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Research Article
Growth and Yield of Chili Pepper (*Capsicum annuum* L.) on the Growing Media of Entisol Aceh Using Various Endomycorrhizae

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Abstract

Objective: This study aims to understand the effect of various endomycorrhizae on the growth and yield of chili peppers, percentage of infected roots and available P on the growing media of entisol Aceh. **Methodology:** The study was arranged a randomized block design non factorial design with three replications. The tested factor endomycorrhizae, consisting of four level namely: M0: Without endomycorrhizae, M1: *Glomus mosseae*, M2: *Gigaspora* sp. and M3: Mixture of *Gigaspora* sp. and *Glomus mosseae*. This study was carried out at the greenhouse of Faculty of Agriculture of Syiah Kuala University as well as the Laboratories of Plant Physiology, Soil and Plant Research Laboratory of Faculty of Agriculture of Syiah Kuala University. **Result:** The result showed that the use of endomycorrhizae affected the growth and yield of chili peppers, percentage detection of mycorrhizae infected roots, available P on the growing media of entisol Aceh. There were no differences between the two types of endomycorrhizae in regard to the growth and yield of the chili pepper. **Conclusion:** Endomycorrhizae also affected the growth and yield of the chili peppers, percentage of infected roots and available P on the growing media of entisol Aceh.

Key words: Growth, yield, endomycorrhizae, chilli peppers, entisol, growing media, infected, detection

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Chili pepper is one of the most important vegetables in Aceh, Indonesia, both for international export and national consumption. According to Harpenas and Dermawan[1] and Syafruddin *et al.*[2] it has a high nutritional and economic value. In Indonesia the national productivity of chili pepper was still very low, producing only a total 7.34 t ha^{-1}. Based on Central Statistic Aceh[3] only produced 6.54 t ha^{-1} in 2013. Usually the national productivity of chili pepper in Indonesia has the potential to reach up to 12 t ha^{-1}. There need to be an improvement to the productivity of plant biomass through using agent of biological control such as bacterial[4,5] and mycorrhizal[6], fertilization[7] and also intensification and extensification of land farming[8].

Mycorrhizaeis a microorganism that can enhance a crop's growth and yield also absorbtion of nutrient and water. Mycorrhizal is one of soil microorganism also playes a role in improving chili peppers both growth and yield. It was presumed that the relationship between several mycorrhizae and entisol found on coastal land affects the growth and yield of chili peppers. Yusnizar *et al.*[6] and Jumini and Razali[9] reported that endomycorrhizae fungus *Glomus mosseae* and *Gigaspora* sp. was really increased of growth and yield chili peppers in entisol soil. Some study showed that a combination of mycorrhizae and phosphate can enhance the growth and yield of chili peppers, infected roots and increase available P on growing media[2,10,11]. Additional in conventional farming also can reduce the use of NPK fertilizer up to 25-50% of the standard dose[5,12] of 1000 kg ha^{-1}.

Difference of location and the rhizosphere cause differences in species diversity and population of the Arbuscular Mycorrhizal Fungi (AMF). Soil dominated by clay fraction (clay) is a condition that suspected correspond to the development of *Glomus* spores and in sandy soil *Gigaspora* genus are found in high amounts. In the sandy soil, the soil pores are formed larger than clay and is alleged to correspond to the state of development of the spores *Gigaspora* larger than *Glomus* spores[13]. Additional, Namanusart[14] noted that the differences between several mycorrhizal fungi, *Gigaspora's* spore is of white cream color and has a diameter of 260-400 mm whereas *Glomus'* spore is of yellow-light to dark brown colour and has a diameter of 195 mm. It was mean that the differences of location, shape and size between the genera will result in different types of effectiveness to mycorrhizal infected crops. The objective of this study to investigate effect of various endomycorrhizae on the growth and yield of chili peppers, percentage detection of mycorrhizae infected roots, available P on growing media of entisol Aceh.

