



## The effect of dosage of mycorrhizal *Glomus mosseae* and some varieties on growth and yield of Chilli (*Capsicum annum* L.) on Entisol soil

Almuna Ramadhani\*, Syafruddin, Syamsuddin

Department of Agroecotechnology, Faculty of Agriculture, University of Syiah Kuala,  
Darussalam, Banda Aceh, Indonesia

Article published on September 30, 2018

**Key words:** Mycorrhizae *Glomus mosseae*, Chili variety, Entisol soil, Biofertilizer.

### Abstract

This study aims to determine the effect of *Glomus mosseae* mycorrhizae dose and varieties on growth and yield of chili (*Capsicum annum* L.) on Entisol soil. This research was conducted at the UNSYIAH Experimental Garden, Banda Aceh. The design used in this study is factorial randomized block design (RBD). The first factor in this study is the dose of mycorrhizal *Glomus mosseae* (D) consisting of 4 levels, namely: D<sub>0</sub>= without mycorrhiza, D<sub>1</sub>= mycorrhiza *Glomus mosseae* 5g plant<sup>-1</sup>, D<sub>2</sub>= mycorrhiza *Glomus mosseae* 10g plant<sup>-1</sup>, and D<sub>3</sub>= mycorrhiza *Glomus mosseae* 15g plant<sup>-1</sup>. The second factor is chili variety (V) consisting of 3 levels, namely: PM 999 varieties, Lado F1 varieties, varieties CTH-01. The variables observed were growth parameters, chili yield, total N-content and P-available on Entisol soil and the percentage of mycorrhizal infected roots. The results showed that mycorrhizal doses were able to increase the value of N-total and P-available on the soil and can improve plant growth and yield, the use of mycorrhizal doses of 15 g tan<sup>-1</sup> generally results in better growth and yield of chilli compared to other doses, while based on the results of research CTH-01 varieties affect the growth and yield of chili plants. There is an interaction between mycorrhizal doses with chilli varieties on growth parameters and chili yield.

\*Corresponding Author: Almuna Ramadhani ✉ [almunaramadhani@gmail.com](mailto:almunaramadhani@gmail.com)

## Introduction

Red chili (*Capsicum annum* L.) is a seasonal vegetable belonging to the eggplant family (*Solanaceae*). This plant originated in the Americas, precisely in the Peruvian region, and spread to other regions on the continent. In Indonesia alone, it is estimated that red chili brought by Persian merchants when stopping in Aceh, among others, are large red chili, cayenne pepper, curly red chili and paprika. Red chili is one type of vegetable that is quite important in Indonesia, both as a commodity consumed domestically and as an export commodity. In general, chili has a lot of nutrients and vitamins, including protein, fat, carbohydrates, calcium (Ca), phosphorus (P), iron (Fe), vitamins, and contains alkaloid compounds such as flavonoids, capsolain, and oil. As a vegetable, in addition to having high nutritional value, red pepper also has high economic value (Daryanto, 2010).

Fresh big chilli production in 2014 amounted to 1.075 million tons. Compared to 2013, there was a production increase of 61.73 thousand tons (6.09 percent). This increase was due to an increase in productivity of 0.19 tons per hectare (2.33 percent) and an increase in harvested area of 4.62 thousand hectares (3.73 percent) compared to 2013. As for the province of Aceh itself, the production of fresh large chili in 2014 amounted to 50.19 thousand tons. Compared to 2013, there was a production increase of 7.77 thousand tons (18.30 percent). This increase was due to an increase in productivity of 0.94 tons per hectare (9.96 percent) and an increase in harvested area of 341 hectares (7.58 percent) compared to 2013 (BPS Dirjen Hortikultura, 2015).

The low production of chili is caused by many factors. Some of them are related to seed quality, cultivation techniques and plant populations (Nawangsih *et. al.*, 2001). Incorrect use of fertilizers is also one of the causes. To meet the increasing need each year and to prevent the low productivity of chilli plants, the increase of red chili production needs to be done through the provision of "biofertilizers". Biofertilizer is a type of fertilizer containing soil-friendly micro organisms (Cruz *et al.*, 2014). One type of micro organism that is currently getting a lot of attention is

Arbuscular Mycorrhizal Fungi (AMF) which can be used and effective in meeting nutrient requirements for plants. AMF is a mutualism symbiotic relationship between mushrooms (*mykes*) and roots (*rhiza*) of high plants (Cruz *et al.*, 2014).

