

## The Combination of Mycorrhizae Species and Variety to the Growth and Yield of Chili Plants (*Capsicum annuum* L.) in Bener Meriah Andisols Soil

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**Abstract:** This study aims to observe the interaction between mycorrhizae species and chili plant varieties to the growth and yield of chili plants in Andisols Soil at Bener Meriah. This study was conducted in Blang Kucak Village, Wih Pesam Subregency, Bener Meriah, Syiah Kuala Faculty of Agriculture Greenhouse and Plant Physiology Laboratory, Service Laboratory of Aceh Indonesian Agency for Agricultural Research and Development (IAARD). The study was conducted from Mei to December 2019. The study used Factorial Randomized Group Design with the pattern of 4 x 5 and 3 replications. The first factor is mycorrhizae species consisted of *Glomus mosseae*, *Gigaspora* sp. and combination of both (*Glomus mosseae* + *Gigaspora* sp.). The second factor is chili plants varieties consisted of LADO F1, PM 999 F1, R1, Perintis, and OR TWIST 42. The result showed that highest root colonization is found in *Gigaspora* sp. with the variety of OR TWIST 42 and R1. The highest P-available in soil is found in *Gigaspora* sp. with the variety of OR TWIST 42. The best growth and yield is found in *Gigaspora* sp. with the variety of OR TWIST 42.

**Key Word:** Andisols, Mycorrhizae, Variety

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### I. Introduction

Chili plants is one of the important fruit vegetables in Indonesia, not only as national consumed commodity but also as exported commodity. Besides having high nutrients content, chili also have high economical value<sup>1</sup>. Red chili pepper (*Capsicum annuum* L.) productivity in Indonesia during 2015 is 8,65 ton ha<sup>-1</sup>, it decreased during 2016 to 8,47 ton ha<sup>-1</sup> and at the end of 2017 kept decreasing to 8,46 ton ha<sup>-1</sup> where as the Aceh chili productivity was 10,67 ton ha<sup>-1</sup> on 2017, however the number of Aceh chili productivity is remain lower compared to the Western Java and Bali<sup>2</sup>. The low productivity of chili in Aceh is caused by the lack of cultivation technology particularly in variety selection and soil fertility management such as in Andisols Land.

Andisols in Aceh is spread around Saree Aceh Besar and Bener Meriah highland. The disadvantages of Andisols is having low retention up to 85% which inhibit the P-available to become very low that only around 13-15% could be absorbed by plant. This phenomenon is exist as the cause of Al<sup>3+</sup> dan Fe<sup>3+</sup> reaction in Andisols<sup>3</sup>. As the result, farmers quest the way for increasing available-P in Andisols, one of which by applying phosphate fertilizer exaggeratedly. Therefore, one way to solve the problem of P availability caused by Al<sup>3+</sup> dan Fe<sup>3+</sup> retention is using soil microorganism such as mycorrhizae.

Mycorrhizae is obligate symbiotic soil fungi in terms of intimate association with 80% terrestrial plant species which most of them included as agriculture crops<sup>4</sup>. Symbiosis between mycorrhizae and plants roots could affect the water availability and drought resistency moreover, the main function of mycorrhizae is to be able to secrete glomalin and phosphate enzyme which enable the fixed-P to be available-P for plant<sup>5,6</sup>. Besides concerning about the use mycorrhizae to remedy the soil fertility and plant productivity, variety should also be concerned.

The use of high quality variety is one of absolute condition for plant productivity increase, particularly chili<sup>7</sup>. The high quality cultivar is one of technology component to increase maximum production, because of the high production, pest and disease resistance, fertilization response, therefore it can boost the quantity of and quality of the plant<sup>8</sup>. Concerning about several inhibiting factor in Andisols land which cause low productivity of chili productivity, this present study is proposed to observe several species of mycorrhizae and chili varieties as the solution for increasing soil fertility and chili plant production.

## II. Material and Methods

### Mycorrhizae Propagation

Mycorrhizae propagation was conducted at Syiah Kuala University Faculty of Agriculture Green house. There were 3 type of mycorrhizae propagated : *Glomus mosseae*, *Gigaspora* sp. and combination of both *Glomus mosseae* and *Gigaspora* sp. After the soil is filtered using 9 mesh filter, it was placed into the plastic bags, each bag contain 5 kg soil. Soil were then sterilized using autoclaved (121°C for 30 minutes) to dispel all contained microorganism in the soil. Sterilized soil then placed into the pot to be planting media. Maize (*Zea mays* L) was used as the host plant for propagating mycorrhizae. After the soil was ready, each type of prepared mycorrhizae species were then put into the planting hole. Each hole was given 5 g of mycorrhizae starter. After adding the mycorrhizae starter, the Maize seeds were put in to the each hole. Each hole consisted of 2 seeds. After planting, the maize plants were then having stressing process for 1 month until the plant and soil was drought. After the stressing process was passed, the plants were then unloaded from the soil and the fine roots were removed, for each 1 cm. Those cutted fine roots were then mixed into the Zeolite and ready to be applicated asmycorrhizae fertilizer.

### Soil Preparation and Seedling

The soil were sterilized from weeds and then tillaged manually. The plots were created with 1 meter width, 40 m length and 50 cm space between each plot. After plots were created, plastic mulches were then adjusted. The mulch adjusted after the basic fertilizer was applicated. Each plot contained 2 row of plants, with each plant distance of 50 x 60 cm following the zig zag pattern. For the seedling, only the seeds with 90% germination rate were used. The seeds were soaked inside the aerator for 1-24 hours. The used cultivar were Lado F1, PM 999 F1, R1, Perintis and OR TWIST 42. Seeds were inside the babybag (10 x 12 cm) using Andisols soil. Each bag consisted of one seed, and then mycorrhizae fertilizer was applicated half dosage from 10 g/plant on the first step based on each type of mycorrhizae.

