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Effectiveness of various *Arbuscular* mycorrhizal fungi doses on percentage the root infection of oil palm (*Elaeis gunensis* Jacq.) on peaty mineral soil

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Abstract

In Indonesia, the development of oil palm is still mostly done on the marginal land of one peat soil. The obstacle to oil palm development on peatlands is the low nutrient content available to plants. The use of arbuscular mycorrhizal fungi (AMF) is one of the alternatives to improve fertilizer efficiency. This study aims to determine the effectiveness of AMF on the percentage of AMF infections in the roots of oil palm plants in peat mineral soils. The research was conducted in farmers' gardens. The oil palm plant used is 1.5 years old after being planted in the garden. This research uses non-factorial treatment design with AMF consist of 4 levels ie 0 gr/plants, 50 gr/plants, 100 gr/plants and 150 gr/plants. Each FMA treatment was repeated 3 times, so that 12 units of experimental units were obtained. Parameters observed included: percentage of root infections. The results showed that administration of several doses of FMA was very effective against the percentage of root infections.

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Introduction

Palm oil (*Elaeis guineensis* Jacq.) Is one of the plantations that have a fairly bright development prospect. Indonesia alone has the largest area of oil palm in the world, which is 34.18% of the world's oil palm (Fauzi *et al*., 2012). In the province of Aceh in 2015, the area of oil palm plantations reached ± 280,320 ha and total production ± 896,313 tons of TBS (Directorate General of Plantation, 2015).

Development of oil palm in Indonesia especially in the province of Aceh is mostly done on marginal land one of which is the land histosol. Histosol is a soil lot of organic matter that occurs due to decomposition of plant remains. Histosol with high acidity (pH) and sour soil conditions can result in low nutrient availability. Histosol can also bind elements of P to become insoluble and not available to plants (Nurhandayani *et al*., 2013).

Biotechnology application by utilizing microorganism as biological fertilizer is one effort to optimize land productivity and maintain and increase crop production. Microorganisms that can be utilized as biological fertilizer such as Arbuscular Fungi Mikoriza (AMF). Mycorrhiza is a form of mutualism asoasiasi between fungi (myces) and root (rhiza) plants. Based on the structure of the body and the way of infection of host plants, mycorrhiza can be grouped into 3 big groups namely endomikoriza, ektomikoriza, and ektendomikoriza (Rumondang & Setiadi, 2011). Fungi are incorporated into endomikoriza much attention because of wider spread and can associate with nearly 90% of plant species, one of them AMF (Sufaati *et al*., 2011). The arbuscular mycorrhizal fungi and the symbiotic mutualist root of life are mutually beneficial. Fungi obtain the carbon and energy supply from the roots and furthermore the fungi assist the roots in nutrient uptake for plants, especially nutrients not available in the soil, such as P, overcome salinity stress and increase water uptake and resistance to drought (Ardiansyah *et al*., 2014). There are several factors that influence the development of FMA is the type of plant and soil (Kartika, 2012).

One of the most important effects of root infections with mycorrhizae in plants is an increase in P uptake (Smith & Read 2008). Rusdi *et al.* (2011) states that the process of mycorrhizal infection is influenced by host plants, mycorrhiza, soil properties and environmental factors and the amount and availability of P in the soil. Several studies indicated that giving mycorrhizae to less fertile soil may increase the growth of corn and sorghum (Guo *et al*., 2013), soybean (Orians & Ustuner, 2014) 100 g/polybags AMF can increase the growth of oil palm seedlings (Same, 2011). However, mycorrhizal excellence for plantation crops in the field has not been widely known.

Based on the description, the use of mycorrhizae in oil palm crops on peatlands is not much in the know. Therefore, this study aims to determine the dose of FMA on the percentage of FMA infections in the roots of oil palm plants on peatlands.

Materials and methods

Place of study

The research was conducted in farmers garden the village Selamat Datang, Darul Makmur District Nagan Raya Province of Aceh, Indonesia. The oil palm plant used is 1.5 years old after being transplanted into the garden. The material used in this research is the seeds of oil palm plant used from PT. Socfindo (Alue Bilie) who has been through the nursery pre nursery 3 months and main nursery for 8 months, mycorrhizal indigenus Glomus species 2 (from the Soil Biology Laboratory of Unsyiah) and rock phosphate (28% P_2O_5). This research was conducted from October 1, 2015 until March 30, 2016. The treatment design used was non-factorial design with experimental unit according to randomized group block. The research factors were dose of AMF consisting of: 0 g/plants, 50 g/plants, 100 g/plants and 150 g/plants with 3 replications.

