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Effect of Arbuscular Mycorrhiza Fungi (AMF) and The Organic Material to The Glomalin Production and The Soil Physical Properties of Ultisols

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***Abstract*— Metabolism of Arbuscular mycorrhiza fungi (AMF) requires nitrogen from organic matter to produce glomalin on hyphae. Glomalin able to granulate the soil particles are dispersed to form a stable soil aggregates to create good soil structure. Improvement of soil structure will provide optimal conditions for the development of organisms and plant roots. AMF and the use of organic matter as a source of N for the AMF has done research on Sitiung Ultisol. The purpose of this study was to determine the effect of AMF and organic material to the glomalin production, as well as its relationship with the soil physical properties. This research was conducted at the greenhouse of Faculty Agriculture Andalas University Padang. West Sumatra Indonesia. Soil samples of soil physical properties observed in the area of mycorrhiza hyphae found (mycorhizalsphere) which is influenced by differences glomalin generated by the AMF. The results of the reserach showed that treatment of AMF and Nitrogen organic ingredients affect significantly on the glomalin, whereas the effect of treatment it gives a different effect on soil physical properties. Organic materials do not affect significantly on the availability of soil water content, but very significant effect on water content at 2.54 pF. AMF species that produce a higher glomalin can be significant in improving soil physical properties, ie versiforme G. and G. luteum although without the use of organic materials or organic. Both these species give a positive response to the growth of maize by mycorrhizalsphere (MGR = mycorrhizal growth response) and nutrient uptake of maize.**

***Keywords*— rizhosphere, mycorhizalsphere glomalin, nitrogen, tihonia, nutrient uptake.**

I. INTRODUCTION

Ultisol are a marginal lands which are found in the humid tropics that has undergone further weathering. High rainfall led to the genesis of this land dominated by washing bases and clay from the upper layer (elluviation process) that accumulate on the horizon B (illuviation process). Soil easily becomes compact and the structure is destroyed by the stroke of raindrops so that soil aggregates on the surface layer of fine particles dispersed into particles. Besides that, largely clay and organic materials lost due to runoff and erosion [1]. This resulted in this land has acidic properties of the physical and chemical properties that are bad for plant growth.

Generally, productivity of Ultisol is very low, which can be seen from the growth and production of corn being planted on this land has a lot of obstacles. Edi and Salvia [2] reported that the productivity of maize in Ultisol of Jambi province at 2005-2009 period is an average of 3.54 tons per ha. They explained that corn production in this period is only 30 to 50 % of the corn crop yield potential. This fact shows that the productivity of maize that is < 5 ton per ha on Ultisol is low [3].

The main problem that needs to be addressed is the improvement of the physical properties of Ultisol and increase the ability of plants to obtain nutrients and water needs. One way to overcome this problem is the use of arbuscular mycorrhizal fungi (AMF) to improve the condition of the soil physical properties and helps plants through a symbiotic relationship. AMF symbiosis with plants produce glomalin on mycorrhizal hyphae have good effect on soil physical properties. AMF symbiosis with plants produce glomalin on mycorrhizal hyphae. Glomalin serves as an adhesive between fine particles and micro aggregate and will be able to create good soil structure and increase soil aggregate stability, thus creating optimum environmental conditions for plant growth [4].

How AMF influence on soil physics and its relationship with the growth of corn plants have been studied [5]. How many glomalin generated AMF to obtain physical properties conditions are optimum of Ultisol in this study are known.

The purpose of this study was to determine the effect of AMF and organic N application of Tithonia in stimulating AMF to produce glomalin and improve the physical properties of Ultisol, as well as its relationship with the growth of corn.

