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Effectiveness of AM Fungi to Increase The Growth and Production of Peanuts Plant Infected by *Sclerotium rolfsii*

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Abstract— *Arbuscular Mycorrhizal Fungi (AM Fungi) are known to have the potential to increase plant growth. This study aims to find the best isolates of Indigenous Arbuscular Mycorrhizal Fungi (AM Fungi) that can increase the growth and production of peanuts plant infected by Sclerotium rolfsii caused stem rot disease. The method used is an experimental method with a Completely Randomized Design with 5 treatments, and 5 replication, namely A: AM Fungi Glomus sp-3 + S. rolfsii; B: AM Fungi Acaulospora sp + S. rolfsii; C: AM Fungi Gigaspora sp + S. rolfsii; D: Combined AM Fungi Glomus sp-3, Acaulospora sp, and Gigaspora sp + S. rolfsii; E: Without AM Fungi + S. rolfsii (Control). The data were analyzed using Analysis of Variance (ANOVA) using the Statistix 8 program and the Least Significance Different (LSD) test at a 5% significance level. The results showed that the Isolates of In general, Glomus sp-3 was able to increase the growth and production of peanuts.*

Keywords— ***Acaulospora, Gigaspora, Glomus, indigenous.***

I. INTRODUCTION

Indonesia's peanut productivity in 2020in 2011, 2012, 2013, 2014 and 2015 tended to fluctuate, namely 1,281 tons / ha, 1,274 tons / ha, 1,352 tons / ha, 1,279 tons / ha and 1,333 tons / ha, respectively. Meanwhile, productivity in West Sumatra was 1.509 tonnes / ha, 1.407 tonnes / ha, 1.540 tonnes / ha, 1.362 tonnes / ha and 1.459 tonnes / ha (BPS, 2018). This productivity is still low compared to its potential productivity which can reach 2.5 - 3 tons / ha (Rahmianna et al., 2015). One of the factors causing the low productivity of peanuts is the presence of plant diseases.

Stem rot caused by *S. rolfsii* fungus is the most detrimental disease (able to reduce pod yield by 60%) (Kator *et al.*, 2015). Therefore it is necessary to take control measures that are environmentally friendly besides being able to increase crop production. one of them is by using indigenous Arbuscular Mycorrhizal Fungi (AM Fungi) (Rahman et al, 2017).

AM Fungi is found in almost all habitats throughout the world and can associate with many plants (INVAM, 2020). Mycorrhizal fungi are one of the living organisms that can increase plant growth and development, reduce stress, remediate soil pollution, help C absorption, and increase plant resistance. Mycorrhizal fungi help plants absorb nutrients by expanding the network of mycorrhizal hyphae in the rhizosphere. Mycorrhizal inoculation changes the root architecture so that the nutrient absorption capacity of the inoculated roots is much better than those that are not inoculated (Ortas and Rafique, 2017).

The study aimed to obtain Indigenous Arbuscular Mycorrhizal Fungi (AM Fungi) isolates that can increase the growth and production of peanuts attacked by *Sclerotium rolfsii* which causes stem rot disease

II. MATERIAL AND METHOD

2.1. Time and Location of Research

This research has been carried out from July 2019 to April 2020 in the greenhouse and the Phytopathology Laboratory, Faculty of Agriculture, Andalas University.

2.2. Research Materials

Local cultivar (*Arachis hypogeae* L.) was used as plant material. *S. rolfsii* isolated from naturally infected peanut plants was maintained on the Potatoes Dextrose Agar (PDA) were then cultured on Corn Meal Sand (CMS) media. This study used four indigenous AM Fungi isolates namely A (*Glomus* sp-3), B (*Acaulospora* sp), C (*Gigaspora* sp), D (Combined *Glomus* sp-3, *Acaulospora* sp, and *Gigaspora*).

