International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 13, No. 1, p. 46-54, 2018

RESEARCH PAPER OPEN ACCESS

The effect of dosage of mycorrhizal fertilizer on growth and yield of some varieties of chilli (*Capsicum annuum* L.) on Inceptisol Krueng Raya Aceh Besar

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Article published on July 24, 2018

Key words: Mycorrhiza, Varieties of chilli, Inceptisol, *Capsicum annuum, Glomus mosseae*

Abstract

The effect is to obtain information on the use of mycorrhiza to solve the problem at Inceptisol Krueng Raya Aceh Besar. This study aims to determine the application of the best dosage of mycorrhiza and chilli varieties suitable to be cultivated on the Inceptisol Krueng Raya Aceh Besar to increase the production of chili. This study was conducted with a randomized block design with three replications. The first factor is mycorrhizal dose with four levels: without mycorrhiza (M_0), mycorrhiza *Glomus mosseae* 5 g plant^{-1} (M_1), mycorrhiza *Glomus mosseae* 10 g plant^{-1} (M_2), mycorrhiza *Glomus mosseae* 15 g plant^{-1} (M_3) and the second factor is chili variety with four levels: Odeng (V_1), Lado (V_2), Laris (V_3), PM999 (V_4). The results showed that with the use of Mycorrhiza *Glomus mosseae* 10 g plant^{-1} with the use of Odeng Varieties can increase yield on plant height (70,67), stem diameter (0,633) and fruit weight (109,22). The combination of these two treatments has been shown to solve the problems that found in inceptisol which is P available on soil. So the mycorrhizal aid can change P bound to P available to increase the production of pepper plant.

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Introduction

Chilli (*Capsicum annuum* L.) is one of the most important comodity and high economic value, both for export and domestic use for daily needs. Red chili fruit has a high nutrient content such as vitamin A and C, and used as a spice so popular by the community, especially in Asia (Harpenas and Dermawan, 2010). The productivity of chilli Indonesia in 2014 is very low around 8.35 ton ha^{-1} while in Aceh Province reaches 10.37 ton ha^{-1} (BPS, 2016).

The low level of productivity in Aceh especially from potential results makes the researchers do various research to get the desired result. One of the usual efforts is the use of improved varieties and the use of biological agents to increase the production of pepper plants. According to Syukur *et al.,* (2012) the use of superior seed is absolutely necessary to increase the productivity of the red pepper plant.

The growing media factor is one of the important factors to increase the production of chili. Good growing media should have potential physical, chemical, and biological properties of the soil. Inceptisol has many problems such as soil fertility rates ranging from low to high. Ussually, the soil properties of inceptisol react slightly acid with low organic content and high wet saturation. The low P nutrient content is caused by clay fixation, Al, Fe, and Ca (Subagyo*et al.,* 2000). Agreed with the statement of Muyassir*et al.,* (2012) that on dry land has low soil fertility and low organic matter, limited availability of water in the dry season so that the land can not be utilized optimally for agriculture.

One effort that can be done to solve the problem on the soil is using mycorrhizal biofertilizer. The use of mycorrhizal biofertilizer can help the nutrient uptake by plants and can improve the aggregation of soil particles. For plants, mycorrhizal biofertilizer is very useful to increase nutrient uptake of phosphate (P). According of Musfal (2008) the plants that are symbiotic with mycorrhiza able to absorb the element P is higher than plants that are not symbiotic with mycorrhiza. it is because, external mycorrhizalhifa tissue is able to expand the absorption area. Considering that there are some problem factors in Inceptisol that cause low productivity of chilli, it is necessary to test on InceptisolKrueng Raya soil with the use of various varieties of red chili with dosage of mycorrhiza so it is expected to solve the problems on the soil and increase the production of chili plants.

Material and methods

Experimental site of study

The research was conducted in the Experimental Garden, the soil analysis was conducted at Soil and Plant Laboratory and root infection by AMF was measured at Plant Physiology Laboratory, Faculty of Agriculture, Syiah Kuala University, Aceh, Indonesia. The study was investigated from May 2017 to January 2018.