(AMF) plays a role in increasing nutrient uptake by plants. Musfal (2010), reported that plants infected with AMF were able to absorb higher P elements than non-infected plants. The high P uptake by plants infected with AMF is caused by AMF hyphae which release *phosphatase* enzymes so that P bound in the soil will dissolve and be available to plants. In general, mycorrhizae are classified into three important groups, namely ectomycorrhiza, endomycorrhizae, and ectendomycorrhizae (Harley and Smith, 2000). Endomycorrhizal fungi are the most common mycorrhizal type, according to Brundrett *et al.*, (2013) endomycorrhiza are fungi that can symbiosis with various host plants included in the taxa of Bryophyta, Pteridophyta, and Spermatophyta. *Glomus aggregatum*, *Glomus fasciculatum*, and *Glomus mosseae* are in the genus *Glomus* and are included in the endomycorrhizae group which can be inoculated in red chili, because red chili is a Spermatophyta plant.

Based on the results of research Safrianto *et al.*, (2015) proved that the administration of *Glomus mosseae* mycorrhizae with a dose of 10g plant<sup>-1</sup> in chili can increase production and weight of chilli fruit and increase P uptake (phosphorus) uptake and chili growth in drought conditions. The results of Husin's (2014) study showed that administration of 10g plant<sup>-1</sup> mycorrhizal inoculum could increase P uptake (phosphorus) and corn height uptake in drought stresses.

Increasing the resilience of a plant other than using mycorrhizae, one of the efforts to increase the yield of red chili is to use quality seeds from a variety. The use of good varieties is also one of the most important things that must be considered in chili cultivation. Considering the large potential of chilli plants, it is necessary to make an effort to increase the resistance of chilli plants to disease pathogens and when chili

seedlings are moved to the field. One of them is by using superior varieties. Superior varieties have one of the superior characteristics of local varieties. These advantages can be reflected in their innate nature which can produce high-yielding fruit, response to fertilization and resistance to pests and diseases (Jumin, 2005). Types of varieties that are suitable for environmental conditions are expected to grow well and get high yields (Prajnanta, 2014).

Young (2013) explains that Entisols are undeveloped soils, with less favorable physical and chemical properties. These properties include the capacity to withstand low water and nutrients, susceptibility to erosion, low cation exchange capacity (CEC), and low clay content. By giving AMF to this soil, it can increase nutrient and water uptake, then mycorrhizae can also increase plant resistance to drought and increase plant growth (Novriani and Madjid, 2016). So that the nature of Entisols which has constraints in terms of soil fertility is expected to use mycorrhizae can change the nature of the soil which was less fertile to be more fertile for agricultural land that is used intensively.

Based on the above problems, it is necessary to conduct research to overcome these problems, namely the use of *Glomus mosseae* mycorrhizae and some varieties in chili plants, to see the dose of *Glomus mosseae* mycorrhizae and the right varieties to increase the production of chili on Entisol soil.

## 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 March 2016 to October 2016.

### Statistical analysis

This research was conducted by Randomized Block Design, with two treatment factors and three replications so there are 36 experimental units and the next test used BNJ at 5% rates.

### Treatment 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: D<sub>0</sub>= without mycorrhiza, D<sub>1</sub>= mycorrhiza *Glomus mosseae* 5g plant<sup>-1</sup>, D<sub>2</sub>= mycorrhiza *Glomus mosseae* 10g plant<sup>-1</sup>, and D<sub>3</sub>= mycorrhiza *Glomus mosseae* 15g plant<sup>-1</sup>.

### Treatment of chilli varieties

There were 3 varieties of chilli used: V<sub>1</sub>= PM 999, V<sub>2</sub>= Lado, V<sub>3</sub>= CTH-01

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 dry stem weight, fresh and dry root weight).

### Percentage of Mycorrhizal Infected Roots

Sukarno (2000) in Nirmalasari (2005) suggested that to see whether there was an association between fungi and root samples, root staining was carried out with the following steps:

1. The plants observed were 1 sample plant aged 45 HST. The plant is revoked and its roots are taken.
2. Plant roots are washed with aquades water until clean, then cut to 1cm in size and soaked with 10% KOH solution for 24 hours which is useful for whitening the roots.
3. Then the roots are colored by soaking in blue typan/acidfuchin (quick parker) for 24 hours.

4. After that it is soaked again in aquades so that the root surface is clean from blue coloring.

5. Root pieces can be observed under a microscope with an enlargement of 100-400 times.

The roots are colonized (%) =

$$\frac{\text{the total of roots infected with mycorrhizae}}{\text{number of roots observed}} \times 100$$

Yield (ton ha<sup>-1</sup>)

Weighing the yield of red pepper is done after the plants are harvested and dried. Crop yields per ha

were obtained by converting from the weight of planting fruit, with the following formula:

$$\text{Yield (ton ha}^{-1}\text{)} = \frac{\text{surface area 1 ha}}{\text{space planting}} \times \text{Weight of Fruit.}$$

### Results and discussion

#### Effect of Mycorrhizal Dosage on the Growth and Yield of Chili Plants

The average growth and yield of chili plants due to the treatment of mycorrhizal doses can be seen in Table 1.