II. Materials and Methods

A. Preparation Growing Media

Preparation of planting media carried out following pot experiments that used by Wright and Upadhyaya [6] 300 mL (450 g) medium which has been sterilized (autoclaved) were placed in nylon mesh at the position in the center of the pot. Nylon mesh can not be penetrated by the roots of plants, but it can be bypassed by AMF hyphae. Air-dried soil sieved using a sieve of 8 mm and a chunk of land was destroyed as well as clean of litter and roots. 22 cm diameter pots filled with soil that is clean as much as 8 kg. A total of 400 mL of medium soil that has been sterilized with steam heating, inserted in a cylindrical tube (PVC pipe) 1 L. Nylon mesh (300 mesh or 45 m) was placed over the cylinder and fastened with a rubber band. Cylinders containing soil was placed in the center of the pot, where nylon mesh bottom.

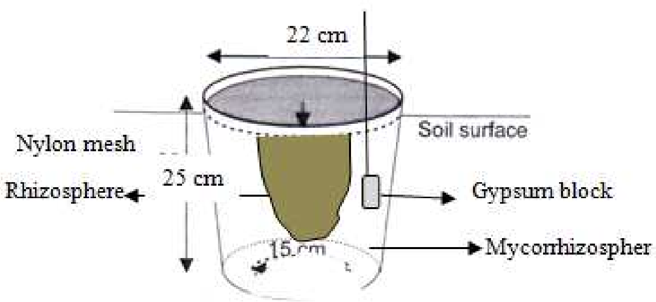

Fig. 1 Gypsum and nylon mesh in media pot

The area around the pot cylinder filled the remaining soil media, rubber binder is released and the cylinder removed carefully. Media in the nylon mesh is an rhyzosphere area and outer are as mycorrhizalsphere area (Figure 1).

B. Design of Experiments

Pots are placed in a greenhouse under treatment in a completely randomized design (CRD). Gypsum block was placed 5 cm from the edge of the pot at a depth of 10-15 cm in the area mycorhyzosphere to observe soil moisture and calculates water needs watering during the study. Media pots watered with deionized water of 200 ml and covered with plastic before planting.

The experiment was arranged in 3 x 2 factorial design with four replications. AMF inoculation treatments of 20 mg of inoculant (F), F1 (G. luteum), F2 (G. verruculosum) and F3 (G. versiforme). Treatment of organic matter Tithonia (T), namely T0 (without organic matter) and T1 (giving 30 mg of N forage Tithonia). Plants without mycorrhiza and organic material used as a control. Pots are placed in a greenhouse under treatment in a completely randomized design (CRD). Gypsum block was placed 5 cm from the edge of the pot at a depth of 10-15 cm in the area mycorhyzosphere to observe soil moisture and calculates water needs watering during the study. Media pots watered with deionized water of 200 ml and covered with plastic before planting.

C. Observation

The observations made are medium and plants. Observation of soil properties of growing media performed at the beginning and end of the study. Intact soil samples for the observation of soil physics and composite soil samples for soil chemical properties.

1) Media pots and plants. The nature of the soil at the beginning of the study were observed initial soil aggregate stability [7] , Total glomalin by Wright et al. [6], soil water content on pF1,0; 2.0 pF; 2.54 pF and 4.2 pF by using a pressure plate and pressure membrane apparatus apparatus. Total soil pore space (TRP), Bulk Density (BV), arease pore space and water drainage and pore spaces available conducted a laboratory analysis of physics at ISRI Bogor [3]. Chemical properties of the soil is soil pH (electrometric method), organic C (Walkley and Black), N-total (Kjeeldahl), available P (Bray II), K, Ca, Mg and Al exchangeable cations (titration), CEC and Saturation bases.

*2) Observations soil physical properties.*Observation of physical properties of soil carried out at the end of the study of media pots. Composite soil samples were taken in the rhizosphere and mycorhizasphere area to determine the total glomalin. Undisturbed soil samples were taken in areas of mycorhizasphere to determine the physical properties of the soil of each treatment. Soil physical properties observed were water content at various pF by using a pressure plate and pressure membrane apparatus (Laboratory ISRI). Total soil pore space (TRP), bulk density (BV), the pore space water drainage and pore spaces available [3] and the aggregate stability index using the method of six et. al [7]. Observations on the plant is AMF colonization (Giovannetti and Mosse, 1980), plant growth, nutrient content and uptake of N, P, K plant (plant extracts with wet digestion method H2SO4 + H2O2) and fresh weight of the plant. Assessment of plant nutrient status determined from the content of plant nutrients which reflected 100% of the control plants. Fresh weight of the plants used to assess the growth response of plants to mycorrhizal fungi (MGR).