Statistical analysis

This research was conducted by Randomized Block Design, with two treatment factors and three replications so there are 48 experimental units and the next test used duncan's multiple range test (DMRT) at 5% rates.

Arbuscular mycorrhiza fungi (AMF)

This research used arbuscular mycorrhiza fungi, *Glomus mosseae* obtain from Plant Physiology Laboratory of Agriculture Faculty, Syiah Kuala University, Aceh, Indonesia.

There were 4 levels of arbuscular mycorrhiza fungi treatment: M_0= without mycorrhiza, M_1= mycorrhiza *Glomus mosseae* 5 g $plant^{-1}$, M_2= mycorrhiza *Glomus mosseae* 10 g $plant^{-1}$, and M_3= mycorrhiza *Glomus mosseae* 15 g $plant^{-1}$.

Treatment of chilli varieties

There were 4 varieties of chilli used: V_1= Odeng, V_2= Lado, V_3= Larisdan V_4= PM999.

Application of arbuscular mycorrhizal fungi (AMF)

Inoculation of mycorrhiza glomus mosseae, applied in two stages.

The first stage was applied to the half-dose nursing medium according to the treatment (except without mycorrhizae not given) and the second stage was given at the time of transplanting to polybag given half dose according to treatment.

Parameters

The observed parameters were growth parameters (plant height, stem diameter, fresh and dry stem weight, fresh and dry root weight and mycorrhizal infected level), and production parameters (number of fruit, fruit weight, fruit length, fresh and drystem weight, fresh and dry root weight).

Results and discussion

Soil analysis

The results of soil support analysis in Table 1. show that nutrient content in the soil almost have low nutrient level.The content of N 0.17% (low), P-available 5.95 mg kg^{-1}(very low), C-organic 0.97% (very low), KTK 24.00 cmol kg^{-1}(medium), soil pH 6.09 (slightly acidic), the conductivity of lsitrik 0.08 (low) is until the soil class texture D(clay).Soil conditions that have problems in almost every nutrient content can be improved with the use of biofertilizers such as mycorrhizal biofertilizer.

Table 1. Result of analysis of supporting soil before the research conducted.

Parameter	Value	information	Reference
pH H_20	6.09	slightly acidic	5.5-6.5
N-total	0.17	Low	0.10-0.20
P-available	5.96	Very low	<10
C-organic	0.97	Very low	<1
Cation exchange capacity	24.00	Medium	17-24
Electrical conductivity	0.08	Low	<8
Class texture	D	Clay	-

Table 2. The result of analysis P-available on soil after harvest.

Treatment	Without Mycorrhiza	Mycorrhiza 5 g $plant^{-1}$	Mycorrhiza 10 g $plant^{-1}$	Mycorrhiza 15 g $plant^{-1}$	Sig.
P-available	5.31 a	6.46 b	6.78 b	6.17 ab	*

Note: Values followed by the same letter in the same row is not significantly different according to 5% Duncan's Multiple Range Test. Significant (*).

According to the results in Table 1.shows that the nutrient content in inceptisol was low and very low. This causes the problems that occur in agricultural land on inceptisol. According to Xu *et al.* (2016) stated that the availability of nutrients in the soil is strongly influenced by soil pH. Based on the statement, it is true that the slightly acidic soil pH on the soil of inceptisol tested causes the nutrient content of the soil to be low in both the N and P nutrient content of the soil.

Table 3. The mean value of mycorrhizal infected levels in chili plants.

Treatment	Without Mycorrhiza	Mycorrhiza 5 g $plant^{-1}$	Mycorrhiza 10 g $plant^{-1}$	Mycorrhiza 15 g $plant^{-1}$	Sig.
value	1.28 a	82.29 b	86.89 b	85.36 b	**

Note: Values followed by the same letter in the same row is not significantly different according to 5% Duncan's Multiple Range Test. More significant (**).

The result of soil analysis after harvest that is P-available soil analysis showed that P-available on inceptisol soil that has applied mycorrhizal fertilizer, gave a significant effect on mycorrhiza dose treatment on growth and yield on pepper plant (Table 2).

Based on Table 2.shows that the best use of mycorrhiza is found in the use of mycorrhiza glomusmosseae 10 g $plant^{-1}$ with a value of 6.87 which is very differentwith no mycorrhiza 5,31.

