

Application of Indigenous AMF from ex-coal Mining Soil Combined with Phosphorus Fertilizers to Improved Oil Palm Seedling Growth (*Elaeis guineensis* Jacq.)

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ABSTRACT

Opencast mining caused heavy deforestation and barren land in Jambi. This ex-mining land must be reclaimed by planting crops based on biofertilizers containing mycorrhizae, this is a potential alternative that provides benefit both agronomy plant and ecosystem specially replanting with oil palm. Those are the technology for reclamation ex-coal mining soil. This research aim is to examine the effect of four combinations indigenous isolate of Arbuscular Mycorrhizae Fungi (AMF), which is originated from ex-coal mining soil that combined with Phosphorous fertilizers to minimize utilizing P fertilizer at oil palm pre-nursery, to improve soil fertility, and seedling growth. Hence, this research was arranged in factorial experiment with 2 factors, using a complete randomized design with three replications. The first factor is five different mycorrhizae isolates, representing a broad range of endomycorrhizae fungi, there are: without indigenous AMF, isolate of *Glomus* sp. 3, isolates of *Glomus* sp. 6, isolates of *Glomus* sp. 15 and isolates of *Glomus* sp. 16. The second factor is P fertilizer: control (without P fertilizers), fertilizer dosage P 25%, 50%, 75%, and 100%. Variables measured are shoot height, number of leaves per plant, total leaf area per plant, and plant stem diameter. The data were analyzed by analysis of variance to see whether there was an interaction between the MVA isolate and the P fertilizer dosage. The result showed a significant effect on palm oil seedling growth, shoot height, number of leaves per plant, total leaf area per plant but there is no interaction on the stem diameter. Plants that are inoculated with mycorrhizae have greater P content in leaves than those not inoculated. The types of isolated *Glomus* sp.3 and dosage P 75% of recommended dosage, give the best seedling growth. This research concluded that inoculation with AMF could minimize P fertilizers doses.

Keywords: AMF; inoculated; mining; oil palm; pre-nursery

INTRODUCTION

Oil Palm is plantation that growth continually until 2018 in Indonesia. The acreage increases for about four times up to 4 million hectares in the last 10 years. It takes a very important contribution to Indonesia economy. The main problem in oil palm plantation is low production (Ermawati & Saptia, 2013). Average yields produced by Indonesian smallholders are much less than the achievable yields (Euler *et al.*, 2016; Woittiez *et al.*, 2017). In order to increase the production and quality practices such as intensification, area expansion and rehabilitation could be done regularly. In Jambi, expansion area could be done through the utilization of ex-coal mining land since the area is still very widely available. Until 2018, continuous coal mining still

practiced that caused barren land increased. Various attempts have been made to utilize the soil and to replanting the barren land, especially with oil palm. Sustainable practices in the oil palm plantation involved careful fertilizers management is needed to reduce excess application over the required amount in the field (Basiron, 2007; Webb, 2009). The application of mycorrhizal technology combined with phosphorus fertilizers to increase oil palm growth and production is one of the strategic alternatives.

Oil palm needs high nutrient, mineral content and water, particularly in the early stages (pre-nursery) (Wahid *et al.*, 2005; Sun *et al.*, 2011). Thus, a typical management practice should use high rates of P fertilizers. P fertilizer combined with AMF provided benefit to

increase crop root system with many root hairs (Acevedo *et al.*, 2014; Ramos-Zapata *et al.*, 2009). This has a positive effect for oil palm with a poorly developed root system. It has no root hairs which caused oil palm not adequately able to take up enough P without AMF assistance.

Phosri *et al.* (2010) stated to improve growth and development of oil palm may initiate with high levels of P fertilizers, but the right dose must be considered because it will inhibit the development of mycorrhizae symbiosis. Hence, plants growth poorly because the plant cannot take up more P. AMF studies proved that responses to AMF fungal species vary with different host plant species (Gaur and Adholeya, 2002; Eom *et al.*, 2000), and therefore, several species should be screened to ensure they are compatible outcome with the plant. According to Liu *et al.* (2007), native and selected strains of the same taxonomic species can give different responses in the plants as well. This study was undertaken to investigate the responses of oil palm seedling to the four isolated indigenous AMF combined with phosphorus fertilizers that could increase oil palm seedling growth and reduced mineral fertilizer at ex-coal mining soil.