D. Statistical analysis

Statistical analysis using CooStat program version 8.0. Data processed by the criteria of comparison analysis of variance (ANOVA) and a further test LSD (Fisher's least significant difference tests). Data from control plants is used to determine the mycorrhizal growth response (MGR) and mycorrhizal plant nutrient status assessment conducted on the controls. MGR is calculated as the ratio of the fresh weight of stem (shoot) of mycorrhizal plants without mycorrhiza [8]. Assessment of plant nutrient status is an indicator of the use of mycorrhizal qualitative advantage. For ease of comparison, differences in nutrient content of the treatment of the control plants is used as the standard calculation of 100%.

III. Result and Discussion

A. *Total glomalin are influenced AMF and N organic materials.*

The influence of the AMF and N from organic materials in the second trial against glomalin production in Table I indicate that the effect of AMF species interactions and organic material to the total real glomalin.

TABLE I
CONTENT OF TOTAL GLOMALIN SPECIES THAT ARE AFFECTED BY THE AMF AND N FROM ORGANIC MATERIALS OF FORAGE TITHONIA.

Organic Matters	Spesies AMF			Main Effect
	G.luteum	G.verruculsum	G.versiforme	of Organic
	F1	F2	F3	
Without organic	4,19 c	4,10 c	5,44 c	4,58 B
30 mg N tithonia	11,06 ab	9,83 b	13,64 a	11,51 A
Main Effect of AMF	7,62 B	6,96 B	9,54 A	

Note: Numbers with different uppercase and lowercase according colom differ according lane showed highly significant with LSD test (P <0.01)

Effect of interactions between species of AMF and total organic matters of Titonia against glomalin produce significantly different values. Innoculiation of G. versiforme and 30 mg N Titonia generate total glomalin highest of 13.64 mg.g-1, followed by inoculation effect G. luteum and 30 mg N Titonia. Glomalin content of the rhizosphere and mycorhizalsphere on all three species of AMF shows a different phenomenon that can be viewed in Figure 2.

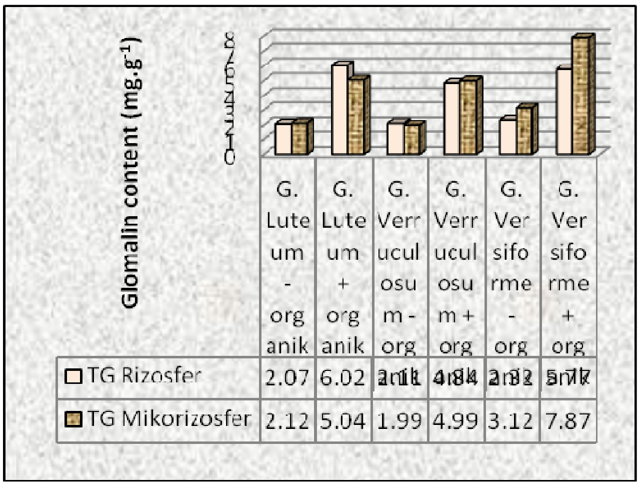

Fig. 2. The content of the rhizosphere and mycorhizalsphere glomalin influenced AMF species and organic materials.

In Figure 2 shows that all the species of AMF were not added organic materials provide glomalin content is lower than with the addition of 30 mg of organic matters from Tithonia forage. In the area of G. Versiforme mycorhizalsphere were given N-containing organic material glomain 36% higher than in the rhizosphere. Different phenomena found in G. luteum, which glomalin content on mycorhizalsphere lower 16% than the rhizosphere.