### Cultivation and Mycorrhizae Application

Cultivation and Mycorrhizae application was conducted at 21 days after sowing with the seedling criteria having 3-4 leaves. Hole diameter and depth were less then 10 cm, during the transplanting half dose of mycorrhizae was applicated as the second step application of each type. The transplanting was conducted in the afternoon. Basic fertilization was given by applicating NPKS fertilizer 50% of recommended dose 250 ha<sup>-1</sup> or 500 g for each plot. The fertilization application conducted 2 weeks and 4 weeks after transplanting by dissolving fertilizer to the water and pour it into the soil near rhizosphere area.

### Plant's Maintenance

Each died plants before 14 days after transplating (DAT) were replaced with new seedling. Plants were watered twice a day, morning and afternoon. Weeds control was conducted manually. Each plant was supported by 120 cm wood stake. In 7-20 DPT, the undproductive shoots were removed. Pest and disease management was conducted chemically. Fruit harvesting was started from 90, 95, 100, 105, 110,115 and 120DPT

### Data Analysis

This study used Factorial Randomized Group Design with the pattern of 4 x 5 and 3 replications. The observed factors were mycorrhizae speciesconsisted of control (without mycorrhizae), *Glomus mosseae*, *Gigaspora* sp., and combination of both *Glomus mosseae* + *Gigaspora* sp. and chili plant varieties Lado F1, PM 999 F1, R1, Perintis, and OR TWIST 42. The study consisted of 2 series, A and B. A was conducted to obtain growth data and yield, and B was conducted to observe mycorrhizae colonization. Hypothesis test was conducted by data processing which obtained parametrically. To perceive the effect of treatment factor to the growth and yield of chili plants, the data were tested by using analysis of variance with the probability of 0,05<sup>9</sup>. If the result of analysis of variance is significant at 5%, the data would then further tested using the mean of treatment to perceive the difference between treatment using Tukey's honestly significant difference (HSD).

## III. Result

### Soil Analysis

Frequent soil analysis was conducted in Syiah Kuala University Faculty of Agriculture Soil and Plant Laboratory. The result of frequent analysis can be seen on Table 1.

**Table 1.** The Soil Fertility Status of Bener Meriah Andisols

Parameters	Score	Reference*)	Condition
pH H <sub>2</sub> O	5,96	5,5-6,5	Rather Acidic
N-total	0,28	0,21-0,50	Moderate
P-available	6,80	<10	Very low

C-organic	2,97	2,01-3,00	Moderate
Cation exchange capacity	20,00	17-24	Moderate
Electrical conductivity	0,09	<8	Low
Texture class	I	-	Clay

Sources : Syiah Kuala University Faculty of Agriculture Soil and Plant Laboratory Analysis, 2019

\*) Indonesian Soil Research Institute (Balittanah), 2009

Table 2 was the result of Andisols soil analysis from Blang Kucak Village, Wih Pesam Subregency, Bener Meriah, Aceh. According to frequent soil analysis result, the pH of the soil sample is rather acidic (5,96), N-total content of 0,28 is moderate, P-available is very low (6,80), C-organic classified as medium, cation exchange capacity is moderate (20,00), low electrical (0,09) and texture class of the soil classified as Clay. The pH characteristic of rather acidic and very low P-available cause the disruption of nutrition absorption in plant due to the high reaction of Al and Fe causing unavailability of certain essential element. Only 13-15% P element that can be absorbed by the plant in Andisols due to the reaction of Al and Fe causing certain elements fixed and unavailable for plant<sup>10</sup>.

### Mycorrhizae colonization on chili plants root

Average chili plants root colonization percentage due to the mycorrhizae species treatment, can be seen on Table 2.

**Table 2.** Average root colonization percentage due to mycorrhizae species treatment

Mycorrhizae species treatment	Root colonization percentage (%)	HSD 0,05
Kontrol (M0)	1,28 (0,00) a	
<i>Glomus mosseae</i> (M1)	61,05 (76,00) b	9,71
<i>Gigaspora</i> sp. (M2)	67,05 (81,33) b	
Combination ( <i>Glomus mosseae</i> + <i>Gigaspora</i> sp.) (M3)	66,13(81,33) b	
LADO F1 (V1)	48,00(77,77)	
PM 999 F1 (V2)	46,84(77,77)	
R1 (V3)	54,54(86,67)	-
PERINTIS (V4)	45,78(75,55)	
OR TWIST 42 (V5)	50,21(80,00)	

Note : Number followed by the same letter in the same column is not significantly different on the level of 0,05 (HSD). Number outside the brackets are transformed using  $\arcsin(x = \frac{\sqrt{I}}{4n} \%)$ .

Table 2 showed the higher mycorrhizae colonization percentage observed in *Gigaspora* sp. significantly different to the control yet not significantly different to *Glomus mosseae* dan combination of both *Glomus* + *Gigaspora* sp..

### P-avalable in Soil

**Table 3.** Average of P-available result analysis after the harvesting period.

Mycorrhizae species treatment	P-available	HSD 0,05
Control (M0)	41,56 a	
<i>Glomus mosseae</i> (M1)	45,28 b	2,44
<i>Gigaspora</i> sp.(M2)	47,33 b	
Combination ( <i>Glomus mosseae</i> + <i>Gigaspora</i> sp.)(M3)	45,99 b	
LADO F1 (V1)	44,56 ab	
PM 999 F1 (V2)	45,01 ab	
R1 (V3)	45,53 ab	2,32
PERINTIS (V4)	43,52 a	
OR TWIST 42 (V5)	46,55 b	

Note: Number followed by the same letter in the same column is not significantly different on the level of 0,05 (HSD).

Table 3 showed that P-available in the treatment of *Gigaspora* sp. is significantly higher than control, however it is not significantly different from any other mycorrhizae species treatment. Furthermore, in the treatment of variety, OR TWISR 42 is significantly different from Perintis, however it is not significantly different from any other varieties.