Table 4. The mean value of mycorrhizal dose for chili plant growth.

Treatment	Plant height	Stem diameter	Fresh stem weight	Dry stem weight	Fresh root weight	Dry root weight
M_0	61.58a	0.519a	33.01a	7.58a	2.87a	1.04a
M_1	66.58b	0.579b	39.78b	9.42b	3.43b	1.52b
M_2	67.00b	0.599c	39.90b	9.51b	3.51b	1.50b
M_3	66.75b	0.591bc	39.06b	9.28b	3.48b	1.47b
Sig.	**	**	**	**	**	**

Note: Values followed by the same letter in the same column is not significantly different according to 5% Duncan's Multiple Range Test.Without Mycorrhiza (M_0), Mycorrhiza 5 g plant $^{-1}$ (M_1), Mycorrhiza 10 g plant $^{-1}$ (M_2), Mycorrhiza 15 g plant $^{-1}$(M_3), More significant (**).

Table 5. The mean value of mycorrhiza dose for chili plant yield.

Treatment	Number of fruits	Weight of fruit	Fruit length
M_0	17.67 a	55.91 a	12.11 a
M_1	20.83 b	77.44 b	12.79 b
M_2	23.92 c	97.77 d	12.74 b
M_3	22.00 b	85.55 c	12.73 b
Sig.	**	**	*

Note: Values followed by the same letter in the same column is not significantly different according to 5% Duncan's Multiple Range Test. Without Mycorrhiza (M_0), Mycorrhiza 5 g plant^{-1} (M_1), Mycorrhiza 10 g plant^{-1} (M_2), Mycorrhiza 15 g plant^{-1} (M_3), More significant (**), Significant (*).

After the use of mycorrhizal fertilizer glomus mosseae showed a significant effect on P uptake on soil compared to ground not given mycorrhizal fertilizer (Table 2). It is suspected because mycorrhizal fertilizers assist the ion exchange process on soil from P-bound soil to P-available so that plants can absorb Pelements for growth process. In accordance with the statement of Syamsiyah *et al.,* (2014) that the high P nutrient uptake in plants using mycorrhiza will lead to the development of hyphae in plant roots which will further aid the root in the process of nutrient uptake.

Table 6. Average value of chili varieties for chili plant growth.

Treatment	Plant height	Stem diameter	Fresh stem weight	Dry stem weight	Fresh root weight	Dry root weight
V_1	67.75b	0.581b	39.61b	9.46b	3.45b	1.53b
V_2	63.92a	0.544a	35.30a	8.13a	3.00a	1.21a
V_3	63.58a	0.553a	37.28ab	8.71ab	3.22ab	1.30ab
V_4	66.67b	0.610c	39.57b	9.48b	3.62b	1.48b
Sig.	**	**	*	*	*	*

Note: Values followed by the same letter in the same column is not significantly different according to 5% Duncan's Multiple Range Test. Odeng (V_1), Lado (V_2), Laris (V_3), PM999 (V_4), More significant (**), Significant (*).

Mycorrhiza infected level

Based on Table 3.shows that the best mycorrhiza infected level was found in the treatment mycorrhiza *Glomus mosseae* 10 g plant^{-1} which was significantly different from the treatment without mycorrhizal administration, but it was not significantly different from the micropiza *Glomus mosseae* 5 g plant^{-1} and 15 g plant^{-1}.

This is in accordance with the statement of Junita (2015) states that giving mycorrhiza can increase the percentage of root infections by mycorrhiza.

Table 7. Average value of chili varieties for chili plant yield.

Treatment	Number of fruits	Weight of fruit	Fruit length
V_1	23.33 b	89.98 c	14.57 b
V_2	20.92 a	79.65 b	11.82 a
V_3	20.50 a	75.29 ab	11.90 a
V_4	19.67 a	72.10 a	12.09 a
Sig.	**	**	**

Note: Values followed by the same letter in the same column is not significantly different according to 5% Duncan's Multiple Range Test. Odeng (V_1), Lado (V_2), Laris (V_3), PM999 (V_4) More significant (**).

