organic matter (O) consisting of 3 levels, namely O0 = Control, O1 = 10 tons/ha, O2 = 20 tons/ha

FMA application is carried out at the time of seed seeding. The seedling medium uses a mixture of top soil and manure according to the treatment. The soil is put into a pot tray measuring 50 holes, each hole is filled with planting medium and given FMA inoculant according to the treatment and the seeds are sown on the planting medium that has been given FMA. The seedbed is placed on the seeding rack. Watering is carried out to a wide capacity. Plant growth is observed until the plant is 4 weeks old after sowing (MSS). Basic fertilizer application with Phonska, SP36 (type of 50% fertilizer recommended for cultivation

This research activity will be carried out in the plastic house of the partner pema farm garden from the National Islamic University of Indonesia by bringing coastal soil from Kuala village, Bireuen Regency using a pick-up car and putting the soil in a 15 kg polybag according to the number of sample plants and reserves with 3 replicates.

Observation of Variables of Cayenne Pepper Plants such as:

1. **Plant height (cm)**

   Plant height measurements are carried out when plants are 15, 30 and 45 HST old, plant height is measured from the base of the stem that has been marked to the highest leaf tip. Observations were made on sample plants in each polybag. Plant height measurement using a meter, then the results of the sample plant measurements are averaged in the observation table.

2. **Rod diameter (cm)**

   Stem diameter measurements were carried out when the plants were 15, 30 and 45 HST old using a caliper. The trick is to place a caliper at the base of the trunk that has been marked for measuring the diameter of the base of the trunk.

3. **Number of leaves per plant (leaves)**

   The number of leaves is calculated when the plant is 15, 30 and 45 HST old by calculating the number of leaves on each chili plant stem

4. **Number of productive branches per plant (branches)**

   The number of primary branches is calculated when the plant is 45 HST old by calculating the number of primary branches in each plant.

RESULTS

Plant height (cm)

The average yield of chili plants at the age of 15, 30 and 45 HST with mycorrhizal treatment can be seen in table 1. The average yield of chili plants at the age of 15, 30 and 45 HST with mycorrhizal treatment can be seen in table 1.

Table 1: The average plant height is 15.30 and 45 HST with mycorrhizal treatment on chili plants

Types of mycorrhiza (10g/plant)		**Plant height**	
	15 HST	**30 HST**	**45 HST**
Kontrol	9,60c	11,37c	18,42ab
Glomus sp	8,02ab	9,37b	19,32c
Gigaspora sp	9,70c	12,5d	19,22c
Mixture	7,85a	8,62a	18, 23a
BNJ 0,05	0,47	1,16	1,96

Remarks: The number followed by the letter has an effect on the BNJ 0.05 follow-up test

Table 1 shows that the treatment of mycorrhiza has a very real effect on plant height at the age of 15 HST where the best treatment is in the treatment of Gigaspora type mycorrhiza with Glomus Moseae type which is (9.70 cm), The lowest average plant height is found in the treatment of mixed mycorrhiza type is not significantly different from the Glomus type of mycorrhiza but is significantly different from the control.

Table 1 shows that the treatment of mycorrhizal type has a very real effect on plant height at the age of 30 HST and 45 HST. Where the best treatment at the age of 30 HST is found in the type of Gigaspora mycorrhiza (12.5 cm), at the age of 45 HST the best treatment is found in Glomus mycorrhiza (19.32 cm) but it is significantly different from other treatments. This is because the elements contained in the treatment given are able to meet plant nutrients well so that they provide very good plant growth. This is also in line with the results of research from (Syamsiyah et al., 2014), which stated that plants fed with mycorrhiza have high absorption of N and P nutrients, because mycorrhiza promotes the development of hyphae in plant roots. This is also explained by research (Octavianti, 2014) which reports that mixed mycorrhiza (Glomus and Gigaspora) have good adaptability and development in tropical and polluted areas.

Number of leaves

The average results of the number of chili leaves at the age of 15, 30 and 45 HST with mycorrhizal treatment can be seen in table 2.

Table 2: The average number of leaves aged 15, 30 and 45 HST with mycorrhizal treatment on chili plants

Types of mycorrhiza (10g/plant)	Number of leaves per plant (strands)		
	15 HST	30 HST	45 HST
Kontrol	8,7b	12,5c	15,1b
Glomus sp	8,2b	11,6b	15,2b
Gigaspora sp	9,5c	14,2d	17,1c
Mixture	6,7a	10,0a	13,1a
BNJ 0,05	1,08	1,012	2,30

Remarks: The number followed by the letter has an effect on the BNJ 0.05 follow-up test

Table 2 shows that mycorrhizal treatment has a significant effect on the number of leaves per plant at the age of 15 HST where the best treatment is in the treatment of Gigaspora mycorrhiza with Glomus Moseae (9.5), The lowest average plant height is found in mixed mycorrhizal treatment is not significantly different from Glomus mycorrhiza and control mycorrhizal species.