2.3. Experiment Details and Statistics Analysis

Experiment design in this study was Completely Random Design (CRD) with 5 treatments and 5 replication. Data were analyzed using Statistix 8 program. Analysis of variance (ANOVA) was used to determine the treatment effects and the differences between treatments were determined using LSD Test on 5%. Treatments were as follow A : AM Fungi *Glomus* sp-3 + *S. rolfsii*; B: AM Fungi *Acaulospora* sp + *S. rolfsii*; C: AM Fungi *Gigaspora* sp + *S. rolfsii*; D: Combined AM Fungi *Glomus* sp-3, *Acaulospora* sp, and *Gigaspora* sp + *S. rolfsii*; E: Without AM Fungi + *S. rolfsii* (Control).

2.4. Experiment Procedure

The planting medium is a mixture of ultisol soil with manure (2:1 v/ v). The mixture medium then was mashed and sieved. The mixture is sterilized for 2 hours at 100ºC and then dried at room temperature for 1 day. The medium was put into 45 x 50 cm polybags. AM Fungi inoculum (100 spores/plant) was introduced at planting time (seeds are ± 7 days old after germinated). Synthetic fertilizer was applied to the planting medium with a half recommendation dose (Urea 0.1 g / polybag, TSP 0.2 g / polybag, and KCl 0.2 g / polybag). Eight weeks after introducing AM Fungi, all plant was inoculated with 50 g inoculum of *S. rolfsii.*

2.5. Observations

2.5.1. Plant height

Plant height measurements are carried out from the base of the marked stem to the highest growth point. Plant height measurements were carried out at the age of 30, 37, 44, 51, 58, 65 and 72 DAP.

2.5.2. Number of leaves

The number of leaves was counted from leaves that opened completely and were done by counting the total number of peanut leaves in each plant sample at the age of 30, 37, 44, 51, 58, 65, and 72 DAP.

2.5.3. Number of branches

The calculation of the number of branches is done by counting all clump branches of each sample plant at the age of 30, 37, 44, 51, 58, 65, and 72 DAP.

2.5.4. Number and weight of pods

Each plant per treatment was counted the number and weight of pods by shedding the pods from the plant, then counted and weighed and differentiated which treatment was the best.

The effectiveness of each AM Fungi treatment on the number and weight of peanut pods was calculated using the formula:

$$EP = \frac{NM - NC}{NM} \; x \; 100\ \% \qquad (1)$$

EP = The effectiveness of peanut growth (number of pods)

NM = number of pods in plants with mycorrhizal treatment

NC = Number of pods in control plants

$$EP = \frac{PM - PC}{PM} \; x \; 100\ \% \qquad (2)$$

EP = effectiveness of peanut growth (pod weight)

PM = pod weight in plants with mycorrhizal treatment

PC = pod weight in control plants

2.5.5. Canopy fresh weight and dry weight

Each plant (canopy to root neck) per treatment was weighed to obtain fresh weight. Then it was dried using an oven at 70ºC until the weight was constant and then weighed (to get dry weight).

2.5.6. Root length

Each plant root (neck to root) per treatment was measured using a ruler. Plant roots are measured when the plants are finished harvesting.

2.5.7. Root fresh weight and dry weight

Each plant root (neck to root) per treatment was weighed to obtain fresh weight. Furthermore, the roots of the plants were dried using an oven at 70ºC until the weight was constant and then weighed (to get dry weight).

The effectiveness of each AM Fungi treatment on fresh weight and dry weight of peanut plant shoots and roots was calculated using the formula:

$$EP = \frac{WM - WC}{WM} \times 100\ \% \quad (3)$$

EP = effectiveness of peanut growth (fresh weight)

WM = weight of fresh roots / plant canopy in mycorrhizal treatment

WC = weight of fresh roots / plant canopy of plants in control

$$EP = \frac{DM - DC}{DM} \times 100\ \% \quad (4)$$

EP = effectiveness of peanut growth (dry weight)

DM = Dry weight of roots/plant canopy in mycorrhizal treatment

DC = Dry weight of the roots/canopy of the plant in the control

III. RESULTS AND DISCUSSION

Plant Height

Combined indigenous AM Fungi was able to increase plant height with the effectiveness of 31.42%. The administration of AM Fungi *Glomus* sp-3 showed results that were not significantly different than the combine with an effectiveness of 15.01% but also not significantly different from other isolates and also controls (Table 1). The comparison of the growth of peanut plants can be seen in Figure 1.

