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RESEARCH ARTICLE

THE APPLICATION OF TYPE OF MYCORRHIZAL TO P UPTAKE, GROWTH AND YIELD OF PEANUT (ARACHIS HYPOGEA L.) IN ULTISOL.

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Abstract

The low availability of P nutrient in Ultisol becomes the limitation factor for plant growth. The research was aimed to know the effect of applicating types of mycorrhizal to P uptake, growth and peanut yield in Ultisol. The research used Randomized Complete Block Design Non-Factorial, which consists of control (M_0), Glomus sp (M_1), Gigaspora gigantea (M_2), and Acaulospora tuberculata (M_3). The parameters were P uptake, plant height, plant fresh weight, plant dry weight, root infection, number of pods per plant, and weight of pod per plant. The result of the research showed that the application of Gigaspora gigantea affected the P uptake and fresh weight biomass, however it was not significantly affected other parameters. The application of Glomus sp was significantly affected to all parameters. While, control and the application of Acaulospora tuberculata was not significant effect to all parameters.

Introduction:-

Peanut (*Arachis hypogea* L.) is one of crop with high economic and strategic value in increasing the income and improving citizen's nutrition. The data from Central Bureau of Statistics (2015), the peanut production in Indonesia has not been consistentin the last 3 years. In 2013 the peanut production was 519.056 ton, in 2014 around 499.338 ton, and in 2015 around 454.349 ton. Meanwhile in Aceh, the peanut production was not still enough to fulfill the market demand. In 2013 around 3.118 ton, 2014 around 2.502 ton, and 2015 around 2.019 ton. The peanut production in Aceh is categorized in low criteria.

The low production of peanut was caused by many factors, and one of the factors was the low availability of fertile land. The limitation of fertile land was caused to utilize the marginal land like Ultisol for cultivating the peanut. Ultisol is the main soil ordo in Indonesia with the total area around 45.794.000 ha or 25% from Indonesia total area (Subagyo*et al*., 2004). But, the fertility status of Ultisol was low. One of the problems from Ultisol was the soil pH is less than 5,5 with the criteria from low to very low. (Prasetyo and Suriadikarta, 2006).

One of the strategies to increase the soil productivity especially the P availability in soil was by mycorrhizal application. The application of mycorrhizal had given the positive effect, especially to the availability of P nutrient.

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According to Kim *et al*. (1989), the inoculation of phosphate solvent bacteria could increase P uptake in tomato. The inoculation of mycorrhizal fungi increases the P uptake in peanut around 75% compared to the one without mycorrhizal inoculation (Astari, 2003). According to Sufardi (2012) the mycorrhizal could increase the P soluble for plant.

A study conducted by Syafruddin (2010) showed that 10 g mycorrhizal application could increase the plant biomass and root morphology (root length and root diameter) in legume and bean. According to Abbout and Robson (1984), every species of mycorrhizal has the specific ability to increasing plant growth in unfertile land. Based on the problems above, the researcher was interested to conduct the research about the best kinds of mycorrhizal to improve the growth and yield of peanut and to increase the P uptake.

Material and Method:-

Materials

Research Location and Time

The research was conducted in a Green House at the Experimental Field, Laboratory of Plant Diseases, Laboratory of Soil Biology, Faculty of Agriculture, Universitas Syiah Kuala Darussalam, Banda Aceh, Indonesia, and in Laboratory of The Agency for Agricultural Technology Studies of Aceh. The research started from November 2017 to March 2018. The average temperature in the green house was 28°C.

Seed and mycorrhizal

The variety of peanut in this research was from The Research Institute for Nuts and Tubers with Bima variety. The mycorrhizal used were from the Laboratory of Plant Pest and Diseases, Bogor Agricultural Institute (IPB) with the following species :*Glomus* sp, *Gigaspora gigantea*, and *Acaulospora tuberculata*.

Ultisol

Ultisol used in this research was collected from Teureubeh village, Janthoe, Aceh Besar district. The initial soil analysis has soil pH 5,40; organic Carbon 0%; total N 0,04%; total P (Bray method) 3,38 ppm; K_2O (Morgan method) 2,41 ppm; CEC 14 cmol kg^{-1}. From the soil analysis, it was known that the ultisol has low nutrient content. The soil was sieved using the 2 mm diameter sifter and was filled into the 20 kg polybags. Then, the polybags were arranged based on the treatment combination.