2. Interaction between mycorrhizae and varieties to the growth of chili plant

Table 4. Average plant heigth on 15, 30, 45 DAT due to the mycorrhizaespecies and variety treatments

Parameters	Mycorrhizae	Varieties					HSD 0,05
		LADO F1 (V1)	PM 999 F1 (V2)	R1 (V3)	PERINTIS (V4)	OR TWIST 42 (V5)	
PH 15	M0	6,67 Aa	6,33 Aa	7,00 Aa	6,67 Aa	6,67 Aa	2,90
	M1	9,67 Ab	9,00 Aab	8,50 Aa	8,67 Aa	15,00 Bc	
	M2	13,33 Bc	9,33 Ab	7,67 Aa	8,17 Aa	9,00 Aab	
	M3	9,67 Ab	9,00 Aab	8,67 Aa	8,33 Aa	11,00 Ab	
PH 30	M0	18,00 Aa	15,00 Aa	15,17Aa	14,50 Aa	15,50 Aa	3,66
	M1	20,83 Ba	19,33 Bb	15,17 Aa	18,83 Abab	28,67 Cc	
	M2	30,17 Cc	24,17 Bc	18,50 Aa	19,17 Ab	20,67 ABb	
	M3	25,50 Bb	19,00 Ab	17,50 Aa	17,50 Aab	20,17 Ab	
PH 45	M0	27,33 Aa	27,33 Aa	24,50 Aa	23,00 Aa	25,67 Aa	7,12
	M1	30,83 Aa	35,17 Ab	31,67 Aab	30,00 Aab	47,33 Bc	
	M2	49,67 Cb	33,00 Abab	32,17 Ab	33,00 ABb	42,67 Cbc	
	M3	46,67 Cb	36,00 ABb	32,17 Ab	34,17 ABb	40,00 BCb	
PB	M0	18,67 Aa	26,67 Aab	23,33 Aa	19,33 Aa	33,00 Aa	14,63
	M1	28,00 Aab	20,67 Aa	25,33 Aa	24,33 Aa	34,00 Aa	
	M2	34,67 Ab	37,67 Ab	27,00 Aa	28,00 Aa	36,67 Aa	
	M3	29,67 Aab	30,33 Aab	33,00 Aa	29,00 Aa	27,33 Aa	
FW	M0	126,07 Aa	134,21 Aa	119,30 Aa	118,45 Aa	140,10 Aa	30,81
	M1	156,57 Bcab	162,21Bca	131,10 Aa	142,97 ABa	179,17 Ca	
	M2	178,26 Bb	147,22 Aa	145,94 Aa	143,35 Aa	170,36 ABa	
	M3	175,56 Ab	156,12 Aa	145,59 Aa	148,86 Aa	168,93 Aa	
DW	M0	35,52 Aa	35,43 Aa	28,41 ABa	22,41 ABa	48,72 Ba	19,16
	M1	48,77 Aa	53,43 ABb	35,35 Aa	36,15 Aab	70,29 Bb	
	M2	73,01 Cb	44,37 Abab	42,17 Aa	37,25 Aab	60,36 BCab	
	M3	70,09 Bb	55,13 ABb	43,95 Aa	43,98 Ab	65,85 Bab	

Note : Number followed by same letter is not significantly different at the level of 0,05 (Tukey's HSD test). Uppercase is notation in the row, lowercase is notation in column. PH= Plant Height, PB= number of productive branch, FW= Plant Fresh Weight, DW= Plant Dry Weight, Pa = P-unavailable. M0 = Control, M1=*Glomus mosseae*, M2= *Gigaspora* sp., M3= Combination of both *Glomus mosseae* + *Gigaspora* sp.

a. Plant Height at 15 DAT

Table 4 shows that the best combination between mycorrhizae and chili variety plant height at 15 DAT is *Glomus mosseae* with the variety of OR TWIST 42 and *Gigaspora* sp. with the variety of LADO F1. Those following treatment combinations are significantly different from the remaining treatments. The correlation between mycorrhizaespecies and chili variety to the plant height at 15 DAT can be seen in Fig. 1.

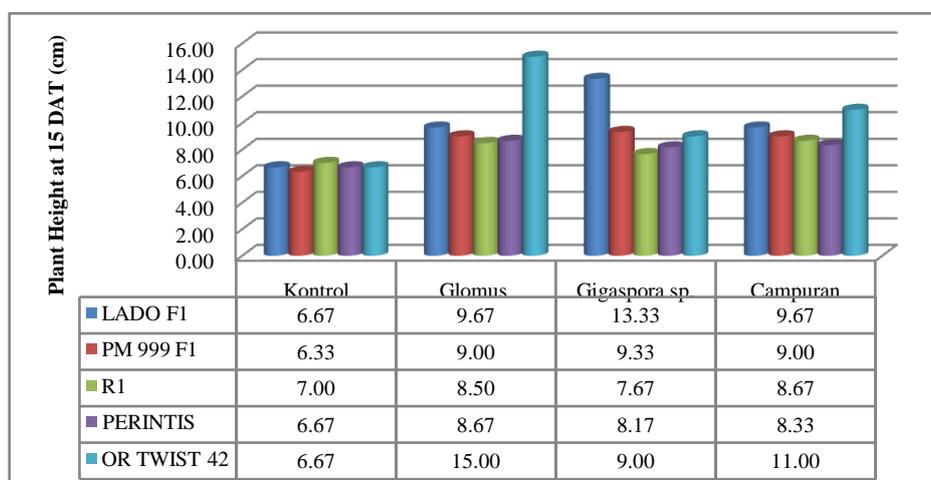


Fig. 1. The correlation between mycorrhizaespecies and chili variety to the plant height at 15 DAT.

b. Plant Height at 30 DAT

Table 4 shows that the best combination between mycorrhizae and chili variety to the plant height at 30 DAT is *Glomus mosseae* with the variety of OR TWIST 42 and *Gigaspora* sp. with the variety of LADO F1. Those following treatment combinations are significantly different from the remaining treatments. The correlation between mycorrhizae species and chili variety to the plant height at 30 DAT can be seen in Fig. 2.