**Table 1.** 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 |
|-----------|--------------|---------------|-------------------|-----------------|-------------------|-----------------|
| Do        | 48,34 b      | 0,17 ab       | 14,13 a           | 5,81 a          | 4,86 a            | 0,46 a          |
| D1        | 44,67 ab     | 0,16 a        | 31,84 bc          | 10,45 b         | 5,07 ab           | 0,48 ab         |
| D2        | 48,95 ab     | 0,21 b        | 25,04 ab          | 12,98 bc        | 5,12 ab           | 0,55 ab         |
| D3        | 46,77 a      | 0,18 ab       | 40,19 c           | 16,26 d         | 5,95 b            | 0,72 c          |
| BNJ 5%    | 3,54         | 0,042         | 10,96             | 2,94            | 0,95              | 0,13            |

Note: Values followed by the same letter in the same column is not significantly different from the 5% level of the BNJ test. Without Mycorrhiza (Do), Mycorrhiza 5g plant<sup>-1</sup> (D1), Mycorrhiza 10g plant<sup>-1</sup> (D2), Mycorrhiza 15g plant<sup>-1</sup>(D3).

Based on the results of the F test on variance analysis showed that the use of 15g plant<sup>-1</sup> mycorrhizal dose generally results in better growth and yield of chili plants. The treatment of mycorrhizal doses significantly affected plant height aged 15 HSPT (Day After Plant Transfers), stem diameter at 30 HSPT, plant wet weight, plant dry weight, plant root dry weight, number of cropping fruit, percentage of mycorrhizal infections in the roots of chili plants, root wet weight, planting fruit weight and yield potential per hectare, but no significant effect on plant height aged 30 and 45 HSPT and stem diameter aged 15 and 45 HSPT, number of productive branches and fruit length.

The results showed that the best treatment of mycorrhizal doses was at a dose of 10g plant<sup>-1</sup> and 15g plant<sup>-1</sup> (D2) on the growth and yield of chilli plants, this was seen in the parameters of plant wet weight, dry weight of plants, wet weight of plant roots, dry weight plant roots, crop weight, number of fruits, yield potential per hectare and percentage of mycorrhizal infections in the roots of chili plants. It is suspected that the dose given as much as 10g plant<sup>-1</sup>

(D2) has been able to increase the growth and yield of chili plants because mycorrhizae contain lots of spores and hyphae which can help the absorption of nutrients and water by the roots of the chili plant. Besides that mycorrhizae can also act as a biological barrier to root pathogen infection, increase plant resistance to extreme dryness and moisture, increase the production of growth hormones and other growth regulating substances such as auxin, and guarantee the occurrence of biogecemic processes (Muhovej, 2004).

**Table 2.** The mean value of mycorrhiza dose for chili plant yield.

| Treatment | Number of fruits | Fruit length | Weight of fruit | Yield    |
|-----------|------------------|--------------|-----------------|----------|
| Do        | 93,58 a          | 11,09 a      | 58,11 a         | 2,16 a   |
| D1        | 128,49 b         | 12,43 b      | 63,06 ab        | 2,98 ab  |
| D2        | 136,44 b         | 12,52 b      | 96,53 c         | 3,17 abc |
| D3        | 163,80 b         | 12,77 b      | 94,72 c         | 3,80 d   |
| BNJ 5%    | 30,80            | 0,67         | 19,25           | 0,77     |

Note: Values followed by the same letter in the same column is not significantly different from the 5% level of the BNJ test. Without Mycorrhiza (Do), Mycorrhiza 5g plant<sup>-1</sup> (D1), Mycorrhiza 10g plant<sup>-1</sup> (D2), Mycorrhiza 15g plant<sup>-1</sup>(D3).

In line with the research of Husein (2014) showed that administration of mycorrhizal inoculum as much as 10g plant<sup>-1</sup> can increase P uptake (phosphorus) and corn height uptake in drought stress conditions. Furthermore, the results of research on various marginal lands in Indonesia show that biological fertilizer applications such as arbuscular mycorrhizal fungi (*Glomus mosseae*) can increase the production of various crops (soybeans, peanuts, tomatoes and rice) and the availability of nutrients for plants between 20-100% (Simarmata and Herdiani, 2004). Furthermore, it refers to the opinion of Zulaikha (2006) that proper administration of mycorrhizal doses in plants will show a significant response, whereas in excessive doses can suppress plant growth, this applies to organic, biological and inorganic fertilizers.