Table 2 shows that the treatment of mycorrhizal species has a very real effect on plant height at the age of 30 HST and 45 HST. Where the best treatment at the age of 30 HST was found in the Gigaspora mycorrhiza type (14.2), at the age of 45 HST the best treatment was in the Gigaspora mycorrhiza type (17.1) but it was significantly different from other treatments. This shows that this type of mycorrhiza can help the growth of chili plants well. With chlorophyll, it will increase the photosynthesis process which will affect both the number of leaves and the area of leaves. The transport of photosynthetic products to the roots determines the ability of the roots to absorb and obtain nutrients. Mycorrhiza has an external hyphae network where the hyphae have a finer size than the root hairs which allows 37 to enter the smallest (micro) soil pores so that it can absorb water at very low soil moisture content conditions. Mycorrhiza-infected root cells will increase in size. This is due to extracellular hyphae that expand the nutrient absorption surface (Fitriani, 2016).

Rod diameter

The average results of the diameter of chili stems at the age of 15.30 and 45 HST with mycorrhizal treatment can be seen in table 3.

Table 3: The average stem diameter is 15.30 and 45 HST with mycorrhizal treatment on chili plants

Type of mycorrhiza (10g/plant)	Stem diameter per plant		
	15 HST	30 HST	45 HST
Kontrol	0,15a	0,25a	0,55a
Glomus sp	0,16b	0,27b	0,58b
Gigaspora sp	0,22d	0,28c	0,65c
Mixture	0,18c	0,32d	0,60d
BNJ 0,05	0,025	0,055	0,031

Remarks: The number followed by the letter has an effect on the BNJ 0.05 follow-up test

Table 3 shows that the treatment of mycorrhiza has a significant effect on the diameter of the stem at the age of 15 HST where the best treatment is in the treatment of Gigaspora mycorrhiza with Glomus Moseae (0.22), The lowest average plant height is found in the control treatment but is significantly different from the Glomus and mixed mycorrhizal types.

Table 3 shows that mycorrhizal treatment has a negligible effect on the diameter of the stem at the age of 30 HST and has a real effect at the age of 45 HST. Where the best treatment at age 30 HST was found in mixed mycorrhiza (0.32), at 45 HST the best treatment was found in Gigaspora mycorrhiza (0.65) but slightly different from mixed treatment and Glomus. This shows that this type of mixed mycorrhiza is superior in the absorption of P nutrients so that it can increase the yield and growth of chili plants. This is in line with the statement (Muzaffarsyah et al., 2022) that the combination of Glomus mosseae and Gigaspora sp. is the type of mycorrhiza that has the most dominant distribution with symbiosis ability and wider adaptation to cultivated plant types when compared to single mycorrhizae. The results of the study (Matondang et al., 2020) stated that the use of mycorrhizal types and types can affect the increase in the growth and production of various plants and plant quality without reducing the quality and productivity of soil ecosystems.

Percentage of mycorrhiza-infected roots (%)

The average percentage of roots infected with mycorrhiza in chili plants at the age of 45 HST with mycorrhizal treatment can be seen in table 4.

Table 4: Average percentage of roots infected with mycorrhiza aged 45 HST with mycorrhizal treatment on chili plants

Type of mycorrhiza (*Glomus Moseae*)	Number of root infections per plant (%)
Kontrol	15,16a
Glomus sp	27,92cd
Gigaspora sp	26,90b
Mixture	27,08c
BNJ 0,05	3,747

Remarks: The number followed by the letter has an effect on the BNJ 0.05 follow-up test

Mycorrhizal treatment was found in the better type of mycorrhizal Glomus (27.92), Glomus Moseae, The lowest average of plant root infection was found in the control treatment, significantly different from the Glomus and mixed treatments. This shows in previous studies that showed the growth and yield of chili plants such as root colonization in chili plants, and the best type was found in the 10g mycorrhiza type/plant., This is in line with research (Azman, 2016) which showed that the 10 g mycorrhiza type per plant was better for the growth and yield of chili plants, which was shown from the wet weight parameter of the plant, plant dry weight, plant fruit weight, number of fruits, yield potential and root colonization in chili plants (Adtiali, 2022) Temperature can also affect many plant growth and development processes, such as respiration, photosynthesis, dormancy, flowering and fertilization. Cold temperatures slow down photosynthesis, slowing down growth and development. Ambient temperature.