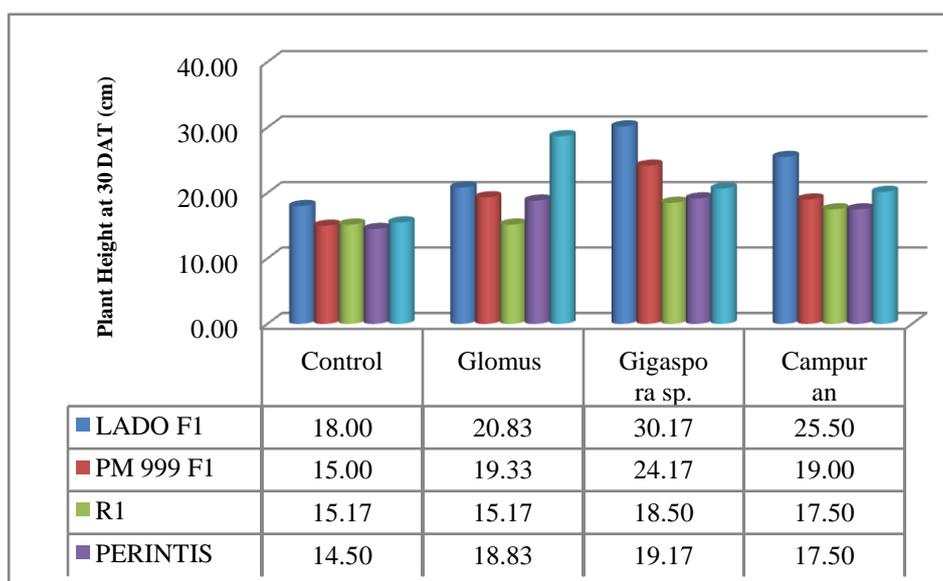


Fig. 2. The correlation between mycorrhizae species and chili variety to the plant height at 30 DAT

c. Plant Height at 45 DAT

Table 4 shows that the best combination between mycorrhizae and chili variety to the plant height at 30 DAT is *Gigaspora* sp. with the variety of LADO F1 . The following treatment combination is significantly different from the remaining treatments. The correlation between mycorrhizae species and chili variety to the plant height at 45 DAT can be seen in Fig. 3.

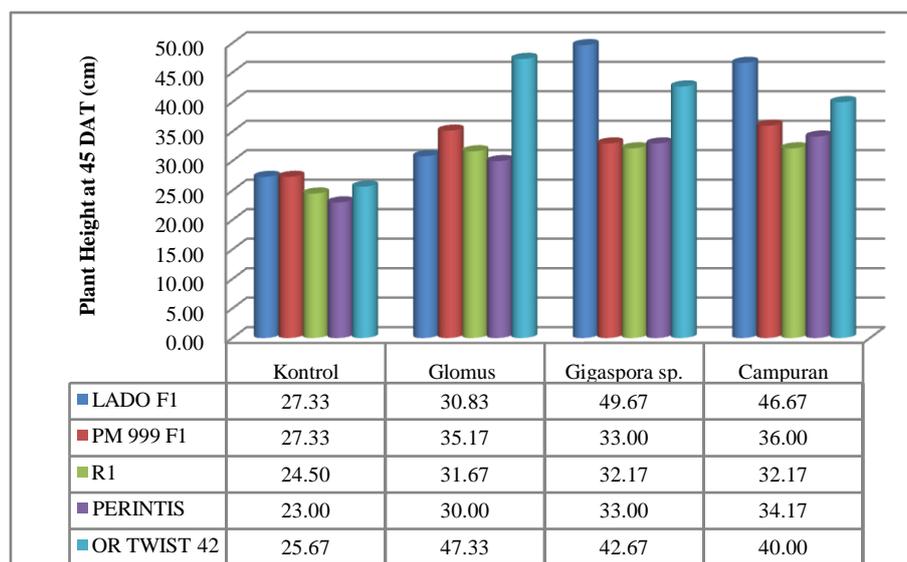


Fig. 3. The correlation between mycorrhizae species and chili variety to the plant height at 45 DAT

d. Number of productive branches at 60 DAT

Table 4 shows that the best combination between mycorrhizae and chili variety to the number of productive branches at 60 DAT is *Gigaspora* sp. with the variety of PM 999 F1. The following treatment combination is significantly different from the remaining treatments. The correlation between mycorrhizae species and chili variety to the number of productive branches at 60 DAT can be seen in Fig. 4.

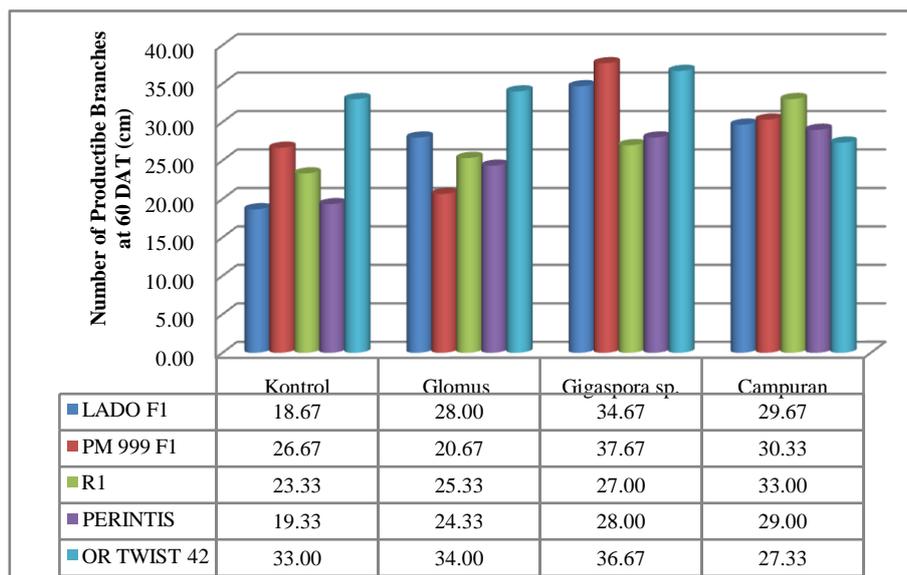


Fig. 4. The correlation between mycorrhizae species and chili variety to the number of productive branches at 60 DAT