In the parameters of the percentage of mycorrhizal infections in the roots of chili plants, the level of root infection is categorized as moderate or categorized according to Lumini, *et. al.* (2012) that is medium, because there are factors that may not be optimal for the mycorrhizae to develop, such as temperature. In this case there are three factors that influence mycorrhizal infection, namely host sensitivity to infection, climatic factors and soil factors. Some plant species associated with mycorrhizae are needed, while the dependency level varies greatly with the plant species tested, root morphology, soil conditions and climatic conditions. Plants with thin roots, have fibrous roots and few root hairs, usually mycorrhizae

grow and develop normally (Muchovej, 2004). Referring to the opinion of Setiadi (2005), that an increase in the percentage of mycorrhizal infections due to inoculation can be associated with an increase in the number of spores in the soil. Infection occurs due to the presence of exudates or typical compounds produced and released by plant roots which causes the development of aroused mycorrhizae.

In the parameters of plant height, stem diameter and number of productive branches is clearly nothing different due to the treatment of mycorrhizal doses, but we can see overall, the results tend to represent 10g plant<sup>-1</sup> mycorrhizal dose (D2), although there is no difference in value significant. This is presumably because on the soil of Entisol it can be said that the soil is still relatively fertile or there are still elements of the soil that allow the mycorrhizae to not work optimally. But the dose of 15g plant<sup>-1</sup> cropping also gives better results we can see in the results of research that gives higher yields on the growth and yield of chili plants this is in accordance with the results of Halis, *et. al.* (2012) which states that 15g plant<sup>-1</sup> of mycorrhizal doses on chili plants gave better results on plant height (21.73cm), root biomass (0.26g) and P content of the plant (0.48%).

Effect of Varieties on Growth and Yield of Chili Plants  
The average growth of chilli yield as a result of the treatment of chili varieties can be seen in Table 3.

**Table 3.** Average value of chili varieties for chili plant growth.

| Treatment | Plant Height | Stem Diameter | Fresh Stem Weight | Dry Stem Weight | Weight of fruit | Fruit length |
|-----------|--------------|---------------|-------------------|-----------------|-----------------|--------------|
| D0        | 40,19 c      | 0,20 b        | 19,91 a           | 8,84 a          | 111.85 a        | 11,64 a      |
| D1        | 36,36 a      | 0,16 a        | 31,75 b           | 11,85 b         | 148.73 ab       | 12,53 b      |
| D2        | 36,43 ab     | 0,18 ab       | 31,76 b           | 13,43 b         | 131.14 b        | 12,43 b      |
| D3        | 3,16         | 0,038         | 9,93              | 2,67            | 27,89           | 0,60         |
| BNJ 5%    | 40,19 c      | 0,20 b        | 19,91 a           | 8,84 a          | 111.85 a        | 11,64 a      |

Note: Values followed by the same letter in the same column is not significantly different from the 5% level of the BNJ test. Without Mycorrhiza (D0), Mycorrhiza 5g plant<sup>-1</sup> (D1), Mycorrhiza 10g plant<sup>-1</sup> (D2), Mycorrhiza 15g plant<sup>-1</sup>(D3).

Based on the results of the F test on variance analysis showed that the treatment of chilli varieties significantly affected plant height aged 15 and 30 HSPT, diameter stem aged 15 HSPT, plant wet weight, plant dry weight, fruit weight per plant, fruit length and potential yield per ton acres. Furthermore, varieties did not significantly affect plant height aged

45 HSPT, stem diameter 30 and 45 HSPT, number of productive branches, wet weight and dry weight of roots, number of fruit plantings and mycorrhizal infections in the roots of chili plants.

CTH-01 variety is a better variety, seen from growth parameters, mycorrhizal infection in the roots of chilli plants and yield of chili.

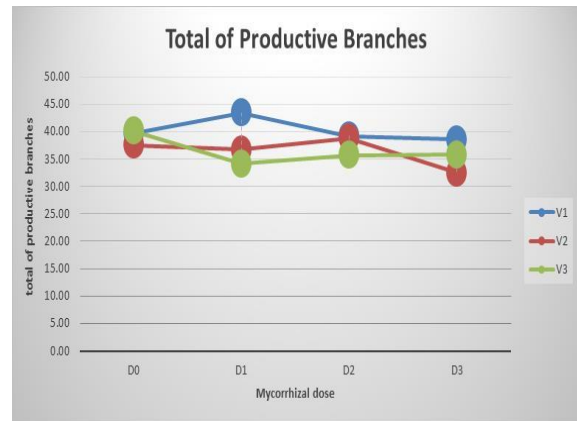
The results showed that the treatment of LADO F1 (V2) and CTH-01 (V3) chilli varieties were good varieties for the growth and yield of chili plants. This can be seen from the parameters of plant height, fruit length, plant wet weight, plant dry weight, plant root weight and dry weight of plant roots. However, there are some parameters that have no statistically significant effect, but the CTH-01 (V3) variety is overall better than the two varieties. This is allegedly due to the characteristics and factors that influence the growth and yield of the chili plant. According to Kirana and Sofiari (2007), each variety has a different plant height, plant height in various varieties is controlled by genetic factors, and also the environment is very decisive.