Inoculum preparation

Propagation of FMA inoculum is based on modified Diederichs & Moawad (1995). Modification is done by using sand and zeolite planting media.

The sand sterilization was performed using an autoclave of 121ºC at 1 atm for 60 minutes twice with an interval of 1 day. Zeolite planting medium is quite washed to remove the powder. Sand media is used to make grow corn seeds and furthermore for zeolite media is used as a growing medium which is put into 200 mL pot. The application of AMF is carried out simultaneously with the planting of corn crops placed in a greenhouse. How to give FMA inoculum containing 300 mycorrhizal spores is by placing an inoculum ± 3cm below the corn sprouts. After 50 maize crops, cutting is done.

Soil analysis

Soil sampling is done with diagonal system with point as much as 5 point (1 center point and 4 diagonal point). The distance between each point ± 50m is measured from the center point, and a new composite of 5 soil samples is done. Analysis of initial soil samples in the form of pH, C-organic, N-total, P-available, Mgdd, Na-dd, CEC, saturation and moisture in field capacity were carried out in Soil and Plant Analysis Laboratory Faculty of Agriculture Syiah Kuala University, Darussalam Banda Aceh.

The initial observation of the number and type of spores

The number and type of spores was calculated at 2 weeks before application, counting the number of spores per 50g of soil was done manually by grouping the same FMA type. Calculation of root infection of FMA on plant roots is done by root staining technique. FMA colonization is characterized by the presence of hyphae, vesicles and arbuscules. Each field of view of the microscope showing colonization is marked (+) and that is not marked (-).

Mycorrhizal application

The mycorrhizal application is performed by lateral root manipulation (LRM) technology. LRM is done by cutting the lateral roots at the end of the leaf canopy ± 120cm at a depth of 20-25 cm with 17 cm wide of the circle around the stem, and the application in the field is done 2 stages with a span of 2 weeks for the semi-circle.

In the first stage the FMA application is performed by evenly distributed on the created entrenchment. The second stage is done on the other half again simultaneously with a period of 2 weeks. The application is done with a period of 2 weeks, as allegedly within 2 weeks lateral roots have begun to grow in the first half of the application circle.

Observation of root infection

Root samples were taken by digging around the canopy of oil palm plants. Root taken is a secondary root of 1kg/plant. The root calculation of AMF is done by root staining technique. AMF colonization is characterized by hyphae, vesicles and arbuscules, each field of view of a microscope showing signs of colonization marked (+) and unmarked (-).

Observation of AMF colonization at the root is characterized by the presence of anatomical characteristics that characterize the presence or absence of AMF colonized root (Pulungan, 2013).

Calculate the percentage of infected FMA at the root by using the formula:

$$Infected\ root\ (\%) = \frac{The\ number\ of\ roots\ is\ infected}{the\ total\ number\ of\ roots\ observed} x\ 100\%$$

Data analysis

Data were analyzed using F-test performed on the percentage of root infection. If the F test shows a real effect it will be continued with further test of the Smallest Real Difference (SRD) at 5% level.

Results and discussion

Result of histosol soil chemical properties analysis (before treatment)

The results of the soil chemical properties analysis showed that chemically the peat minerals soil used in this study turned out to have very low quality. It is characterized by a sour soil chemical reaction with a pH of 4.50 and has a relatively low nutrient content and availability. The soil chemical properties can be seen in Table 1.

Table 1. Characteristics used in the study (Hardjowigeno & Widiatmaka, 2007).