e. Plant Fresh Weight

Table 4 shows that the best combination between mycorrhizae and chili variety to the plant fresh weight is *Glomus mosseae* with the variety of OR TWIST 42. However the following treatment combination is not significantly different to the *Glomus mosseae* (M1) with the variety of PM 999 F1. The correlation between mycorrhizae species and chili variety to the plant fresh weight can be seen in Fig. 5.

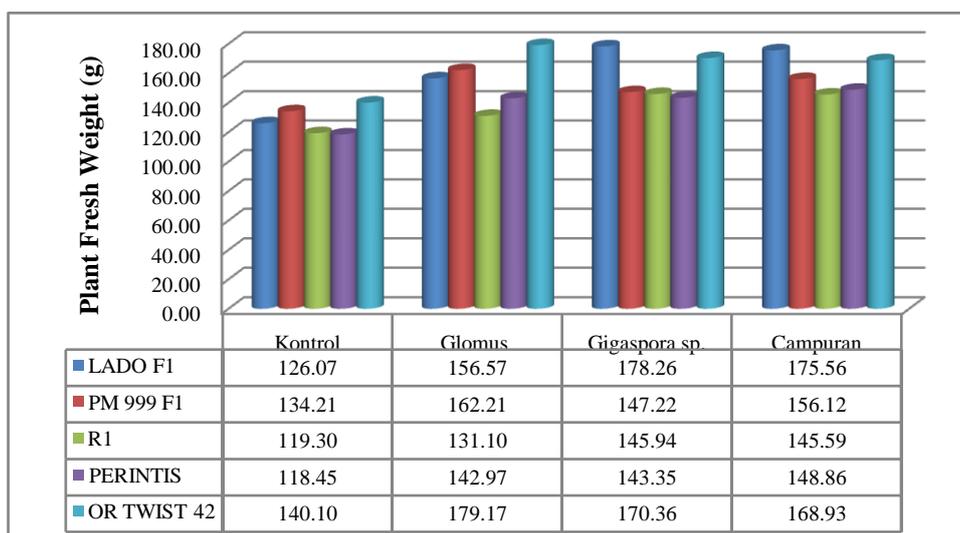


Fig. 5. The correlation between mycorrhizae species and chili variety to the plant fresh weight

f. Plant Dry Weight

Table 4 shows that the best combination between mycorrhizae and chili variety to the plant dry weight is *Gigaspora sp.* with the variety of LADO F1. However the following treatment combination is not significantly different to the *Gigaspora sp.* with the variety of OR TWIST 42. The correlation between mycorrhizae species and chili variety to the plant dry weight can be seen in Fig. 6

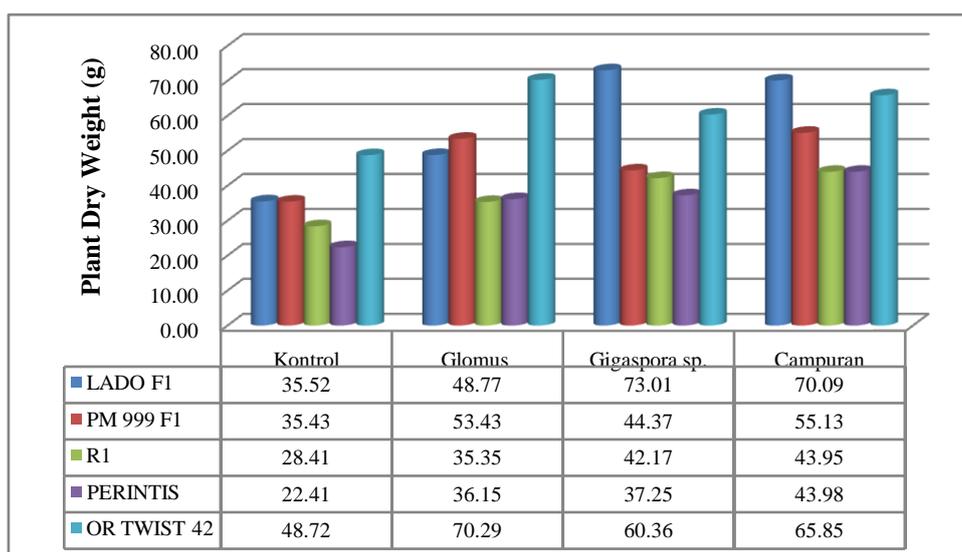


Fig. 6. The correlation between mycorrhizae species and chili variety to the plant dry weight

### 3. Interaction between mycorrhizae and varieties to the yield of chili plant

Table 5. Average yield of chili plants due to the mycorrhizae species and variety treatments