MATERIALS AND METHODS

The pot experiment was carried out in the greenhouse. While soil analysis performed at the Laboratory of Soil and Plant and measuring infection of root by AMF was conducted at the Plant Physiology Laboratory, Faculty of Agriculture, Syiah Kuala University, Banda Aceh, Indonesia. The stages of this study are soil preparation, compatibility test between chili pepper varieties and endomycorrhizae, seed preparation and treatment, nursery, initial soil analysis, sterilization and preparation of the growing media, application of mycorrhizae, planting and maintenance of plant, harvesting, detected of mycorrhizal infected root and final analysis of available P on the growing media.

Soil preparation and initial soil analysis: The experimental soil used was entisol from Lampuuk Aceh Besar mixed with organic manure 500 g kg^{-1}. Soil pH was 7.25 with sandy loam texture. The soil was put in a pot experiment consisted of 12 kg soil. Initial soil analysis was carried out before planting process to find out about the physical and chemical properties before it was made into a growing media. The results of this initial soil analysis will be compared to the final growing media analysis. Characteristic of experimental soil can been seen in Table 1.

Compatibility test between chili pepper varieties and endomycorrhizae: The preliminary experiment in this study was the compatibility test between chili peppers of PM 999, Lado F1 and CTH-01 hybrid varieties and endomycorrhizae during the nursery process. The compatible variety was then used in the study. Parameter was observed in this test the mycorrhizae infection percentage on the roots of

Table 1: Characteristic of soil experiment (Entisol)

Parameters	Values	Method
pH H_2O	7.25	pH 1:2.5
pH KCl	6.30	pH 1:1.25
C-organic (%)	1.64	Walkley and Black
N total (%)	0.22	Kjeldahl
P av (ppm)	4.06	Bray II
Exch. Ca (cmol kg^{-1})	3.00	NH_4COOCH_3 pH 7
Exch. Mg (cmol kg^{-1})	0.30	NH_4COOCH_3 pH 7
Exch. K (cmol kg^{-1})	0.19	NH_4COOCH_3 pH 7
Exch. Na (cmol kg^{-1})	0.39	NH_4COOCH_3 pH 7
CEC (cmol kg^{-1})	12.80	NH_4COOCH_3 pH 7
Base saturation (%)	30.31	1 M KCl
Electrical conductivity (mS cm^{-1})	0.25	EC
Texture	Sandy loam	Pipette
	Sand 76.00%	
	Silt 10.00%	
	Clay 14.00%	

Source: Laboratory analysis, 2015

the chili peppers. Results of the preliminary experiment test showed that the most compatible chili pepper variety was Lado F1.

Nursery: The seed were soaked in clean water for 12 h and germinated for 3-4 days. After the germination process, the sprouts were then moved into the polybags nursery which has been filled with entisol soil. During the nursery period, the sprouts were watered every day and sprayed with organic pesticides.

Sterilization and preparation of the growing media: The objective of this sterilization was to remove microorganism from the growing media. The sterilization was conductive by autoclave at 120°C for 30 min. The growing media consisted of entisol soil obtained from Lampuuk Aceh Besar. The soil experiments were given organic manure 250 g polybag^{-1} in 12 kg capacity polybag.

Application of endomycorrhizae: The types of endomycorrhizae using the mycorrhizae *Glomus mosseae, Gigaspora* sp. and a mixture of both. Each plant was given 15 g of endomycorrhizae during the planting process to their treatment[2].

Planting and maintenance of plant: The chili peppers were planted after seedling for 24 days in the nursery. The growing media were watered until it reached field capacity before planting. The planting was simultaneously done with visually uniform seedling. Maintenance of the plant included watering, follow-up fertilization using 1/4 dose 250 kg ha^{-1} or 2.5 g polybag^{-1} of Mutiara NPK fertilizers at 30 days after transplanting, pest control physical and mechanical means as well as the use of organic pesticides, removal of orthrotopic branches, installation of stakes and binding.