MATERIALS AND METHODS

The oil palm pre-nursery experiment had been conducted at Teaching and Research

Farm, Agriculture Faculty, Jambi University, Jambi. The research used factorial experiment which arranged as completely randomized design with three replications. The first factor is the Mycorrhizae Isolate (AMF indigenous) which consist of five levels: none of indigenous AMF inoculation, isolate of *Glomus* sp. 3, isolates of *Glomus* sp. 6, isolates of *Glomus* sp. 15, and isolates of *Glomus* sp. 16. The second factor is the doses of P fertilizer, which consists of 5 levels: without P fertilizer, fertilizer with 25%, 50%, 75% and 100% recommended doses. The growth variables measured were seedling height, stem diameter, number of leaves and total seedling leaf area. The data obtained were analyzed by analysis of variance to see whether there was an interaction between the isolate and the P fertilizer doses. Then analyzed with Duncan Multiple Range Test. All statistical analyses were run in SPSS. Significant results are shown with at $P < 0.05$.

RESULT AND DISCUSSION

Seedling Height. There was interaction between mycorrhizae isolates and the P dose on the palm oil seedlings height. The highest height was obtained at the combinations of isolate *Glomus* sp. 3 and 75% of P doses. This was followed by the plant of none AMF with P₁. The lowest plant height was achieved at m₃ p₂ (*Glomus* sp.15 with 50% of P doses). The results were described in Table 1.

Table 1. Average of palm oil seedling height at every combination of mycorrhizae isolate and P doses of recommended

Mycorrhizae Isolate	P Doses					Average
	p ₀	p ₁	p ₂	p ₃	p ₄	
m ₀	20.55 a A	23.50 a A	20.40 a A	21.12 a A	20.68 a A	21.25A
m ₁	20.52 a A	19.22 a A	21.75 a A	26.00 b B	23.20 a A	22.14 A
m ₂	20.28 a A	19.55 a A	22.53 a A	21.57 a A	19.77 a A	20.74 A
m ₃	20.57 a A	22.00 b A	16.30 a A	20.25 a A	19.62 a A	19.75 A
m ₄	22.25 a A	22.93 a A	21.28 a A	19.28 a A	18.42 a A	20.83 A
Average	20.83 a	21.44 a	20.452 a	21.64 a	20.33 a	

Number in row followed by the different letter (lowercase) and number within a column with uppercase were significantly different at $P \leq 0.05$ using Duncan Multiple Range Test (DMRT)

This result has shown that indigenous isolate *Glomus* sp. 3 that compatible with palm oil. The symbiosis can increase palm oil

seedling growth. AMF has some symbiotic associations that formed between plants and soil fungi that takes an essential role in plant

growth, and improved soil quality that benefits for both associations. Bucher (2007) said that AMF symbiosis is a natural association between the roots of higher plants and can improve the host plants growth and the acquisition of nutrients, especially P from soil.

Seedling Stem Diameter. The highest seedling stem diameter was obtained by the

combination m_1p_3 (m_1 : Mycorrhizae isolate *Glomus* sp. 3, m_3 : 75% of Phosphorous doses). This was followed by m_0, p_1 (*Glomus* sp. 15 with 50% of P doses) (Table 2). The responses of plants to environments are shown by plant height and stem diameter. The highest stem diameter has shown that *Glomus* sp. 3 was compatible with palm oil seedling.

Table 2. Average of palm oil seedling stem diameter at every combination of mycorrhizae isolate and P doses of recommended

Mycorrhizae Isolate	P Doses					Average
	p_0	p_1	p_2	p_3	p_4	
m_0	3.33 a B	3.72 b B	3.32 a AB	3.48 ab A	3.22 a AB	3.41A
m_1	3.40 a B	3.10 a A	3.15 a AB	3.93 b B	3.70 b B	3.46A
m_2	3.05 a AB	3.10 a A	3.83 b B	3.18 a A	3.30 a AB	3.23A
m_3	2.65 a A	3.58 b AB	2.40 a A	3.30 b A	2.87 a A	2.96 A
m_4	3.20 a B	3.43 a B	3.57 b B	3.20 a A	2.90 a A	3.26A
Average	3.13 a	3.39 a	3.23 a	3.42 a	3.19 a	

Number in row followed by the different letter (lowercase) and number within a column with uppercase were significantly different at $P \leq 0.05$ using Duncan Multiple Range Test (DMRT)

Once the symbiotic association between oil plant and a mycorrhizae species was established for a host species, the symbiosis is a mutualistic effect and significant to increase plant height, stem diameter, and plant biomass.