Effect of organic matter on growth and yield of chili plants

1. Plant height (cm)

The average height of chili plants at the age of 15, 30 and 45 based on Organic Matter Treatment Table 5.

Table 5: Average plant height in organic material treatment at 15.30 and 45 HST ages

Organic Material Treatment	Plant height (cm)		
	15 HST	30 HST	45 HST
Control	37,07b	46,00b	89,20b
10 ton/ha	33,47a	37,75a	61,22a
20 ton/ha	38,24c	47,16c	90,20c
BNJ 0,05	0,66	1,64	2,77

Remarks: The number followed by the letter has an effect on the BNJ 0.05 follow-up test

Table 5 shows that plant height at the age of 15 HST has a very real effect on the 20 tons/ha (38.24) Organic Material control treatment that has been carried out. At the age of 30 HST, the highest plant height was found in the treatment of 20 tons/ha (47.16), at the age of 45 HST, the highest plant height was also found in the treatment of 20 tons/ha, which was significantly different from other treatments.

2. Rod diameter

Rata rata diameter batang cabai pada umur 15, 30 dan 45 berdasarkan perlakuan Bahan Organik Tabel 6.

Table 6: Average stem diameter in organic matter treatment at 15, 30 and 45 HST age

Organic Material Treatment	Rod diameter		
	15 HST	30 HST	45 HST
Control	0,70a	1,10a	2,35a
10 ton/ha	0,75c	1,17a	2,42ab
20 ton/ha	0,71ab	1,15a	2,51bc
BNJ 0,05	0,03	0,07	0,09

Remarks: The number followed by the letter has an effect on the BNJ 0.05 follow-up test

Table 6 shows that the diameter of the stem at the age of 15 HST has a real effect on the treatment of 10 tons/ha of Organic Material (0.75). At the age of 30, HST had a significant effect on the diameter of the planting stem, the better value was found in the treatment of 10 tons/ha (1.17). At the age of 45, HST has a real effect on the diameter of the planting stem, the better value is found in the treatment of 20 tons/ha (2.51) although it is different from the application of other organic matter.

3. Number of leaves (strands)

The average number of chili leaves at the age of 15, 30 and 45 based on the treatment of Organic Matter Table 7.

Table 7: Average number of leaves in Organic matter treatment at the age of 15, 30 and 45 HST

Organic Material Treatment	Number of leaves (strands)		
	15 HST	30 HST	45 HST
Control	32,75a	55,75b	67,25b
10 ton/ha	33,75b	41,00a	54,00a
20 ton/ha	34,57c	58,47c	87,99c
BNJ 0,05	1,42	1,43	2,52

Remarks: The number followed by the letter has an effect on the BNJ 0.05 follow-up test

Table 7 shows that the number of leaves at the age of 15 HST has a real effect on the treatment of 20 tons/ha of Organic Material (34.57) that has been carried out. At the age of 30 HST had a real effect on the number of leaves per plant, the highest value was found in the treatment of 20 tons/ha (58.47) Organic matter at the age of 45 HST had a real effect, the number of leaves of the plant had the highest value was found in the treatment of 20 tons/ha (87.99).

DISCUSSION

The results of the study show that Organic Matter has a very real effect on the yield of chili plants. The best Organic Material is found in Organic Matter 20 tons/ha in the generative phase which can be seen from the weight parameters of 110 HST old crops and 45 HST mycorrhizal infections.

During the growth period, the best plant growth quality is found in local organic matter of 10 tons/ha. This shows that 10 tons/ha of Organic Matter is able to compete with 20 tons/ha of Organic Matter, although it does not have a real influence. 10 tons/ha has also given the highest response during the growth period of chili plants. This is evidenced in several parameters in growth such as plant height aged 45 HST, stem diameter aged 15, 30 and 45 HST, number of leaves aged 45 HST, and providing the best value.

Organic matter of the 20 tons/ha type has superior properties that are able to achieve maximum production, in contrast to 10 tons/ha which can survive longer but does not provide maximum yield

with a shorter growth life compared to Organic Matter. There have been many studies on the use of organic matter to improve coastal sand soils, the results of the study (Hasibuan, 2015) show that with organic matter and carbide waste of 20 tons per hectare in the beach sand soil actually increases the number of clay fractions, dust, micropores, elasticity levels, decreases volume weight, specific gravity and increases fresh weight, dry weight, oven dry weight and onion bulb diameter compared to control. The results of the study (Prasetyo, 2014) show that the application of chicken manure up to 20 tons per hectare actually improves soil quality (organic matter content and KPK). This means that the organic matter has better capabilities and can be used as an improvement for the sandy soil of Kulon Progo beach.