Harvesting: Chili peppers were harvested after it has turn 100% red or 90 days after transplanting. Commonly the harvesting was done in every 5 days.

Observation parameter: The parameter observed in this experiment were (1) Plant height at 30, 50 and 70 days after transplanting, (2) Fruit quantity, (3) Fruit weight, (4) Percentage detection of mycorrhizae[15] and (5) Available P on the growing media.

Statistical analysis: The effects of the various endomycorrhizae on growth and yield of chili pepper, percentage of infected roots and available P on the growing in entisol Aceh. Would be evaluated by using ANOVA ($p<0.05$) and proceed with Least Significant Difference (LSD) test at level 5% to determine significant differences between treatments.

RESULTS

Plant height: The results showed the significance of endomycorrhizae on the height of 30, 50 and 70 DAT plants. The application of the endomycorrhizal fungus *Glomus mosseae* produced the tallest height. However, it has a non-significant difference compared to the mixture of the endomycorrhizal fungus *Glomus mosseae* and *Gigaspora* sp. at 30, 50 and 70 DAT.

Fruit quantity: The results indicated that endomycorrhizae have a significant effect on the quantity of chili pepper fruits. The endomycorrhizae fungus produced the largest amount-although the differences are non-significant-among other endomycorrhizae.

Fruit weight: The result showed that endomycorrhizae affected on the weight of chili pepper fruits. The mixture of endomycorrhizae fungus *Glomus mosseae* and *Gigaspora* sp., produced the heaviest weight. However it has non-significant difference compare to other endomycorrhizae.

Percentage detection of mycorrhizae infected roots: The results indicated that endomycorrhizae affected the percentage detection of mycorrhizae infected roots of chili peppers. The endomycorrhizal fungus *Gigaspora* sp., produced the highest percentage detection, though it has a non-significant difference compare to other mycorrhizal.

Available P on the growing media: The result showed that the endomycorrhizae affected the final analysis of available P on the chili peppers' growing media. The mixture of the endomycorrhizal fungus *Glomus mosseae* and *Gigaspora* sp., produced the highest value of final analysis of available P and has significant difference compared to other types of endomycorrhizae.

DISCUSSION

Utilization of various endomycorrhizae in enstisol soil could be increased in growth and yield of chili pepper. Usually the increase in chlorophyll content which affects plant growth

Table 2: Average value of endomycorrhizae to plant height (cm) at 30, 50 and75 Day After Transplanting (DAT)

	Day After Transplanting (DAT)		
Endomycorrhizae	30	50	70
Without mycorrhizae	28.49[a]	60.29[a]	94.58[a]
Glomus mosseae	33.75[b]	83.46[c]	129.73[c]
Gigaspora sp.	27.79[a]	70.94[b]	114.20[b]
Mixture of *Glomus mosseae*+*Gigaspora* sp.	30.74[ab]	80.02[bc]	121.77[b]
$LSD_{0.05}$	5.04	10.10	7.57

Value followed by the same letter, the same columns is not significantly different at LSD test (p<0.05)

Table 3: Average value of various endomycorrhizae on the quantity of chilli pepper fruits

Endomycorrhizae	Fruit quantity (U)
Without mycorrhizae	48.67[a]
Glomus mosseae	67.17[b]
Gigaspora sp.	59.00[b]
Mixture of *Glomus mosseae*+*Gigaspora* sp.	59.09[b]
$LSD_{0.05}$	9.96

Value followed by the same letter, the same columns is not significantly different at LSD test (p<0.05)

Table 4: Average value of various endomycorrhizae on the weight of chilli pepper fruits

Endomycorrhizae	Fruit weight (g)
Without mycorrhizae	95.07[a]
Glomus mosseae	117.59[b]
Gigaspora sp.	113.08[b]
Mixture of *Glomus mosseae*+*Gigaspora* sp.	119. 98[b]
$LSD_{0.05}$	17.17

Value followed by the same letter, the same columns is not significantly different at LSD test (p<0.05)

is influenced by nitrogen elements[16] and dose and types of mycorrhizal[2,17] on growth and yield chili peppers. The application of mycorrhizae clearly influenced in the weight of chili pepper fruits despite the absence of any significant differences between the results, even after mixing them together. Its similar to study who have been conducted by Safrianto *et al.*[10] and Syafruddin *et al.*[2].