PM 999 (V1) variety showed the best response are plant height, stem diameter and number of productive branches compared to other varieties, but the response was not too different from the treatment of other varieties, it means that PM 999 (V1) variety is better during growth chili. Furthermore in the parameters of the production of chilli and mycorrhizal infections in the roots of chilli plants, varieties of CTH-01 (V3) showed a superior response compared to varieties of PM 999 (V1) and LADO F1 (V2). The results of research by Adisarwanto (2000) explain that varieties that can adapt to their environment can grow well and also have superior properties if planted in suitable conditions will be able to produce good potential results.

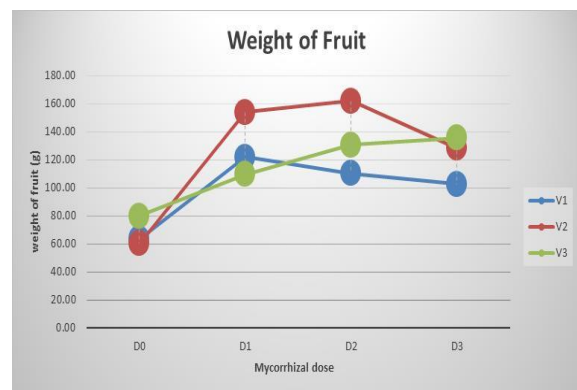
*Interaction between Mycorrhizal Dosage and Chili Varieties*

There was a significant interaction between mycorrhizal doses with chilli varieties on plant wet weight, plant dry weight, plant height and stem diameter aged 30 HSPT, root wet weight, root dry weight, crop fruit weight, number of planting fruit and yield potential per hectare. However, there was no significant interaction on plant height and stem diameter aged 15 and 45 HSPT, number of productive branches, fruit length and percentage of mycorrhizal infections in the roots of chili plants.

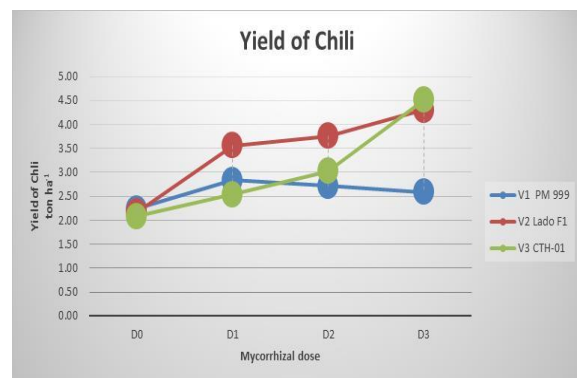
Better interaction is found at a dose of 10g plant<sup>-1</sup> with LADO F1 variety on parameters of 30 HSPT plant height, root wet weight and root dry weight, crop weight and yield potential per hectare.



**Fig. 1.** Interaction between mycorrhizal doses with chilli varieties on the total of productive branches of chili plants.



**Fig. 2.** Interaction of mycorrhizal doses with chilli varieties on weight of fruit.



**Fig. 3.** Interaction of mycorrhizal doses with chilli varieties against yield potential.



The results showed that there was an interaction between mycorrhizal doses with chilli varieties to a good combination found at a dose of 10g plant<sup>-1</sup> with LADO F1 (V2) variety. This was seen from the parameters of plant height 30 HSPT, root wet weight and plant root dry weight, crop weight and yield potential ton ha<sup>-1</sup>. Furthermore, on wet weight and dry weight of plants, better interaction was found in varieties of CTH-01 (V3) with a dose of 10g plant<sup>-1</sup>, but there was no statistical difference between the varieties of LADO F1 (V2). In the number of planting fruit, good interaction was found in PM 999 (V1) varieties with a dose of 10g plant<sup>-1</sup> (D2), but it was not statistically different from the LADO F1 (V2) variety.

According to Sieverding (2001), different types of plant varieties will show different infections and mycorrhizal development in the roots of these plants. But with different infections will affect the growth and yield of plants inoculated mycorrhizae, Like the absorption of nutrients and water by roots to plants. In addition Fakuara (2014) suggested that mycorrhizal infection can increase P uptake by plants from the soil through mycorrhizal hyphae and enzyme phosphatase produced by fungi capable of catalyzing the hydrolysis of phosphorus complexes which are not available to be soluble and available phosphorus.

The type of effective mycorrhizal inoculants given to plants depends on the mycorrhizal species, the type of plant and the soil condition and the interaction between the three (Syafuddin, *et. al.* 2000). The number of spores also affects the percentage of the degree of root infection. Mayerni and Hervani (2008) explained that the development and density of spores positively correlated with an increase in root colonization so that absorption of nutrients is better and will support plant growth. Nurmasiyah, *et. al.* (2013) stated that plants that are colonized by mycorrhizae will provide better growth.

#### Soil Analysis

This initial soil analysis was carried out in the Testing and Service Laboratory of the Agricultural Technology Assessment Institute (BPTP) Aceh.