The ability to store water in the soil is determined by the porosity and content of organic matter in the soil. A high total soil porosity of 35 will store higher water. Soil organic matter also plays a role in the availability of water in the soil, because organic matter can hold water well and can increase the total porosity of the soil. Therefore, by having a higher total porosity of soil and soil organic matter, the P4 treatment has a higher water availability than other treatments. The application of organic matter in the form of compost will form more micropore spaces, where micropores are pores that the soil uses to bind water. The more micro pore spaces are formed, the soil will have an increasing storage capacity, the soil will fill the soil pore space, usually the filled soil pore space is large pores, first fill the micro pores. If there is evaporation or use of water by plants, the large pores are left by water first and then follow the micropores.

Sandy soil is soil whose sand fraction content is dominant or greater than 50% of the total fraction. In (Ginanjar, 2017) states that in general, sandy soils have a rough texture, the aggregate is weak to not aggregated, porous, has a low storage capacity and is susceptible to water and wind erosion. One of the efforts to increase the productivity of this beach sand land is to manage the availability of nutrients by including various materials that can improve physical properties and increase and maintain the availability of nutrients in the soil.

The results of the research conducted showed that mycorrhiza had a very real effect on the growth of chili plants. The best types of mycorrhiza are found in Glomus Moseae. This shows that the type of Glomus Moseae in chili crops on coastal soils has given the best results both in the generative phase which can be seen in the parameters of the number of cultivated fruits and the most mycorrhizal infections in the vegetative phase.

This is in line with (Hermawan et al., 2023) best growth and yield of red chili plants is found in the application of mycorrhizal type 10 g/plant to the weight variables of the crop fruit (16.56 g), mycorrhizal colonization in the roots of vegetative vase plants (72.67%) and mycorrhizal colonization in the roots of plants in the generative phase (78.38%). Hazra et al, (2023), mycorrhizal administration can multiply spore populations and the percentage of mycorrhizal infections in roots.

In research (Maulana & Harahap, 2023) shows that the application of FMA Glomus Moseae is quite effective in colonization of plant roots. Plants infected with FMA will be stronger to survive in dry conditions because hyphae fungi are able to absorb water in the soil through soil pores. Hyphae in the soil can spread widely which helps in the absorption of more water (Murni & Purnamayani, 2019)

The high NaCl content in coastal areas causes the soil to become saline so that only certain plants can grow normally. The salt content in the soil will affect the growth and production of plants. According to (Khairuna, 2019) saline causes hypertonic soil solution against cell fluid, which in turn will cause the flow of cell fluid into the soil around the roots, as a result of which the roots cannot suck the nutrient-containing solution and plant cells will eventually die due to lack of water. Indirectly, the high salt content in the soil can cause a decrease in groundwater that is able to be absorbed by plants and this event will cause plants to wilt physiologically. The amount of NaCl levels in the soil can occur due to the high input of water containing salt or because the evaporation rate exceeds precipitation. This means that saline soils are not only found in coastal areas, but also in dry areas with low rainfall (Karolinoerita & Annisa, 2020) Sodium (Na+) is also important for carbon fixation in C4 crops, such as maize, sugarcane and sorghum crops. While C3 crops include rice, wheat, and soybean crops. According to (Maulana, 2020), the application of mycorrhiza Glomus sp and Gigaspora sp to various types will give a high response to cayenne pepper plants compared to without mycorrhizal

application. (Maulana & Harahap, 2023) states that applying the right type of mycorrhiza to plants will have a real influence on plant growth.

CONCLUSION

The high NaCl content in coastal areas causes the soil to become saline so that only certain plants can grow normally. The salt content in the soil will affect the growth and production of plants. The type of mycorrhiza has a very real effect on the height of plants aged 15 HST, 30 HST, 45 HST, has a very real effect on the number of leaves aged 30 HST and 45 HST and root infections aged 45 HST, has a real effect on the diameter of the stem aged 15 HST, The growth and yield of chili plants are best found in the type of mycorrhiza Gigaspora sp 10g. Organic matter had a significant effect on plant height of 15, 30 and 45 HST, stem diameter of 15, 30 and 45 HST and Number of Leaves 15, 30 and 45 HST.

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