But at G. verruculosum glomalin content between rhizosphere and mycorhizalsphere relatively the same, only 3% higher in the rhizosphere than mycorhizalsphere. It can be stated that G. versiforme containing the highest total glomalin shows the development of hyphae more aggressive, especially on mycorhizalsphere.

Influence of organic materials showed a positive response to the increased content of glomalin. Glomalin the content of the three AMF species were tested there was an increase of 2 to 3 times higher than without organic matter. This fact proves that the contribution of organic matters used by the AMF for its needs. AMF is able to break down organic materials to obtain N drawn by the external hyphae form of ammonium or amino acids [9][10] later changed to arginine. [11][12][13].

B. *Relationship with the total glomalin soil physical properties.*

Effect of inoculation of AMF were given 30 mg of N from organic materials exhibit different patterns of water consumption of the three AMF species were tested. The average number of the provision of water every day in plants inoculated with the AMF organic matter is presented in Figure 3.

Figure 3 shows that the amount of water supply is likely to increase in line with the phase of plant growth. In the initial phase of flowering weeks to 7 or 5 weeks of observation, increased crop water requirement is higher. Water needs in the treatment with the species G. versiforme look lower than other AMF species. This phenomenon illustrates that the plants were inoculated with G. versiforme to use water more efficiently. This fact proves that the total high glomalin is a representation of the amount of hyphae that much, because hyphae able to access water and nutrients more than the micro pore space [14].

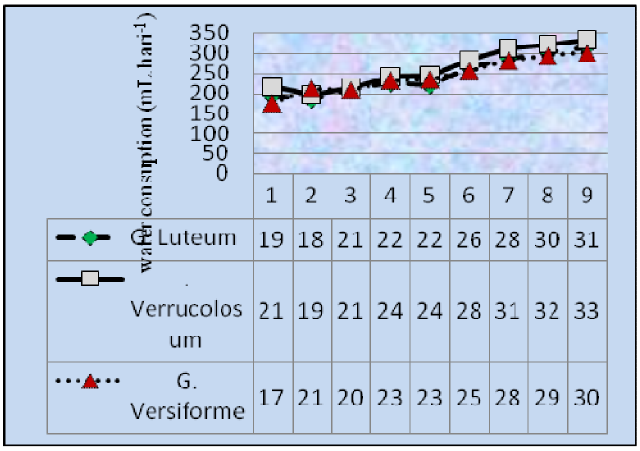

Fig. 3.The supply of water on average per day in each week (mL) in plants inoculated AMF added organic matter.

AMF species and N from organic materials that real interaction effect on water content at pF 2.54 (Table 2), while the interaction effect is not significant to the water content of 4.2 pF.

Table II shows that the water content at a high of 2.54 pF (36.03% by volume) was found in the treatment of inoculation and treatment G. G. versiforme luteum, but significantly different from G. verruculosum. Furthermore, the influence of organic materials on water content at field capacity (pF 2.54) lower than in the treatment without organic matter. Treatment interaction of species AMF and organic materials also significantly affect the availability of water that can be presented in Table III.

TABLE II
THE WATER CONTENT OF THE SOIL AT 2.54 PF INFLUENCED AMF SPECIES AND ORGANIC MATTERS OF TITHONIA.

N from organic matter	Spesies of AMF			Main effect of N organic
	G.luteum F1	G.verruculsum F2	G.versiforme F3	
Without N	33,67 c	33,40 c	35,13 abc	36,02 A
30 mg N tithonia	36,23 ab	34,90 bc	36,93 a	34,07 B
Main effect of AMF	34,95 AB	34,15 B	36,03 A	

The numbers are followed by different capital letters indicate significantly different effect. with LSD test (P <0.05), while the figure number followed by the same capital letter indicates the effect of which is not significantly different.

TABLE III
AVAILABILITY OF WATER (PORE WATER AVAILABLE) WHICH AFFECTED THE SPECIES AMF AND ORGANIC MATERIALS TITHONIA.