The results of the initial and final soil analysis can be seen in Tables 5 and 6:

**Table 4.** Result of analysis of supporting soil before the research conducted.

| Parameter                | Value | Unit Measurement      |
|--------------------------|-------|-----------------------|
| pH H <sub>2</sub> O      | 6,84  | -                     |
| N-total                  | 0,25  | %                     |
| P-available              | 33,77 | mg kg <sup>-1</sup>   |
| C-organic                | 0,98  | %                     |
| Cation exchange capacity | 30,40 | cmol kg <sup>-1</sup> |
| Electrical conductivity  | 0,13  | mS-cm <sup>-1</sup>   |

Entisol is land that tends to be a new original land. They are characterized by features that are less youthful and without a natural genetic horizon, or also they only have initial horizons. Entisol soil problems are low physical and chemical properties. This soil is generally sandy so the structure is loose, porosity and aeration is large, permeability is fast, the water holding capacity is low because the clay and organic matter content is also low. P, and K levels of nutrients are widely found in this soil, but are not available to plants. N nutrients that are car-based are not very available on this land, because this land is very poreus. This land cation exchange capacity (CEC) and base cation (KB) is low due to low organic matter content. Therefore, it is necessary to add organic matter to increase the organic matter content of Entisol soil. Organic material used is manure (Darmawijaya, 2001).

The availability of P is influenced by soil pH and free Al and Fe content (Tan 1998, Winarso 2005). The problem with Entisol soil is that the content of organic matter is classified as low, N-total and available P-are classified as low. The results of the preliminary analysis show that the type of soil used in this study is an imbalance between N and P nutrients (Table 4). In Entisol soil, especially N nutrients with very low availability due to very high washing rates and very low sources of N from organic matter. P nutrients in the Entisol soil type are also low in availability. This is caused by soil pH, increased Al, Fe and Mn ions in soil solution,

increased Ca availability, the amount and level of decomposition of low organic matter and microorganism activity (Hakim, *et. al.*, 2006).

The management of this soil by utilizing FMA has a role to improve soil fertility so that essential macro nutrients such as N and P.

**Table 5.** The result of analysis P-available on soil before harvest.

| Treatment   | Without Mycorrhiza | Mycorrhiza 5g plant <sup>-1</sup> | Mycorrhiza 10g plant <sup>-1</sup> | Mycorrhiza 15g plant <sup>-1</sup> | BNJ 5% |
|-------------|--------------------|-----------------------------------|------------------------------------|------------------------------------|--------|
| N- Total    | 0,22 a             | 0,25 b                            | 0,25 b                             | 0,26 b                             | 0,017  |
| P-available | 23,45 a            | 25,60 a                           | 25,15 ab                           | 26,59 b                            | 2,22   |

**Table 6.** The result of analysis P-available on soil after harvest.

| Treatment   | Without Mycorrhiza | Mycorrhiza 5g plant <sup>-1</sup> | Mycorrhiza 10g plant <sup>-1</sup> | Mycorrhiza 15g plant <sup>-1</sup> | BNJ 5% |
|-------------|--------------------|-----------------------------------|------------------------------------|------------------------------------|--------|
| N-Total     | 0,25 a             | 0,27 b                            | 0,30 c                             | 0,32 d                             | 0,018  |
| P-available | 26,61 a            | 31,26 b                           | 33,82 c                            | 36,93 d                            | 2,20   |

Entisol soil from the initial analysis on the N-Total parameter had a significant effect on the dose of FMA, ie the dose of 5g plant<sup>-1</sup> (D1) had a significant effect on the dose of 0g plant<sup>-1</sup> (D0), dose 10 (D2) and dose 15 (D3) g plant<sup>-1</sup>, while the highest P-available value was obtained at a dose of 15g plant<sup>-1</sup> (D3). The results of the last analysis on the Entisol soil on the parameters have a significant effect on the dose of FMA which is a dose of 15g plant<sup>-1</sup> (D3) has a significant effect on the dose of 5g plant<sup>-1</sup> (D1), dose 10 (D2) and dose 0 (D0)g plant<sup>-1</sup>. Furthermore, P-Available parameters have a significant effect on the dose of 0g plant<sup>-1</sup> (D0), 5g plant<sup>-1</sup> (D1), 10g plant<sup>-1</sup> (D2) and 15g plant<sup>-1</sup> (D3). However, the highest P-available value was obtained at a dose of 15g plant<sup>-1</sup> (D3).

*N-Content*

The treatment of mycorrhizae administration on Entisol soil in the final N-total analysis was very different from the value of the initial N-total analysis (Table 5). The total N-total increases with the addition of *Glomus mosseae* mycorrhiza. The highest administration of mycorrhizal doses results in high soil nitrogen levels. According to Stevenson (1994), administration of mycorrhizae directly is a source of N nutrients and indirectly, mycorrhizae help supply N nutrients through N<sup>2</sup> fixation by providing energy for N<sup>2</sup> fastening bacteria.