Testing mycorrhiza infected levels given mycorrhiza fertilizer including the category of infected rates was very high compared to without giving mycorrhiza which is very low category.This is presumably because, the level of problems in inceptisol used was very low phosphat and soil pH slightly sour make mycorrhiza can develop well on the ground so as to increase the propagation of FMA inoculum on the soil.According to research results Giri *et al.,* (2007) stated that mycorrhiza application on stress conditions in pepper plants can increase the rate of mycorrhiza and infected plant yields.

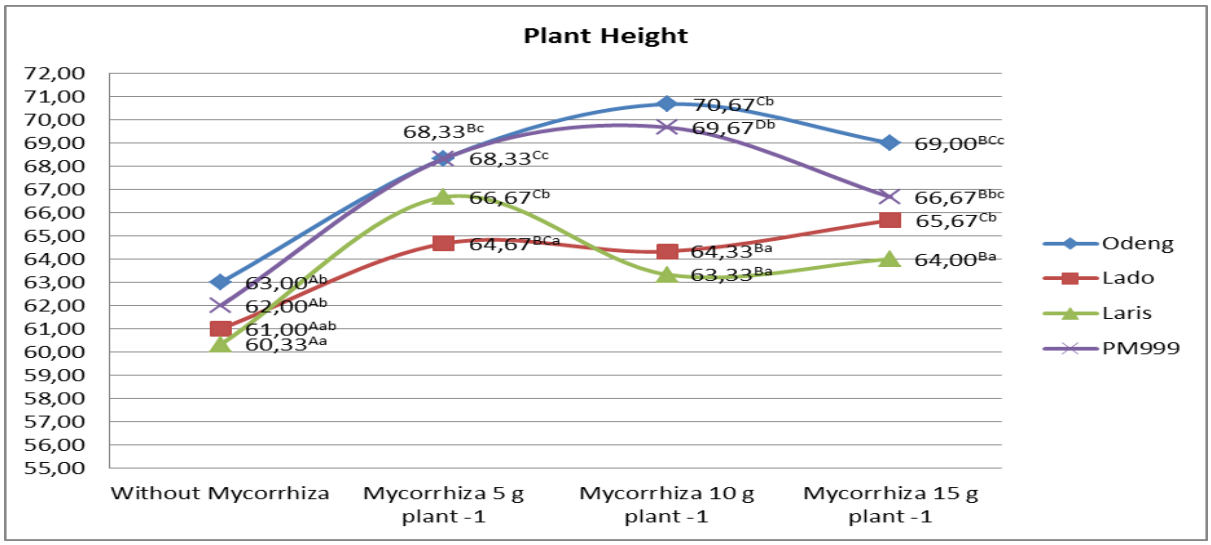

Fig. 1. The result of Interaction between dose of mycorrhiza and chili variety on plant height.

The effect of mycorrhiza dose on growth and yield of chili plants

The result of variance analysis showed that the dose of mycorrhiza had a very significant effect on plant height, stem diameter, fresh stem weight, dry stem weight, fresh root weight, dry root weight, fruit weight and number of fruit and significant effect on fruit length.

Based on Table 4. shows that plant height, fresh stem weight, dry stem weight, fresh root weight is best found in the treatment of mycorrhiza *Glomus mosseae* 10 g plant^{-1}, significantly different from without mycorrhiza, but not significantly different from dosage of mycorrhiza *Glomus mosseae* 5 g plant^{-1} and 15 g plant^{-1}.

The best stem diameter was found in the treatment of dose mycorrhiza *Glomus mosseae* 10 g plant^{-1} which was significantly different from other treatments. The best dry root weight found in the treatment of dose mycorrhiza *Glomus mosseae* 5 g plant^{-1} was significantly different from the treatment without mycorrhiza, but different it was not significant with the dosage treatment of mycorrhiza *Glomus mosseae* 10 g plant^{-1} and 15 g plant^{-1}.