Based on the Table 1, entisol soil was low content of nutrient especially nitrogen , phosphorous and potassium. Endomycorrhizae clearly effective to absorb P and other nutrient in entisol soil on growth and yield of chili peppers. Available phosphorous, nitrogen and potassium was affected in quantity and weight of chili peppers. Syafruddin *et al.*[2] noted that the application of mycorrhizal clearly influenced the weight and quantity of chili peppers fruits. Endomycorrhizae was affected in quantity and weight of chili peppers fruits (Table 2-4). Mycorrhizal could be increase nutrient absorption-especially phosporous and potassium through its external hyphae[10,15] which directly affects the weight of chili pepper fruits. One of the limiting factors for using entisol soil was lack and low content of water and its

Table 5: Average value of various endomycorrhizae on the percentage of mycorrhizae infected roots of pepper fruits

Endomycorrhizae	Percentage of mycorrhizae infected roots
Without mycorrhizae	4.82[a]
Glomus mosseae	17.72[b]
Gigaspora sp.	17.93[b]
Mixture of *Glomus mosseae*+*Gigaspora* sp.	17.66[b]
$LSD_{0.05}$	0.50

Value followed by the same letter, the same columns is not significantly different at LSD test (p<0.05)

Table 6: Average value of various endomycorrhizae on the available P on the chili pepper' growing media

Endomycorrhizae	Available phosphorous
Without mycorrhizae	2.82[a]
Glomus mosseae	4.06[b]
Gigaspora sp.	4.00[b]
Mixture of *Glomus mosseae*+*Gigaspora* sp.	4.02[b]
$LSD_{0.05}$	1.17

Value followed by the same letter, the same columns is not significantly different at LSD test (p<0.05)

affected on water holding capacity. Lack of water can cause weight deficiency to the fruits. Syafruddin *et al.*[17] reported that the symbiotic relationship between roots and mycorrhizal can enhance nutrient uptake and water absorption.

The rate of infection of the roots by endomycorizae largely determine to the growth and yield of chili peppers. Safrianto *et al.*[10] and Syafruddin *et al.*[17] stated the number of root infection by the AMF shows that plants are able to absorb P and other elements effectively. Langer *et al.*[15] stated the type of mycorrhiza and the environment directly determines the level of infection by mycorrhizal roots. The rate of infection will be correlated with nutrient uptake and water in the soil. Roots by mycorrhizal infection rate in this study was relatively the same and not different from each other (Table 5).

The ability of mycorrhizae in root infecting be correlated to the level of availability of P in the growing media of chili peppers. Endomicorrhizae fungus of mixture *Glomus mosseae* +*Gigaspora* sp. was produced the highest value of available P and different from other mycorrhizal treatment (Table 6). It was mean this finding was similar to Nurmasyitah *et al.*[16] and Khairuna *et al.*[18] study. They reported that there were differences between the endomycorrhizae in helping the release of soil-bound P elements. The P element whose function is to form nucleid acid, phosphatide, chromosome and coenzyme in plants.

CONCLUSION

The use of endomycorrhizae also affected the growth and yield of the chili peppers, percentage of infected roots and available P on the growing media of entisol Aceh.

However, there were no differences between the various endomycorrhizae. In addition, the issue of the limited amount of available P and other nutrient in entisol soil can be solved by adding endomycorrhizae to the soils. Field-scale studies need to be done to compare the growth and yield of chili peppers by using different varieties and doses of endomycorrhizae.

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