Number of Seedling Leaf. The highest numbers of seedling leaf were obtained by the combination of m_1p_1 (Table 3), even although there is no interaction between indigenous isolate AMF and Phosphorus doses.

Table 3. Average of palm oil palm seedling leaves number at every combination of mycorrhizae isolate and P of recommended doses

Mycorrhiza Isolate	Doses P					Average
	p_0	p_1	p_2	p_3	p_4	
m_0	3.67 b A	3.67 b A	3.50 ab AB	3.17 a A	3.17 a A	3.43 A
m_1	3.33 a A	3.83 b B	3.50 ab AB	3.79 b B	3.33 a AB	4.45 B
m_2	3.33 ab A	3.17 a A	3.67 b B	3.17 a A	3.50 b B	3.37 A
m_3	3.50 ab A	3.67 b AB	3.17 a A	3.50 ab AB	3.50 ab B	3.47 A
m_4	3.67 c A	3.50 ab A	3.50 ab AB	3.50 ab AB	3.33 a AB	3.50 A
Average	3.50 a	3.57 a	3.47 a	3.37 a	3.37 a	

Number in row followed by the different letter (lowercase) and number within a column with uppercase were significantly different at $P \leq 0.05$ using Duncan Multiple Range Test (DMRT)

This research shown that, Indigenous AMF, isolate *Glomus* sp. 3 trend was the most compatible mycorrhizal species, which was established with oil palm as the host plant,

therefore, the symbiosis shown an increase in leaf production.

Total Seedling leaf Area. The highest number of total leaf seedling was obtained by the combination m_1p_3 . This research shows that

inoculation indigenous AMF, isolate *Glomus* sp.3, was increased oil palm growth. Then symbiotic relationship between AMF and roots

of higher plants contributes significantly to plant nutrition and its growths (Amaya-Carpio *et al.*, 2009).

Table 4. Average of oil palm seedling total leaves area at every combination of mycorrhizae isolate and P of recommended doses

Mycorrhiza Isolate	Doses P					Average
	P ₀	P ₁	P ₂	P ₃	P ₄	
m ₀	81.63 b B	93.83 c B	56.80 a A	87.56 c B	71.39 b A	78.24 B
m ₁	72.52 ab A	61.80 a A	79.46 b AB	66.18 a A	82.67 c B	72.53 A
m ₂	69.37 a A	63.27 a A	90.61 c B	71.39 b A	64.27 a A	71.78 A
m ₃	71.50 b A	72.69 b A	53.61 a A	79.90 b AB	74.48 b A	70.44 A
m ₄	73.28 b A	84.16 c B	82.86 c B	57.92 a A	65.66 a A	72.78 A
Average	73.66 a	75.05 a	72.67 a	72.59 a	71.69 a	

Number in row followed by the different letter (lowercase) and number within a column with uppercase were significantly different at $P \leq 0.05$ using Duncan Multiple Range Test (DMRT)

These positive responses in productivity to AMF colonization have been mainly attributed to enhanced up taken by AMF of relatively immobile soil ion such as phosphorus (Liu *et al.*, 2007). The positive effect of *Glomus* sp. colonization on plant growth was observed by reference (Dreyer *et al.*, 2008; Ruiz-Lozano & Azcón, 2000; Jaiti *et al.*, 2007). The arbuscular mycorrhizae fungi supply nutrient to their host plant, especially phosphorus (Joner *et al.*, 2000). The fungi absorb phosphate from the soil through their extra radicle hyphae and incorporate it into cytosolic pool, while the excess of phosphorus is transferred to the vacuoles and translocation to the intra radicle hyphae.

CONCLUSION

The result shows that, the isolated *Glomus* sp. 3 combined with 75% P doses reduced from recommended doses showed highly effective to promoting oil palm growth seedling. The total leaf area and seedling height, which were inoculated with these fungal being increased, compared with non-inoculated plants. Therefore, rationale for indigenous AMF application in the pre-nursery seems highly warranted coupled with the reduction in the amounts of P given to the seedling. Furthermore, there is a potential indigenous

AMF application and could reduce in P fertilizers especially in oil palm at pre-nursery.

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