Parameters	Mycorrhizae	Chili Variety					HSD 0,05
		LADO F1 (V1)	PM 999 F1 (V2)	R1 (V3)	PERINTIS (V4)	OR TWIST 42 (V5)	
NFP	M0	66,67 Aa	61,00 Aa	59,67 Aa	57,67 Aa	74,00 Aa	32,43
	M1	80,67 ABab	75,67 Aa	112,33 Bb	73,00 Ab	89,33 ABab	
	M2	106,33 ABbc	109,33 ABab	94,00 Ab	95,67 ABb	127,33 Bc	
	M3	119,00 Cc	80,00 ABb	109,67 BCb	67,00 Aab	117,67 Cbc	
WFP	M0	445,58 ABa	423,11 ABa	381,87 Aa	351,49 Aa	557,96 Ba	173,60
	M1	531,37 ABab	533,94 ABa	629,86 Bb	448,80 Aa	548,55 ABa	
	M2	627,97 ABb	581,85 ABa	601,60 ABb	468,25 Aa	692,80 Ba	
	M3	650,76 Bb	524,62 ABa	652,12 Bb	470,34 Aa	641,79 ABa	
LFP	M0	15,33 Ba	10,50 Aa	16,00 Ba	11,83 Aa	15,67 Ba	1,80
	M1	16,33 Ca	11,67 Aa	14,50 Ba	11,67 Aa	16,33 Ca	
	M2	16,50 Ca	11,59 Aa	14,50 Ba	11,67 Aa	16,67 Ca	
	M3	16,33 Ca	11,67 Aa	14,67 Ba	11,50 Aa	16,33 Ca	
PY	M0	10,52 ABa	9,99 ABa	9,02 Aa	8,30 Aa	13,17 Ba	4,10
	M1	12,55 ABab	12,61 ABb	14,87 Bb	10,60 Aa	12,95 ABa	
	M2	14,83 ABb	13,74 ABb	14,20 ABb	11,06 Aa	16,36 Ba	
	M3	15,37 ABb	12,39 ABb	15,40 Bb	11,11 Aa	15,15 ABa	

Note :Number followed by same letter is not significantly different at the level of 0,05 (Tukey's HSD test). Uppercase is notation in the row, lowercase is notation in column. NFP = Number of fruit perplant, WFP= Weight of fruit perplant, LFP=Length of fruit perplant, PY= Potential yield ton<sup>1</sup>

#### g. Number of fruit perplant

Table 5 shows that the better combination between mycorrhizae and chili variety to the number of fruit per plant is *Gigaspora* sp. with the variety of OR TWIST 42 compared to the combination of both *Glomus mosseae* + *Gigaspora* sp. with the variety of LADO F1 which is significantly different from remaining treatments. The correlation between mycorrhizae species and chili variety to the number of fruit perplant can be seen in Fig. 7.

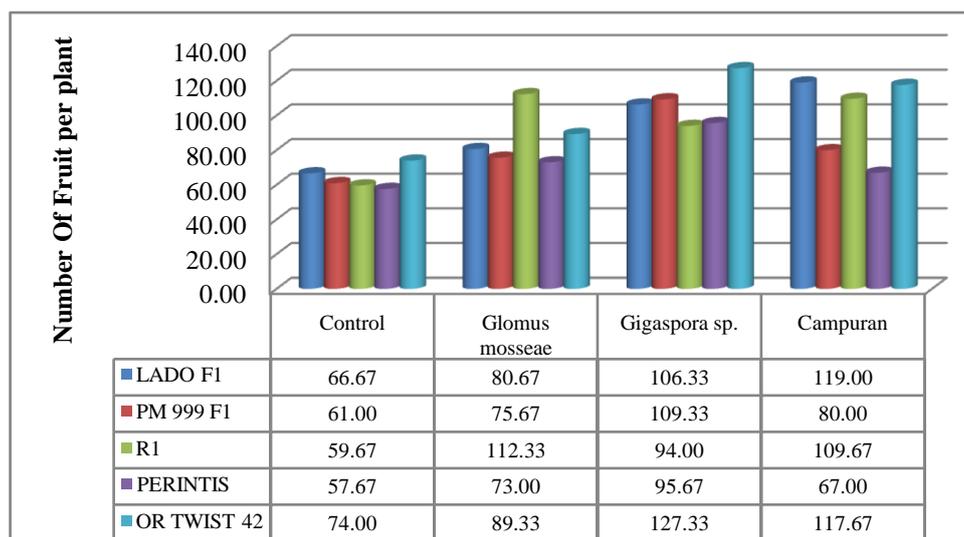


Fig. 7. The correlation between mycorrhizae species and chili variety to the number of fruit per plant

h. Fruit weight per plant (g)

Table 5 shows that the combination between mycorrhizae strain and chili variety to produce highest fruit weight per plant is *Gigaspora* sp. with the variety of OR TWIST 42 and combination *Glomus mosseae* + *Gigaspora* sp. with variety of R1 which are significantly different compared to remaining treatments. The correlation between mycorrhizae species and chili variety to the fruit weight per plant can be seen in Fig. 8.

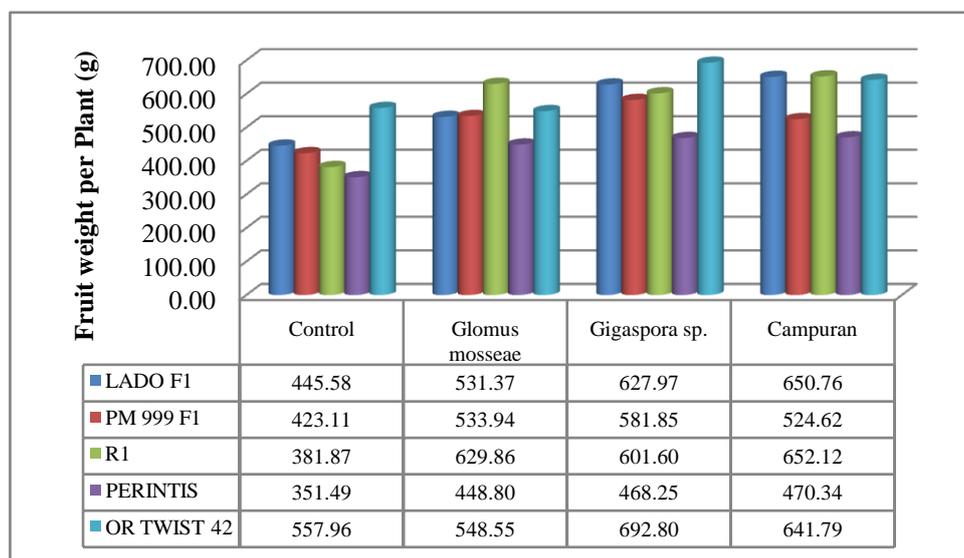


Fig. 8. The correlation between mycorrhizae species and chili variety to the fruit weight per plant

i. Fruit length (cm)