The mycorrhiza is then able to utilize the energy from the decomposition of organic matter to tether N<sup>2</sup> from the air (Kahindi *et al.*, 2014).

*P-Available*

The treatment of *Glomus mosseae* mycorrhizae also had an effect on increasing the P-available soil of Entisol. The administration of mycorrhizae of *Glomus mosseae* affecting P-available elements in Entisol soil can be seen in (Tables 5 and 6). The highest value P-available was obtained from the use of mycorrhizae in the treatment dose of 15g plant<sup>-1</sup> cropping (D3) on chili varieties CTH 01 (V3) and PM 999 (V1). g in chilli plants gave better results on plant height (21.73cm), root biomass (0.26g) and P content of the plant (0.48%).

However, this value has an increase of the P-available value in the initial soil analysis (Table 6), this proves that mycorrhizae help provide and help the absorption of P-available in plants in accordance with the results of Musfal (2010), that plants infected with AMF can absorb elements P is higher than non-infected plants. The high P uptake by plants infected with AMF is caused by AMF hyphae which release phosphatase enzymes so that P bound in the soil will dissolve and be available to plants. So that more P-available absorbing plants are very good for plant growth and yield. In accordance with the opinion of Bolan (2013) states that AMF is very instrumental in improving dusty clay.



Whereas P availability through extraradical hyphae tissue can produce *phosphatase* enzymes which are released in the soil so that they are able to release P which is fixed by Al and Fe ions. AMF increases the activity of acid phosphatase in the soil, so organic P compounds in the soil can become available to plants after they are hydrolyzed by the enzyme *phosphatase* (Feng *et al.* 2003).

### Conclusion

Based on the results of the study The use of 15g plant<sup>-1</sup> mycorrhizal doses generally results in better growth and yield of chili plants. Then the CTH-01 variety is a better variety, seen from growth parameters, mycorrhizal infection in the roots of chilli plants and yield of chili. Better interaction is found at a dose of 10g plant<sup>-1</sup> with LADO F1 variety on parameters of 30 HSPT plant height, root wet weight and root dry weight, crop weight and yield ton ha<sup>-1</sup> of chili. The results of the last analysis on Entisol soil showed that at the dose of AMF, the dose of 15g plant<sup>-1</sup> (D3) the value of N-content and P-available was higher and it showed that *Glomus mosseae* AMF could increase the N and P content in Entisol soil.

### Recommendation

The need for further research on various treatments for mycorrhizal doses of several other chilli varieties on Entisol soil that has not been used for mycorrhiza and other mycorrhizal types.

### References

**Adisarwanto.** 2000. Increase the production of peanuts in paddy fields and dry land. Penebar Swadaya, Jakarta.

**Bolan NS.** 2013. A critical review on the role of micorrhizal fungi in the uptake of phosphorus by plants. *Plant and Soil* **134**, 189-207.

**BPS and the Directorate General of Horticulture.** 2015. Vegetable production in Indonesia. BPS. Aceh.

**Brundrett M, Bougher N, Dell B, Grove T, Malajezuk N.** 2013. Working with mycorrhizal in forestry and agriculture. ACIAR, Canberra.

**Cruz AF, Ishii T, Kadoya K.** 2014. Effect of arbuscular mycorrhizal fungi on tree growth, leaf water potential, and levels of 1 aminocyclopropane-1-carboxylic acid and ethylene in the roots of papaya under water-stress conditions. *J. Mycorrhiza* **10(3)**, 121-123.

**Darmawijaya MI.** 2001. Soil Classification. Basic Theory of Soil Researchers and Implementation of Agriculture in Indonesia. Gadjah Mada University Press, Yogyakarta.

**Daryanto.** 2010. Technical Efficiency Analysis of Large Red Chili Farming Production and Farmer Behavior in Facing Risks. *Agro Economic Journal* **Vol. 28 No. 2 things** 153-188.

**Feng G, Song YC, Li XL, Christie P.** 2003. Contribution of arbuscular mycorrhizal fungi to utilization of organic sources of phosphorus by red clover in a calcareous soil. *Appl soil ecol* **22**,139-148.

**Gomez KA dan Gomez AA.** 1995. Statistical Procedure for Agricultural Research. Translated by Endang Sasudin and Justika S. Baharshay. UI Press, Jakarta.

**Halis Murni P, Fitria AB.** 2012. Effect of Types and Dosages of Arbuscular Mycorrhizal Fungi on the Growth of Chili (*Capsicum annum* L.) in Untisol Soil. Jambi University, Jambi.