Table 1. Height of peanut plants (72 DAP)

Treatment	Height of plant (cm)		Effectiveness (%)
D (Combine)	51.36	a	31.42
A (*Glomus* sp-3)	45.98	ab	15.01
B (*Acaulospora* sp)	43.02	b	9.16
C (*Gigaspora* sp)	39.46	b	0.96
E (Control)	39.08	b	0.00
Cv = 12.75			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

3.2. Number of leaves

The number of peanut leaves with the treatment of several types of indigenous AM Fungi can be seen in Table 2. *Glomus* sp-3 indigenus AM Fungi was able to increase the number of leaves with an effectiveness of 39.88% and AM Fungi *Acaulospora* sp also increased the number of leaves with 22.83% effectiveness, however, has not given significantly different results compared to other isolates and also controls.

Table 2. Number of peanut leaves at 72 DAP.

Treatment	Number of leaves (sheet)		Effectiveness (%)
A (*Glomus* sp-3)	32.60	a	39.88
B (*Acaulospora* sp)	25.40	ab	22.83
D (Combine)	24.00	b	18.33
C (*Gigaspora* sp)	22.60	b	13.27
E (Control)	19.60	b	0.00
Cv = 22.57			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

3.3. Number of branches

The number of peanut branches can be seen in Table 3. The provision of various types of indigenous AM Fungi can increase the number of peanut branches with an effectiveness of 21.43 - 50%. AM Fungi *Glomus* sp-3 gave the best results in increasing the number of peanut branches with 50% effectiveness.

3.4. Number and weight of pods

The number and weight of peanut pods in each treatment can be seen in Tables 4 and 5. Applications of various types of indigenous AM Fungi can increase the number and weight of peanut pods (Tables 4 and 5). The highest number of pods was found in the provision of AM Fungi *Glomus* sp-3, namely 5.40 with 51.85% effectiveness and the highest pod weight was also found in the provision of AM Fungi *Glomus* sp-3, namely 12.35 grams with an effectiveness of 53.04% compared to the control.

Table 3. Number of peanut branches (72 DAP) (Transformation to √ (x + 1)).

Treatment	Number of branches	Transformation to $\sqrt{x+1}$)		Effectiveness (%)
A (*Glomus* sp-3)	4.40	2.3214	a	50.00
B (*Acaulospora* sp)	3.60	2.1307	ab	38.89
D (Combine)	2.80	1.8944	ab	21.43
C (*Gigaspora* sp)	2.40	1.7664	ab	8.33
E (Control)	2.20	1.7301	b	0.00
Cv = 22.27				

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

Fig 1. Growth comparison of peanut plants inoculated with indigenous and control AM Fungi. A. Glomus sp-3, B. Acaulospora sp, C. Gigaspora sp, D. Combine, E. Control

Table 4. Number of peanut pods (110 DAP) (Transformation to Log (x + 1)).

Treatment	Number of pods (grain)	Transformation to Log (x + 1)	Effectiveness (%)
A (*Glomus* sp-3)	5.40	0.7947 a	51.85
B (*Acaulospora* sp)	4.80	0.7373 ab	45.83
C (*Gigaspora* sp)	4.40	0.7282 ab	40.91
D (Combine)	4.40	0.6816 ab	40.91
E (Control)	2.60	0.5362 b	0.00
Cv= 23.50			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

Table 5. Weights of peanut pods at 110 DAP (Transformation to Log x).