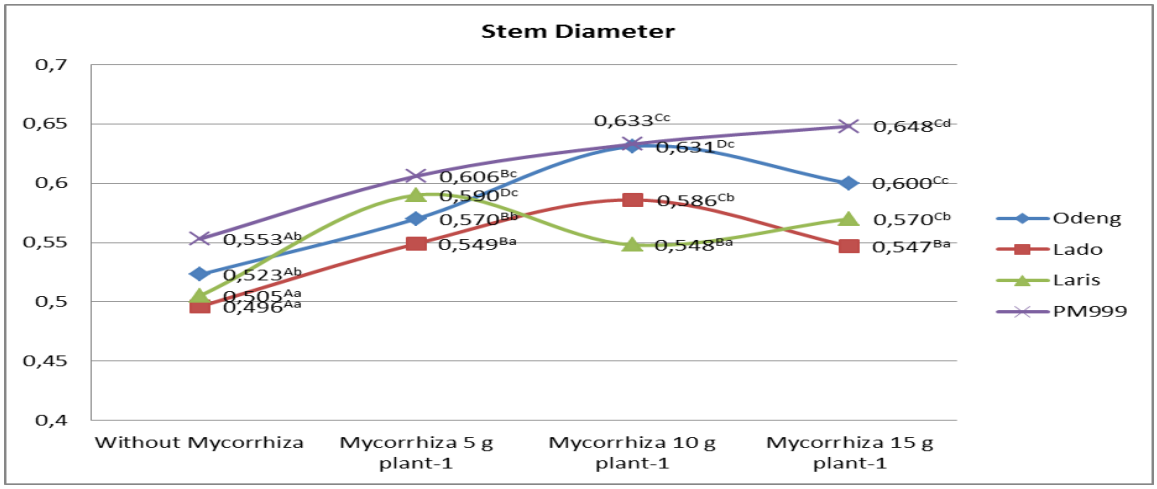

Fig. 2. The result of Interaction between dose of mycorrhiza and chili variety on stem diameter.

Based on Table 5. shows that the best fruit weight and fruit counts were found in the treatment of dose mycorrhiza *Glomus mosseae* 10 g plant^{-1} which was significantly different from other treatments.The best fruit length was found in the treatment of dose mycorrhiza *Glomus mosseae* 5 g plant^{-1} which was significantly different from the treatment without mycorrhizal administration, but not significantly different with the treatment of mycorrhiza *Glomus mosseae* 10 g plant^{-1} and 15 g^{-1} plants.

The application of mycorrhiza was proven to provide the best growth and yield. This is presumably because mycorrhiza can help the plant to obtain nutrients so that it can be used by plants.

This is in agreement with some other experts who suggest that arbuscular mycorrhizal inoculation may improve fruit yield in chili plants (Abdel Latef, 2013; Abdel latef and Chaoxing, 2014; Boonlue *et al.*, 2012; Hernadi *et al.*, 2012; Tanwar *et al.*, 2013). The same is stated by Erman *et al.* (2011) that arbuscular mycorrhizal inoculation is very effective and can result in a large increase in yield, root colonization and phosphorus content in seeds and buds.