**Hardjowigeno S, Widiatmaka.** 2007. Assessment of the Effect of Long Term Tillage on the Arbuscular Mycorrhiza Colonization of Vegetable Grop Crown in Andisol, *Agrivita* **33(1)**.

**Harley JL, Smith MS.** 2000. Mycorrhizal Symbiosis. Academic Press, Inc. New York.

**Husein EF.** 2014. The response of several types of plants to mycorrhiza arbuscular vesicles and phosphate fertilizers on ultisols. Pages 4-8 in the proceedings: Utilization of Mycorrhizal Fungi to Increase Crop Production in Marginal Lands. Indonesian Mycorrhiza Association - Jambi University, Jambi.

- Kahindi JHP, Woomer P, George T, de Souza FMM, Karanja N, Giller KE.** 2014. Agricultural intensification, soil biodiversity and agroecosystem function in the tropics: the role of nitrogen-fixing bacteria. *Applied Soil Ecology* **6**, 55-76.
- Kirana R dan E Sofiari.** 2007. Heterosis and Heterobeltiosis in the Crossing of Five Chili Genotypes with the Diallel Method. *Horticulture Journal* **17(2)**, 11-17.
- Lumini E, Bianciotto V, Jargeat P, Novero M, Salvioli A, Faccio A, Becard G, Bonfante P.** 2013. Presymbiotic growth and spora morphology are affected in the arbuscular mycorrhizal fungus *Gigaspora margarita* cured of its endobacteria. *Cell. Microbiol* **9**, 1716-1729.
- Muchovej RM.** 2004. Importance of mycorrhizae for agricultural crops. Gainesville, FL 32611. Institute of Food and Agricultural Sciences (IFAS), University of Florida.
- Musfal.** 2010. The Potential of *Arbuscular* Mycorrhizal Fungi to Increase Corn Crops, Institute for Agricultural Technology Assessment Medan North Sumatra.
- Nawangsih AA, Imdad dan HP Wahyudi A.** 2001. Cabai Hot Beauty. Swadaya Spreader, Jakarta P 8-15.
- Novriani dan A Madjid.** 2016. Mycorrhizal Roles and Prospects. Sriwijaya University Postgraduate Program, Palembang.
- Nurmasyitah, Syafruddin dan Sayuthi.** 2013. Effect of Soil Type & *Arbuscular* Mycorrhizal Fungi Dose on Soybean Plants on Soil Chemical Properties, *Agrista Journal* **vol. 17, no. 3**, hal. 103-110.
- Prajnanta F.** 2004. Vercoming the Problems of Planting Chili. Jakarta, Swadaya Spreader.
- Safrianto Roki, Syafruddin, Sriwati Rina.** 2015. Growth and Yield of Chili (*Capsicum annum* L.) on Andisol by Giving Various Sources of Organic Fertilizer. *Florateg's Journal* **10(2)**, 34-43.
- Setiadi Y.** 2005. Know Mycorrhiza as Biological Fertilizer and Its Application Techniques. [bio-tech training organizer paper]. Bogor, the Inter-University Center of Bogor Agricultural University.
- Sieverding E.** 2001. Vesikuler Arbuscular Mycorrhiza Management in Tropical Agrosystem. Deutsche Gessellschaft fur Tecnosche Zusmmenourheit (GTZ) Gmbh, Federal Republic Germany.
- Simarmata T, dan E Herdiani.** 2004. Effect of FMA Inoculum and Cage Fertilizer on P available, P retention in soil and yield of red onion (*Allium ascolanicum* L.). Page 14-20 in proceedings: utilization of Mycorrhizal Fungi to Increase Crop Production in Marginal Lands. Indonesian Mycorrhizal Association, Jambi University.
- Simatupang S.** 2017. Nature and Characteristics of the Soil. Institut Pertanian Bogor, Bogor.
- Stevenson FJ.** 2004. Humus Chemistry. Genesis, Composition, Reaction. 2<sup>nd</sup> ed. John Wiley and Sons, New York.
- Sumarni N dan Muharam A.** 2005. Red Chili Plant Cultivation. Vegetable Crops Research Institute, Bandung.
- Syafruddin, Langer I, Schweiger P, Puschenreiter M, Wanzel WW.** 2010. Crude Oil Contamination and *Arbuscular* Michoryza Differentially effect on *Phaseolus Vulgaris* Root Morfology. International Symposium Land use After Tsunami. Aceh, Indonesia.
- Tarigan S, dan W. Wiryanta.** 2003 Bertanam Cabai Hibrida Secara Intensif. Agromedia Pustaka. Jakarta **page: 16 – 17, 33**, 90 – 92.
- Young A.** 2013. Tropical Soil and Survey. Cambridge University Press, London.
- Zulaikha S.** 2006. Phosphate uptake and response of tomato plants to mycorrhizae and phosphate fertilizer to ultisol soil. *Jbioshenia. Vsp* **3(2)**, 83-92.