Treatment	Weights of pods (gram)	Transformation to Log x	Effectiveness (%)
A (*Glomus* sp-3)	12.35	1.0347 a	53.04
B (*Acaulospora* sp)	11.62	0.9868 ab	50.09
D (Combine)	10.50	0.9864 ab	44.76
C (*Gigaspora* sp)	9.78	0.9831 ab	40.70
E (Control)	5.80	0.7453 b	0.00
CV = 22.96			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD tes

3.5. Canopy fresh weight and dry weight

The fresh and dry weight of peanut canopy in each treatment can be seen in Tables 6 and 7.

Table 6. Fresh weight of peanut canopy (110 DAP)

Treatment	Fresh weight of canopy (gram)		Effectiveness (%)
A (*Glomus* sp-3)	57.53	a	40.17
B (*Acaulospora* sp)	57.06	a	39.68
C (*Gigaspora* sp)	49.78	ab	30.86
D (Combine)	46.07	ab	25.29
E (Control)	34.42	b	0.00
Cv= 16.72			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

The application of various types of indigenous AM Fungi can increase the fresh weight of peanut canopy (Table 6). The highest canopy fresh weight was found in the provision of AM Fungi *Glomus* sp-3, namely 57.53 grams with an effectiveness of 40.17% and the highest canopy dry weight was also found in AM Fungi *Glomus* sp-3, namely 16.81 grams with an effectiveness of 55.21% compared to control (Table 7).

3.6. Root length

The root length of peanut in each treatment can be seen in Table 8 and Figure 2. The longest roots were found in plants given AM Fungi *Glomus* sp-3 with a root length of 37.40 cm and an effectiveness of 29.95%.

Table 7. Dry weight of peanut canopy (110 DAP)

Treatment	canopy dry weight (gram)		Effectivenes s (%)
A (*Glomus* sp-3)	16.81	a	55.21
B (*Acaulospora* sp)	12.40	ab	39.27
D (Combine)	11.37	bc	3377
C (*Gigaspora* sp)	11.26	bc	33.13
E (Control)	7.53	c	0.00
Cv = 28.71			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

Table 8. Length of peanut roots (110 DAP)

Treatment	Length of roots (cm)		Effectiveness (%)
A (*Glomus* sp-3)	37.40	a	29,95
B (*Acaulospora* sp)	32.60	ab	19,63
C (*Gigaspora* sp)	29.90	ab	12,37
D (Combine)	28.20	b	7,09
E (Control)	26,20	b	0,00
Cv = 21.03			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

The administration of AM Fungi *Acaulospora* sp and *Gigaspora* sp also increased plant root length but it was not significantly different compared to control. Meanwhile, giving combined AM Fungi did not show significantly different results from the control (Table 8).

Fig 2. Comparison of root lengths of peanut plants inoculated with indigenous and control AM Fungi. A. Glomus sp-3, B. Acaulospora sp, C. Gigaspora sp, D. Combine, E. Control.

3.7. Root fresh weight and dry weight

The fresh weight and dry weight of peanut roots in each treatment can be seen in Tables 9 and 10. The application of AM Fungi *Glomus* sp-3 and *Acaulospora* sp gave significantly different effects on root fresh weight with the effectiveness of 49.34 and 44.71% respectively (Table 9). AM Fungi *Glomus* sp-3 was also able to increase root dry weight with 43.14% effectiveness compared to control plants. Other isolates did not give significantly different results compared to controls (Table 10).

Table 9. Fresh weight of peanut roots (Transformation to $\sqrt{x}$).