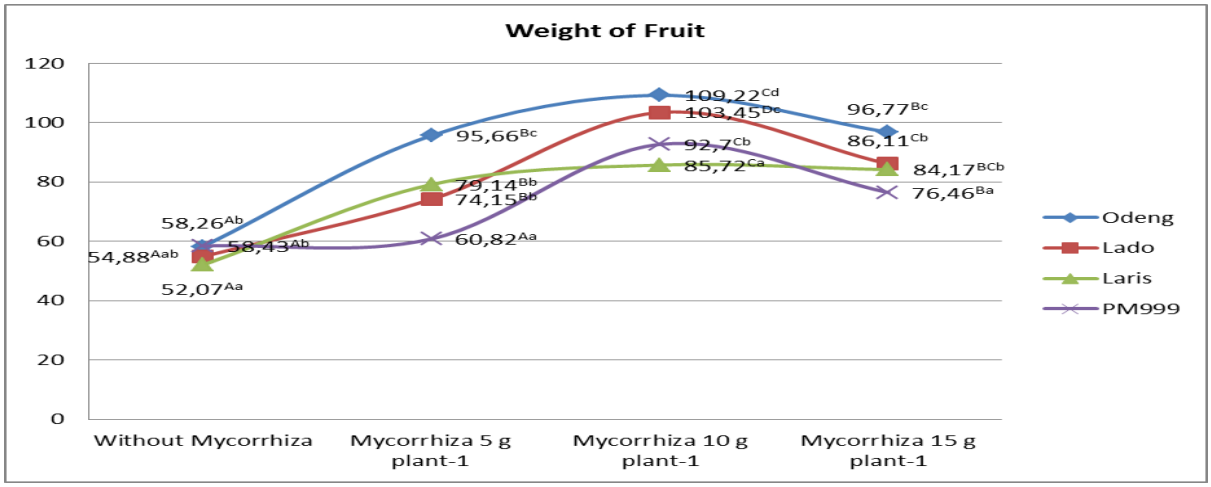

Fig. 3. The result of Interaction between dose of mycorrhiza and chili variety on fruit weight.

The effect of chilli varieties on the growth and yield of pepper plants

The results showed that the varieties of chilli had a significant effect on plant height, stem diameter, fruit length, fruit weight, number of fruit and significant effect on fresh stem weight, dry stem weight, fresh root weight, and dry root weight.based on Table 6. shows that the use of Odeng variety provides the best growth in plant height observation, wet stem weight, dry root weight compared to the use of other varieties.

In stem diameter, dry stem weight, wet root weight is the best found in PM999 varieties. However, the use of both the best chili varieties of Odeng and PM999 has a very significant effect compared to the use of varieties of Lado and Laris. Based on Table 7.shows that the number of fruits, fruit weight and fruit length is best found in the use of odeng varieties significantly different from other treatments. Based on Tables 6 and 7.show that there are two best varieties namely Odeng and PM999. Both varieties are suspected to have high adaptability, good pathogen resistance and more compatible with the use of mycorrhizal so that it is superior to some aspects of growth and yield.

This agrees with Pereira *et al.* (2015) suggesting that root colonization by arbuscular mycorrhizal fungi may increase plant resistance to both biotic and abiotic stresses in host plants.

The impact of good growth on Odeng and PM999 varieties made the results was higher than two other varieties. This makes the Odeng and PM999 varieties more suitable for incepticol tested to solve the problems contained in the soil.

The effect of interaction between dosage of mycorrhiza and chili varieties on growth and yield of chili plants

The result of variance analysis showed that there was a real interaction between dosage of mycorrhiza and chilli varieties to plant height, stem diameter, and fruit weight.

Based on fig 1 and 3.shows that the best plant height and weight fruit was found in a combination of mycorrhiza *Glomus mosseae* treatment with 10 g plant^{-1} with the use of Odeng varieties. Based On fig 2.Shows that the best stem diameter was found in a combination of mycorrhiza *Glomus mosseae* 15 g plant^{-1} with the use of PM999 varieties.

In general, plants using mycorrhiza have better growth than plants without using mycorrhiza. The mutual relationships between mycorrhizal fungi and host plants yield positive benefits for both.

Because the mycorrhizal fungi contained in plants can be used as biofertilizer to support growth and yield on plants. According to Barea *et al.,* (2011) mycorrhizal fungus can increase plant resistance to environmental stresses, nutrients and drought. According to Cekic (2012) that the inoculation of chili plants with mycorrhizal can increase the relative water content, P, chlorophyll and karatenioid contents.

According to research by Syafruddin *et al.,* (2010) that the administration of mycorrhizae in chili and other vegetables grown on andisol and entisol in Lampuuk Aceh Besar has a positive effect on the growth and yield of pepper plants.

Conclusion

Based on the results of the study, it can be concluded that the use of mycorrhiza *Glomus mosseae* 10 g plant^{-1} with Odeng varieties can increase the heigt of plant (70,67), Stem diameter (0,633), and fruit weight (109,22). Giving mycorrhiza on Inceptisol soil can cause a change in terms of the availability of nutrients needed by plants.

Recommendations

Arbuscular mycorrhizal fungi was able to improve soil fertilizer from Inceptisol because the arbuscular mycorrhizal fungi was able become the agent of biofertilizer in the soil to improve the yield on problematic soils.

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