Analysis aspect	Unit	Value	Method	Criteria
pH (H_2O)	-	4,50	Elektrometrik	sour
C-organik/ C-organic	(%)	9,04	Walkley & Black	very high
N-total/ N-total	(%)	0,74	Kjeldahl	low
C/N	-	12,19	-	medium
P_2O_5 Total/ P_2O_5 Total	(mg/ 100g)	21,38	HCl 25 %	medium
K_2O Total/ K_2O Total	(mg/ 100g)	16,07	HCl 25 %	medium
P_2O_5 Tersedia/ P_2O_5 available	(ppm)	2,60	Bray P	very low
K_2O Tersedia/ K_2O available	(ppm)	6,03	Morgan	very low
KTK / CEC	(Cmol/kg)	20,00	Ektraksi NH_4OAc pH7	medium
Tekstur tanah/ soil texture		-	Pipet	
- Pasir/ sand	(%)	62,09		
- Debu/ silt	(%)	14,22		
- Liat/ clay	(%)	23,69		

The nutrient content of very low peat minerals soil marked with N-total is available low, P-total and K-total are moderate, while P is very low and available for K is very low. This is due to very high C-organic peat soil, causing essential elements such as P and K are not available. In accordance with the proposed Nurhandayani *et al.* (2013), histosol is a soil lot of organic matter that occurs due to decomposition of plant remnants. Histosol has a high acidity (pH) and has a different thickness, so it can cause less nutrient availability.

The results of initial observation analysis of the number and type of spores

Initial observations indicate that the number and type of dominant spores found is *Glomus*. The number and type of spores found per 50gram of dominant soil is *Glomus* sp2. Differences of mycorrhizal characteristics *Glomus* sp1, *Glomus* sp2 and *Glomus* sp4 are in shape and color. *Glomus* sp1 black and yellow with round shape, *Glomus* sp2 yellow and brown with round shape while *Glomus* sp4 reddish brown with oval shape (table 2).

Table 2. Type of AMF, number of spore and root infection of indigenous AMF.

Spora genre	Number of spora total per g (soil)	Mycorrhizal characteristics	
		Phase	Color
Glomus sp1	4,00	Round	Black and yellow
Glomus sp2	7,00	Round	Yellow and brown
Glomus sp4	4,25	Oval	Reddish brown

Notes: (1) Result at laboratory soil biology Unsyiah, Aceh (2016).

Based on the calculation of the number of spores performed, *Glomus* sp2 is the dominant AMF type encountered at the study site. This indicates that *Glomus* has a high degree of adaptation to a sour soil environment. The existence of AMF can be influenced by various factors namely host plant, AMF and soil type. Differences in soil types are factors that can directly affect the existence of AMFThis can happen because each type of soil contains different organic and soil pH, so that spores of the FMA Genus can be found vary (Saputra *et al.*, 2015).

Arbuscular Mycorrizal Fungi (AMF)

The results of observations of various doses of AMF on the percentage of root infections showed very significant results. This is thought to the highest dose of AMF 150 g/plants could the highest root infect compared to other combinations. Most root infections at AMF dose were 27.83%, whereas the lowest infection at dose without AMF was 16.83% (Fiq 1).

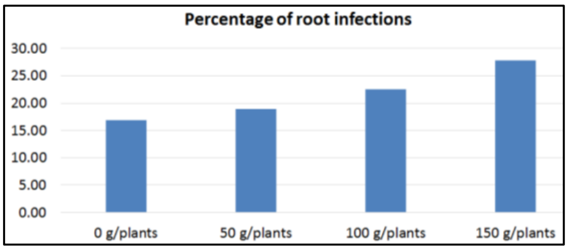

Fig 1. Average of level root infection caused by interaction between FMA dose and rock phosphate fertilizer.

Fig. 1 shows that the mycorrhiza has a very real effect. The increased percentage of mycorrhizal infection is thought to be due to mycorrhiza being able to interact with soil microorganisms and plant roots in increasing the percentage of mycorrhizal infections. Rinti *et al.* (2015), AMF associations with plant roots can enhance plant growth and survival under optimal conditions or water stress thus improving nutritional status. Because the bermikoriza root can absorb nutrients in bound form and not available in the soil. In addition to this, AMF at the root of the plant will increase the surface area of nutrient and water absorption (Pulungan, 2013).

In addition, the effectiveness of nutrient absorption by AMF can not be separated also from environmental factors and the plant itself. In accordance with the opinion Nurhayati (2012) which states that the level of mycorrhizal infection is determined by the compatibility of mycorrhizae with plants, environmental factors and interactions and chemical compounds produced by plants.

Conclusion

AMF awarding has a very significant effect on the percentage of root infections. The best dose of AMF in infecting roots is 150 g/plants.

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