Fertilizer

The fertilizer used was cow feces as the basic fertilizer with dose of 10 t ha^{-1} (100 g $polybag^{-1}$), NPK phonska fertilizer with dose of 250 kg ha^{-1} (2,5 g $polybag^{-1}$). The NPK phonska fertilizer was applied in 2 phases, the first phase was appliedat the beginning of planting with dose of 1,25 g $polybag^{-1}$ and the second phase was 30 DAP (Days After Planting) with dose of 1,25 g $polybag^{-1}$.

Method

Experimental design

The non-factorial randomized group design was used in this research with 4 rates and 3 replications. The rates were control (M_0); *Glomus* sp 10 g $plant^{-1}$ (M_1); *Gigaspora gigantea* 10 g $plant^{-1}$ (M_2); *Acaulospora tuberculata* 10 g $plant^{-1}$ (M_3).

Research Implementation

The first step was collecting the Ultisol soil sample from Jantho, Aceh Besar district. The soil sample was taken from the top layer (0-25 cm), then the soil was sieved using the 2 mm sifter. The mycorrhizal application was given to every polybag based on the treatment combination. The mycorrhizal was applied when the seeding time. Every polybag was planted 2 seeds and the application of mycorrhizal was given once in the beginning. He water management was done every morning and afternoon based on field capacity. The pest and diseases control was done when the peanut were attacked and using pesticide (Decis). The harvesting time was once the peanut reached 90 DAP with the criteria of 65% leaves are browning.

KOH 10% and alcohol 50%

KOH was used to soften and whiten the root infected by mycorrhizal. Alcohol 50% was used to preserve the infected root by mixing the plant root and alcohol.

Stain
The stain was used to give color to the mycorrhizal. It was applied by mixing vinegar acid 5% (750 ml) and one bottle stain (Quink Parker). Then the root was soaked in the solvent for 24 hours.

Observation
Plant height
The plant height was measured from the beginning of stem to the growth point at 15 DAP, 30 DAP, and 45 DAP.

Wet and dry weight of the Plant
The soil sample in peanut was cleaned up first, then was scaled using analytic scale. The wet weight was scaled in 45 DAP, then it was continued to be dried the in the oven for 48 hours with the temperature of 60°C.

P uptake
P uptake was analyzed when peanut in 45 DAP. The peanuts were washed and dried in the oven for 48 hours with the temperature of 60°C. After that, the peanuts were grinded before the P uptake analysis was done using H_2SO_4+H_2O_2. Nutrient uptake formula was the percent of nutrient in plant (%) X plant dry weight.

Percentage of mycorrhizal inoculation
The percentage of root infection by mycorrhizal was done in Plant Diseases Laboratory, Faculty of Agriculture, Universitas Syiah Kuala when the peanuts were in 45 days after planted and counted using Brundrett et al. (1996) method. The steps were, the plant root when 45 DAP was cut into 2 cm, then was washed using distillate water, soaked in KOH 10% for 24 hours, after that the root was washed until clean and soaked again using HCl 5% for 24 hours, then the root was soaked using solvent of trypan/acid fichin for 24 hours, then the root was soaked again using distillate water. Ten root samples were taken and observed using NIKON microscope with 100-400 magnification, the last data was calculated byusing the formula as follows:
The percentage of infection root =

$$\frac{\text{number of root infected by mychorrizal}}{\text{number of root observed}} \text{X } 100\ \%$$

The infected root was marked in one of internal mycorrhizal structure like arbuscular, vesicular, internal hyphae and spore. The percentage of root infected by mycorrhizal was determined based on Rajapakse and Miller criteria (1982) which modified as follows: first class was root infected 0%-5% (very low), second class was root infected 6%-25% (low), third class was root infected 26%-50% (medium), fourth class was root infected 51%-75% (high), fifth class was root infected 76%-100% (very high).

Number of pods per plant
Number of pods per plant was countedduring the harvesting time. The pod must be dried in the oven until the weight was constant. The dried pod was scaled using analytic scale.

Results and Discussion:-

P uptake
The ANOVA test was showed that the application kinds of mycorrhizal was significant by effected to P uptake. The mean of P uptake showed in the Table 1. and the best kinds of mycorrhizal treatment was found in Gigaspora gigantea, while the lowest P uptake was found in control treatment. The kinds of mycorrhizal like Glomussp and Acaulospora tuberculata were not significant effect to P uptake.