N of Organic matter	Spesies of			Main Effect N organic
	G.luteum F1	G.verruculsum F2	G.versiforme F3	
Without N	8,23 ab	7,57 b	11,13 a	10,29 A
30 mg N tithonia	10,70 a	9,63 ab	10,53 ab	8,98 A
Main Effect of AMF	9,47 AB	8,60 B	10,83 A	

In Table III shows that the organic material no real effect on the water pore space available (PAT), but the effect of AMF species showed significantly different values. The highest soil water availability was 10.83% in the volume are treated with G. versiforme inoculation. This value indicates that the value is not significantly different from the inoculation G luteum. Effect of inoculation of AMF species that have the lowest availability of water content in the G verruculosum inoculation treatment and showed the value is not significantly different from the inoculation G luteum, but significantly different with G versiforme. The highest water availability from the influence of the interaction is at G versiforme without organic matter, which is 11.13% by volume. This situation shows that the availability of water will be different from the various treatments with AMF inoculation. Treatment with inoculation G luteum and G verruculosum shows the pore space available water would be higher if the added organic material. Water pore space available on the inoculation G verruculosum with no organic material is given the lowest (7.57% by volume). The value will be significantly different than the inoculation G. luteum by organic matter and G versiforme without organic matter.

Effect of interaction of both factors on the characteristics of soil physical properties and compared with the initial soil conditions can be presented in Figure 4.

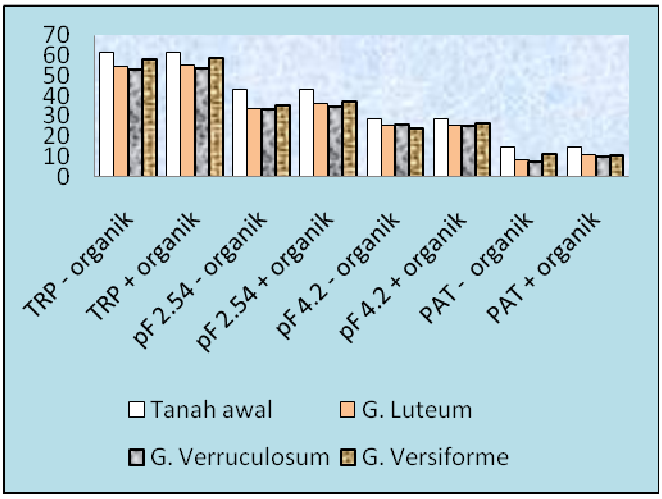

Fig. 4. Characteristics of soil physics which influenced organic material and AMF species compared with initial soil conditions (white columns).

Observation of physical characteristics of the land after receiving treatment showed lower values than the initial soil. This happens because when handling potting soil before filling mechanically ground changes occur that affect the physical properties of the soil. However, ground handling is the same for all treatments before filling the pot. Leir [15] describe qualitatively soil texture, soil structure and the ability of plant roots (plant root ability) is a crucial factor determining the amount of soil water availability for crops. In the simplest approach to soil physical properties, availability and least often associated with the concept of field capacity and permanent wilting point. The ability of plant roots to access water and nutrients is often limited by soil physical properties (such as hardness, density) or chemical properties (acidity, aluminium), then the role of mycorrhizae can help plants cope with this problem.

C. The response of plants terfadap AMF inoculation and organic matter.

Effect of inoculation AMF and organic matter in plants can be seen from MGR and nutrient uptake value based on the nutrient uptake of the control plants (without inoculation AMF and organic administration). Mycorrhizal growth response (MGR) is a ratio of the fresh weight of the plant (shoot weight) mycorrhizal inoculation to plants without AMF. The response of plants to AMF inoculation and organic matter can be seen in Figure 5 and Figure 6.