Treatment	Fresh weight of roots (gram)	(Transformation to $\sqrt{x}$).	Effectiveness (%)
A (Glomus sp-3)	2.27	1.4670 a	49.34
B (Acaulospora sp)	2.08	1.4252 a	44.71
C (Gigaspora sp)	1.74	1.3019 ab	33.91
D (Combine)	1.48	1.2160 ab	22.30
E (Control)	1.15	1.0575 b	0.00
Cv = 19.44			

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

Table 10. The dry weight of peanut roots (110 DAP)

Treatment	dry weight of roots (gram)	Effectiveness (%)
A (*Glomus* sp-3)	0.51 a	43.14
B (*Acaulospora* sp)	0.44 ab	34.09
C (*Gigaspora* sp)	0.39 ab	25.64
D (Combine)	0.39 ab	25.64
E (Control)	0.29 b	0.00
Cv = 28.40		

The numbers followed by the same lowercase letters in the same column indicate no significant results among treatments at 5% level by LSD test

Observations on all plant growth parameters showed varied results. In general, indigenous AM Fungi has a positive effect on the growth of peanut plants compared to controls. In this study, the application of combined AM Fungi and *Glomus* sp-3 was able to increase the height of peanut plants with the effectiveness of 31.42% and 15.01% (Table 1). The results of Delvian's (2003) study also found that thecombined inoculum of *Acaulospora* sp-1 and *Gigaspora* sp (S1M6) was more able to increase plant height than the inoculum of one type of *Gigaspora* sp (S1M2) in Leucaena leucocephala plants. The ability of combined AM Fungi isolates to increase plant height was thought to be related to the ability of AM Fungi to help plants absorb nutrients through external hyphae networks. Prasasti et al., (2013) stated that the capacity of plants to absorb water and nutrients, especially P elements, will increase along with the development of external hyphae tissue in plant roots due to infection from AM Fungi. In addition, AM Fungi can also stimulate the formation of plant growth hormones such as cytokinins and auxins which play a role in cell division and elongation, thereby optimizing plant height growth (Talanca, 2010). The same thing was stated by Ortas and Rafique (2017) that AM Fungi helps plants absorb nutrients by expanding the hyphae network in the rhizosphere. Mycorrhizal inoculation changes the root architecture and studies have shown that the nutrient absorption capacity of inoculated roots is much better than those that are not inoculated.

AM Fungi *Glomus* sp-3 was the best in increasing the number of leaves, number of branches, number of pods, pod weight, shoot fresh weight, shoot dry weight, root length, root fresh weight, and root dry weight (Tables 2 - 10). AM Fungi *Glomus* sp-3 gave significantly different results to all observed parameters of peanut plant growth compared to control. AM F *Glomus* sp-3 was able to increase canopy dry weight (55.21%) and roots (43.14%) (Tables 7 and 10). This is because AM Fungi can increase nutrient uptake by plants. Lizawati et al., (2014) stated that dry weight is an indication of the success of plant growth because the dry weight of plants shows the presence of protein content, and photosynthesis results in the form of organic compounds that can be deposited after the moisture content are dried. The greater the dry weight of the plant, the more efficient the photosynthesis process is and the higher and faster the productivity and development of tissue cells, so that plant growth is better, which ultimately increases the dry weight of the plant. In addition, root length, fresh weight, and root dry weight of peanut plants can also increase because the root volume increases due to colonization of AM Fungi. This is consistent with the statement of Prasasti et al., (2013) that mycorrhizae affects the dry weight of the roots because plants infected with mycorrhizae will make the volume and length of the roots wider so that the dry weight of the roots will increase.

AM Fungi *Glomus* sp-3 was also able to increase the number and weight of peanut pods with the effectiveness of 51.85% and 53.03%, respectively (Tables 4 and 5). The ability of AM Fungi in increasing the number and weight

of peanut pods was related to the ability of AM Fungi in colonizing plant roots, especially in the planting medium used, namely ultisol soil. Rajmi et al., (2018) stated that ultisols are acid dry land that has low fertility and productivity, one of which is the problem of availability of elements P, stunted plants, small leaf size, and the development of roots, pods, and seeds are hampered. Meanwhile, the results showed that AM Fungi was able to increase the growth and production of peanut plants, which indicated that AM Fungi was able to colonize peanut roots well so that it could help the roots absorb nutrients.

IV. CONCLUSION

In general, the AM Fungi *Glomus* sp-3 was able to increase the growth and production of peanuts with the effectiveness of 15.01 – 55.21%.

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