Table 1:- Mean of peanut P uptake caused kinds of mycorrhizal application

Kinds of mycorrhizal (M)	P uptake
	..... (mg plant^{-1}).....
M0 (Control)	1,667 a
M1 (*Glomussp*)	2,710 ab
M2 (*Gigasporagigantea*)	3,367 b
M3 (*Acaulosporatuberculata*)	2,517 ab
BNJ $_{0,05}$	0,92

Note: Number followed by the same letters was not significantly different from BNJ test of 5%.

It was assumed that the application of *Gigaspora gigantea* was able to giving the positive effect to P uptake in peanut. Agustina (2004) said that, P nutrient was taking the important role in plant for growth and cultivate the plant. Yusrizal (2017) was told that the application of mycorrhizal *Gigaspora* increasing the P uptake significantly compared without the mycorrhizal. Hidayat*et al*. (2018) was added that the mycorrhizal like *Gigaspora* increasing N, P, and K uptake from compost to chili.

Suherman*et al*. (2013) was showed that the presents of mycorrhizal increasing P and K uptake through external hyphae. Mycorrhizal was the important factor in soil P mobilization to root so increasing the growth of host plant (Das *et al*., 2013). The research from Karnilawati *et al*. (2013) was told that the application of mycorrhizal was not significant effect to plant P uptake, but the application of organic matter was able to released P and mineralisation process, so it could increase the availability P nutrient eventhough in the low criteria.

Simanungkalit (2001) was said that the mycorrhizal potential to present the nutrient for plant especially P nutrient. The statement before correlated with the statement from Husin*et al*. (2012) that the mycorrhizal producing phosphatase to helping the availability of P nutrient, which is not available for plant so it could increase P uptake by plant. According to Munawar (2011) that plant which symbiosis with mycorrhizal will absorb P nutrient around 10-27% higher than plant without mycorrhizal treatment around 0,3-13%. Then, the increasing of nutrient especially P uptake caused mycorrhizal inoculated was able to increasing the peanut fresh weight in Ultisol.

Plant growth:-
The ANOVA test was showed that the application kinds of mycorrhizal was significant effect to plant height in 45 DAP, plant fresh weight and plant dry weight, but it was not significant effect to plant height in 15 DAP and 30 DAP. The mean of plant height, plant fresh weight and plant dry weight of peanut was showed in Table 2.

Table 2:- Mean of plant height, plant fresh weight, and plant dry weight caused kinds of mycorrhizal application

Kinds of mycorrhizal (M)	Plant height			Plant fresh weight	Plant dry weight
	15DAP	30 DAP	45 DAP		
	.....(cm)			..... (g)	.. (g).....
M0 (Control)	18,37 a	35,92 a	45,52 a	68,99 a	19,67 a
M1 (*Glomussp*)	19,14 a	37,40 a	50,97 b	78,48 ab	29,10 b
M2(*Gigasporagigantea*)	18,44 a	36,55 a	48,11 ab	82,55 b	28,57 ab
M3(*Acaulosporatuberculata*)	18,16 a	34,91 a	48,22 ab	76,50 ab	26,83 ab
BNJ $_{0,05}$	3,13	5,85	3,26	11,68	8,72

Note: Number followed by the same letters was not significantly different from BNJ test of 5%.

In Table 2.was showed that the highest plant height in 45 DAP in *Glomus* sp treatment, and the lowest plant height was found in *Gigaspora gigantea* and *Acaulospora tuberculata* treatment. The heaviest plant fresh weight was found in *Gigaspora gigantean* treatment, and the lowest plant fresh weight was found in control treatment. Then, the heaviest plant dry weight was found in *Glomus* sp treatment, and the lowest dry plant weight was found in control treatment, *Glomus* sp, and *Acaulospora tuberculata*.