Table 5 shows that the combination between mycorrhizae strain and chili variety to produce the highest fruit length per plant is *Gigaspora* sp. with the variety of OR TWIST 42 and LADO F1 which are not significantly different compared to *Glomus mosseae* and combination of *Glomus mosseae* + *Gigaspora* sp.. The correlation between mycorrhizae species and chili variety to the fruit length per plant can be seen in Fig. 9.

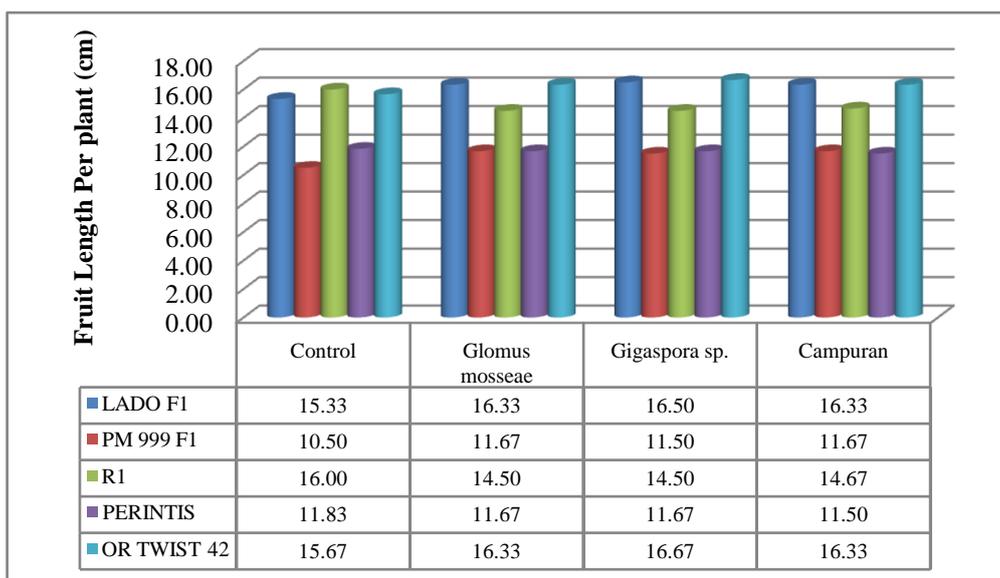


Fig 9. The correlation between mycorrhizae species and chili variety to the fruit length per plant

j. Potential yield (ton ha<sup>-1</sup>)

Table 5 shows that the combination between mycorrhizae strain and chili variety to produce the highest potential yield (ton ha<sup>-1</sup>) is *Gigaspora* sp. and combination of *Glomus mosseae* + *Gigaspora* sp. with the variety of OR TWIST 42 and R1 which are significantly different compared to remaining treatments. The correlation between mycorrhizae species and chili variety to the potential yield per ton can be seen in Fig.10.

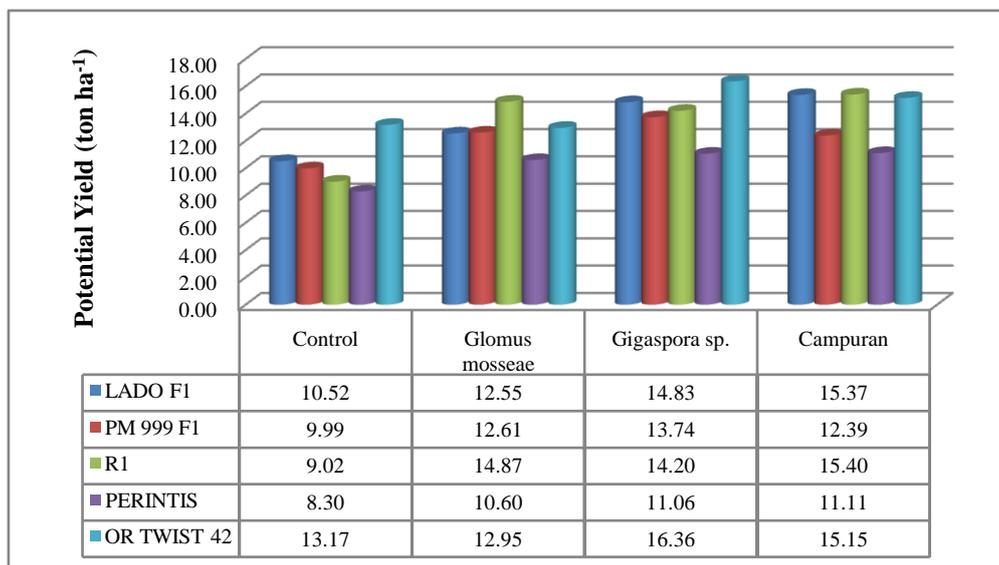


Fig. 10. The correlation between mycorrhizae species and chili variety to the potential yield (ton ha<sup>-1</sup>).