The response of plants inoculated mycorrhizal growth positive, and achieve 1.5 times better than the plants without mycorrhizal inoculation (Figure 5). Plants inoculated with G. versiforme showed better response than other species, either given or without organic matter. The three species shows that the species G. verruculosum have a lower response than other species. The analysis showed that organic matter does not affect the real against MGR, while the AMF species showed significantly different influence. The highest MGR values are found in the species G. versiforme which is equal to 2.26. by organic materials. The value is significantly different from the species of G. verruculosum, but did not show differences in the species G. luteum. This proves that the AMF species are able to produce glomalin more as a representation of the development of hyphae which will affect plant growth. AMF hyphae very important role to help the plants in the absorption of nutrients and water for plants. Nutrient uptake value is an expression of the control (without mycorrhizal) based on 100% for each treatment AMF and organic materials.

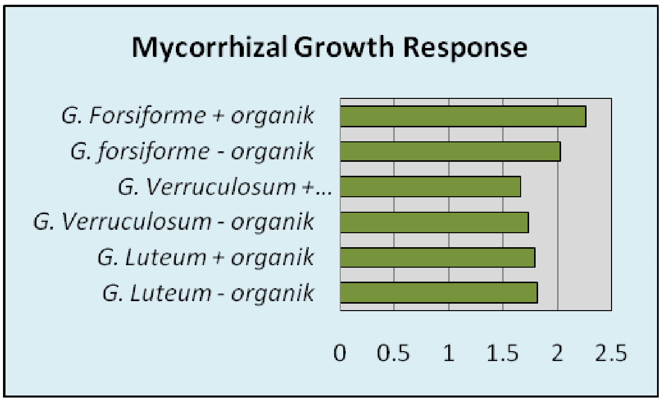

Fig. 5. Response growth of mycorrhizal (MGR) who influenced AMF inoculation and organic matter.

The influence of AMF and organic material to the nutrient uptake can be understood in Figure 6.

Figure 6 shows that nutrient uptake value is an expression of the control (without mycorrhizal) based on 100% for each treatment AMF and N from organic material. Effect of AMF species on nutrient uptake are better than controls. This phenomenon indicates that the AMF help to absorp nutrients.

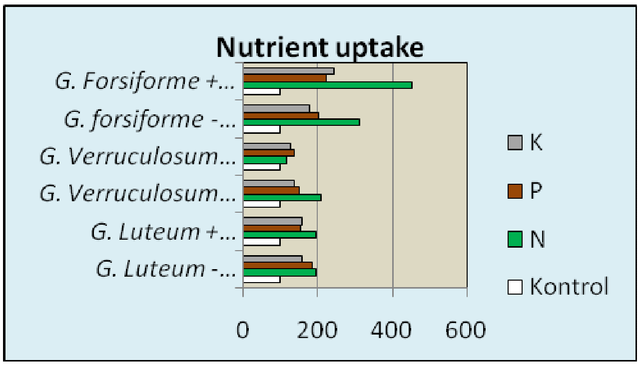

Fig. 6. Absorption nutrients is influenced by inoculation of AMF and organic matter

The effect of N from organic materials are not the same on every species of AMF for nutrient uptake. At the innoculation of G. versiforme, organic matter treatment was significantly higher than without organic matter, and two times better than the control. But at the inoculation with G luteum and G verruculosum showed lower to nutrient uptake when added organic materials compared to no organic matter.

The influence of G. versiforme and organic material to the uptake of N can achieve a 5-fold compared to control. This proves that the number of hyphae that much can be mined and absorb N from source of organic matter to produce glomalin and partly given to the host plant [9][10]. However, AMF species that produce glomalin / hyphae fewer have the ability to absorb N too low, resulting in a lower uptake.

IV. Conclusions

Based on the description above can be concluded that; i.e : The Inoculation of the AMF and organic ingredients significantly affect total glomalin, thus providing optimum soil physical conditions for the growth of corn plants. Organic materials not directly affect the physical properties of the soil, because the amount is too small, however, significantly affect the total glomalin. Total glomalin is a representation of the development of hyphae. AMF species were more responsive to the provision of organic material can generate higher glomalin, so real influence on soil physics and plant growth.

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