Luschen *et al*. (1997) said that every plant with high plant and plant biomass was happened nutrient competition so effected to vegetative parameters and produce less of branch, pod, and seed per plant. Wahyu (2013) said that the mycorrhizal was able to absorb nutrient so the growth and vegetative phase become increased. Besides that, there is the increasing of peanut dry weight caused the application of mycorrhizal compared with control. It was suspected the ability of mycorrhizal in absorb the nutrients from the soil. The result was correlated with the statement from Govindarajulu *et al*. (2005) that the mycorrhizal hyphae was able to absorb N inorganic from soil to plant. The increasing of peanut dry weight was correlated with N nutrient in plant. Sufardi (2012) also said that the nitrogen plays a role in vegetative phase like leaves and stem formation. Therefore, the association of mycorrhizal and peanut was able to increase N uptake that caused to the increasing of peanut dry weight.

The research from Fitriana (2017) was found that the application of *Glomus* sp to soybean giving the best growth compare with control treatment. It caused the root of plant which colonized by mycorrhizal *Glomus* sp absorb the nutrient faster so the plant grows well and effecting to plant fresh weight.

Matsubara *et al*. (2000) was added that the host plant root colonized by mycorrhizal will produce hyphae intensively so increasing the capacity of absorb the water and nutrient. Goldsworthy and Fisher (1992) said that the increasing of plant fresh weight was caused by nutrient availability, so it's increasing cell division and increasing the plant fresh weight.

It proved that *Glomus* sp was increased peanut growth through the ability to absorb the nutrient from the soil. The mycorrhizal like *Glomus* sp has the ability to adapt in Ultisol. Zulaikha and Gunawan (2006) said that the chili growth caused by mycorrhizal application grow well, compared with control to plant height, total leaves area, and plant dry weight.

Peanut yield

The ANOVA test was showed that the kinds of mycorrhizal application to peanut was significant effect to percentage of root infection, total pod per plant, and pod weight per plant. The mean of percentage of root infection, total pod per plant, and pod weight per plant was showed in Table 3.

Table 3:- Mean of percentage of percentage of mycorrhizal inoculation, number of pods per plant, and weight of pod per plant caused kinds of mycorrhizal application

Kinds of mycorrhizal (M)	Percentage of mycorrhizal inoculation	Total pod per plant	Weight of pod per plant
	..... (%)	..... (pod)	..... (g) .....
M0 (Control)	20,00 a	9,78 a	26,23 a
M1 (Glomus sp)	86,67 c	24,33 b	52,57 b
M2 (*Gigaspora gigantea*)	70,00 b	17,22 ab	42,32 ab
M3(*Acaulospora tuberculata*)	70,00 b	23,44 b	44,43 ab
BNJ $_{0,05}$	14,15	10,91	19,55

Note: Number followed by the same letters was not significantly different from BNJ test of 5%.

In Table 3.was showed that the best percentage of root infection, total pod per plant, and pod weight per plant found in *Glomus* sp treatment, and the lowest found in control treatment. It told that, all kinds of mycorrhizal application was able to associate with peanut. Singh *et al*. (2008) said that, the high competitiveness and adaptation of *Glomeraceae* was able giving the best impact compared with another family of mycorrhizal.

According to Chapman *et al*. (2011) FMA effectiveness was depend on environment factor and compability with host plant and kinds of mycorrhizal. According to Hart and Reader (2002) said that the species of *Glomus* sp more faster infecting the host plant if compared with *Acaulospora* species. It correlates with the next infection and determine the infection level of mycorrhizal.

Beside the application of mycorrhizal was able to improving the nutrient absorption, it could minimize water consumption for plant in Inceptisol. Fitriana *et al*. (2018) said that the application of mycorrhizal to soybean was able to absorb water eventhough the water is limit, but the presents of root infected by *Glomus* sp could be the facilitator in water absorption in dry condition.

Gosling *et al* (2016) said that the plant doing photosynthesis actively will giving the positive effect to root elongation, so the root which colonized by mycorrhizal will having the long root compared with plant without mycorrhizal. Sutedjo (2010) also said that the function of P nutrient in plant could increase the young plant growth become mature plant generally, and it could increase the seeds production. According to Sukmawati (2013) the mycorrhizal treatment will giving the heaviest total weight of seed compared without mycorrhizal treatment.

Conclusion:-

The results from this research was concluded that the best application of mycorrhizal was found on *Glomus* sp because it was increased plant height, plant dry weight, percentage of root infection, number of pods per plant, and weight of pod per plant. Meanwhile, the *Gigaspora gigantea* species was increased P uptake and plant fresh weight in Ultisol.

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