**Discussion**

**The effect of mycorrhizae species and variety to the root colonization**

The result of the study showed that the better root colonization percentage is found in *Gigaspora* sp. which is significantly different from the control yet not significantly different to remaining treatments. It is believed that each species of mycorrhizae has similar infection method yet different type of host plant will affect how high or low the mycorrhizae colonization. The physiological status of the plant significantly affects the plant response to the mycorrhizae colonization and contribution<sup>11</sup>. The *Gigaspora* showed the highest colonization rate compared to the combination of *Gigaspora* + *Acaulospora tuberculata*<sup>12</sup>. This shows that the AMF effectivity rate is depend on the inoculated mycorrhizae species. The single inoculated mycorrhizae species is better resulting compared to the combined species<sup>13</sup>. This is definitely affect the growth and yield of

the plant. The *Gigaspora* sp. capable of increasing the growth and yield of chili plants cultivated in Andisols soil<sup>14</sup>.

Beside those possibilities, root colonization by mycorrhizae can not be separated from the role of plant in producing carbon for mycorrhizae growth and development in root. OR twist 42 and R1 are two varieties with high percentage of mycorrhizae root colonozation. Both of varieties are capable of growing well in media and correspond to the inoculated fungi species, since the colonization percentage mostly depend on the Arbuscula Mycorrhizal Fungi (AMF) species and host plant as the food producer to the development of mycorrhizae. Each species of mycorrhizae has different effectivity rate and physiological interaction to the host plant<sup>15</sup>. A species of *Glomus macrocarpus* was very slow on colonizing the root of *Allium cepa* and it is not significant neither to the growth nor to the P element intake, whereas *Glomus mosseae* and *Gigaspora* sp. colonized the root of *Allium cepa* larger thus the intake of P element and the plant growth was increasing<sup>16</sup>.

#### ***The effect of mycorrhizae species and variety to the soil P-available for growth and yield of chili plant***

According to the soil analysis conducted immediately after the harvesting period finished, the P-available shows better average value when *Gigaspora* sp. applied. *Gigaspora* sp. is more capable of increasing P-available in the soil for chili plants though it is not significantly different from *Glomus mosseae* or combination of both *Glomus mosseae* + *Gigaspora* sp. It is expected that *Gigaspora* sp. showed well response to the crumbly soil that has high Al and Fe heavy metal reaction. Thus, *Gigaspora* sp. plays important role to form hyphae tissue and enlarge the area of nutrition absorption therefore the P-fixed will be able to be well released. This possibility may occur since most of the *Gigaspora* sp. has known to form larger spore compared to the *Glomus* sp. The stated that mycorrhizae's role is more significant at the phosphorus deficient soil<sup>17</sup>, thus if the plant is infected by mycorrhizae, it can rectify the nutrition cycle, soil structure, and distribute the nutrition for soil organism, increase the nutrition absorption for plant, particularly P element, since mycorrhizae secrete phosphate enzym and organic acids such as oxalate which can release and serve P-available for the plant<sup>18</sup>.

Besides the idea above, the variety influence is also hold important role in the association of mycorrhizae and plant to the P-available in soil. In this case, OR Twist 42 and R1 are better in increasing the P-available for the plant that are correspondingly capable of increasing growth and yield. It is strongly expected since both of varieties have excellent genotype and capable of well adapting in their growing environment thus the root system is also capable of absorbing nutrients, especially P element. Each variety has different capability from one to another, each variety carries its own genetic information<sup>19</sup>. Genetic factor is more affecting in increasing growth and yield of chili plants compared to environment factor<sup>20</sup>.

#### ***Interaction of mycorrhizae species and variety to the growth and yield of chili plants***

The result showed that there is interaction between mycorrhizae species and variety to the plant height at 15, 30, and 45 DAT, productive branches number, plant fresh weight, plant dry weight, number of fruit per plant, fruit weight per plant, fruit length per plant, potential yield ton<sup>-1</sup>. It is expected that mycorrhizae requires quite decent host plant for supporting its growth and chili plant. Chili plant is a plant that require unflooded land and no high temperature, its growing criterias are similiar to the mycorrhizae characteristic which capable of well thriving in the chili plants required growing condition, thus in the present study, there are parameters that are significantly affected to the growth and yield of the chili plant. Mycorrhizae association has recorded to be suitable to several host plants in tropical region, since the mutualism symbiosis between mycorrhizae and host plant is significantly affected by phenological condition, climate and soil condition<sup>20,21</sup>. These will affect to the mycorrhizae hyphae development on chili plant in supporting water and nutrition absorption. Mycorrhizae colonization on plant root will produce external hyphae therefore it will play the role of increasing root capacity on absorbing water and nutrition for the plant<sup>22</sup>.

Over all, the best combination to the growth and yield, among all species of mycorrhizae, is *Gigaspora* sp. with the variety of OR TWIST 42. Combination of both mycorrhizae shows positive response in case of nutrition absorption by enlarging the nutrition absorption area of the root due to the existence of mycorrhizae hyphae and spore development thus the plant is capable of increasing growth and plant.

The rapidity of nutrition absorption particularly P to the AMF hyphae could reach approximately six times faster compared to uncolonized root<sup>23</sup>. The species *Gigaspora* sp. could increase growth and yield of chili in Andisols<sup>24</sup>. Several researches have also shown that the application of mycorrhizae *Glomus mosseae* and *Gigaspora* sp. were capable of increasing the growth of chili plants in Entisols and Andisol soil<sup>25,26</sup>.

### **V. Conclusion**

The result showed highest root colonization is found in *Gigaspora* sp. with the variety of OR TWIST 42 and R1. The highest P-available in soil is found in *Gigaspora* sp. with the variety of OR TWIST 42. The best growth and yield is found in *Gigaspora* sp. with the variety of OR TWIST 42.

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Maulana Zubir, et. al. "The Combination of Mycorrhizae Species and Variety to the Growth and Yield of Chili Plants (*Capsicum annum* L.) in Bener Meriah Andisols Soil." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 13(6), 2020, pp. 57-67.