Effect Of Vesicular-Arbuscular Mycorrhizae Inoculation And Liquid Organic Fertilizer Application To The Phosphorus Concentration On Soybean (Glycine Max L.) In Soils Post-Coal Mining

Putri Indah Nurhikmah, Eko Kusumawati, Dwi Susanto

Abstract: This study aims to determine effect of Vesicular-Arbuscular Mycorrhizae and Liquid Organic Fertilizer application to the phosphorus concentration on soybeans grown in acid soils of post-coal mining. The research use completed randomized factorial design, consisted of two treatment: (1) Vesicular-Arbuscular Mycorrhizae Inoculation, M0= 0 gr, M1= 10 gr, M2= 20 gr, M3= 30 gr, and M4= 40 gr per plant. (2) Liquid organic fertilizer application ,P0= 0 mL, P1= 10 mL and P2= 20 mL per plant .The results showed that the inoculation of Vesicular-Arbuscular Mycorrhizae as much as 40 grams and 20 mL of Liquid Organic Fertilizer gave the best result to the increased concentrations of phosphorus in plant tissue but did not show any increased in the phosphorus concentrations of soil.

Keywords: Glycine max L, Liquid Organic Fertilizer, Soil Post-Coal Mining, Vesicular-Arbuscular Mycorrhizae

1 INTRODUCTION

Indonesia is known as a country with large mining materials and is an important source of income for the country. On the other hand, mining also has a negative impact. In the report [6] suggests that the negative impacts of mining activities are the deterioration in the condition of soils used to mining (tailing), the profile changing of the soil layers, solidification, nutrient depletion, low pH, the decreased of microbial population, pollution by heavy metals and nutrient-poor primarily N and P. One of the efforts to improve the ability of nutrient absorption by plants on former coal mine land is with the use of biofertilizer. Biofertilizer has advantages compared to artificial chemical fertilizers because the materials derived from nature so as not to cause environmental pollution problems as well as artificial chemical fertilizers. The biofetilizers, among others, by the provision of Vesicular-Arbuscular Mycorrhizae (VAM) into the soil and Liquid Organic Fertilizer (LOF) derived from organic materials. Plants associated with mycorrhiza can adapt well in mining areas where the nutrient are very limited. It is related to the ability of mycorrhizae to provide phosphorus from the soil. In addition to the increase of nutrient uptake, mycorrhizae is also able to accumulate toxic elements. Plants that have mycorrhiza are more tolerant to heavy metals than plants that do not have mycorrhizae and have higher P levels total than plants that do not have mycorrhizae [1].

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Approximately 20% of protein consumed by Indonesian households comes from legumes, especially soybean and peanuts, therefore the demand for soybeans continues to increase, both for consumption and food industry. Meanwhile, the production of peanuts and soybeans in the country is still not able to meet the needs. An alternative that can be used to increase the production of soybean is by the addition of VAM. The ability of VAM to adapt and its tolerance to heavy metal content gives a positive expectation of the utilization of this fertilizer as an effort to the reclamation of land damaged by post-coal mining [7]. Based on the background above, it is necessary to do a research about the effect of VAM and LOF to the levels of phosphorus soil and plant tissues of soybeans grown in acid soils of post-coal mining.

2 MATERIALS AND METODS

This study was conducted in March - May 2017 at the Laboratory of Plant Physiology, Faculty of Mathematics and Natural Sciences. Analysis of P conducted in the Laboratory of Soil Science, Faculty of Agriculture, Mulawarman University, Samarinda, Indonesia. The materials used in this study is the soybean seed, Vesicular-Arbuscular Mycorrhizae (VAM) be obtained from the Laboratory of PPHP Pandaan Pasuruan, soil post coal mining used was taken in PT. Indominco Mandiri Tbk Bontang, East Kalimantan, Indonesia, Liquid Organic Fertilizer based stem of bananas, HNO_3 p.a, ml $HCLO_4$ p.a, standard solution (0-16 ppm), dye P, concentrated P-reagent, titrisol, and KOH.

2.1 Research Design

The research use completed randomized factorial design, consisted of two treatment: (1) Vesicular-Arbuskular Mycorrhizae Inoculation, M0= 0 gr, M1= 10 gr, M2= 20 gr, M3= 30 gr, and M4= 40 gr per plant. (2) Liquid organic fertilizer application ,P0= 0 mL, P1= 10 mL and P2= 20 mL per plant .

2.2 Prosedur

Soybean seeds selected with a disability are a uniform size. Soybean seeds soaked in water for 24 hours, the good seeds

will sink, bad seeds will float. Good seed is the seed that is ready for treatment. Soil mines to the planting medium is taken at a depth of 0-20 cm. Soil weighed 2 kg in accordance with a predetermined dose. Then the soil has been mixed incorporated into polybag allowed to stand for 7 days with watered every day. Weighed seeds that will be used later drained beans. VAM evenly mixed with the seeds that have been soaked in water. VAM provided with the prescribed dosage. Seeds that have been inoculated immediately planted in the planting medium. Maintenance done by watering twice a day, every morning and evening. Fertilization of Liquid organic provided with the prescribed dosage. Plant growth parameters were the levels of phosphate soil and plant tissues.

2.3 Data Analysis

Data were analyzed by analysis of variance (ANOVA) at the stage of 95%. When there is a significant difference between the carrying, conducted by Duncan test with a level of 95%.

3 RESULT AND DISCUSSION

3.1 P levels total in soil

Phosphorus total soil analysis conducted by P measurement method using HNO_3 and $HCLO_4$. The effect of giving VAM and LOF to the P total soybean soil (Glycine max L) during 8 MST can be seen in the table below. The results show (Sig. ≤0,05)

VAM	LOF		
	P0	P1	P2
M1	0.25±0.03^{ab}	0.22±0.04^{a}	0.25±0.03^{ab}
M2	0.22±0.03^{a}	0.23±0.07^{a}	0.36±0.07^{abc}
M3	0.24±0.01^{a}	0.36±0.14^{abc}	0.54±0.27^{bc}
M4	0.16±0.03^{a}	0.36±0.06^{abc}	0.57±0.09^{c}

Table 1. *The effect of giving VAM and LOF to the P total soybean soil during 8 weeks after planting .*

Description: The numbers followed by the same letters on the columns and rows indicate no significant difference, whereas the different letters indicate significant difference at Duncan test with a 95% confidence level Table 1 shows that with the administration of VAM on soil without LOF did not show any significant increase, this is indicated by the treatment of M4 is not significantly different with M0. The result of P total soil average shows significantly different result on P2M4 treatment, with VAM 40 grams and LOF 20 ml on P0M0 (control) treatment. The interaction between VAM and LOF treatment significantly affected on P total soil average with the highest value at P2M4 treatment is 0.02. Allegedly the concentration of VAM as much as 40 grams and LOF 20 ml is the optimal dose to increase the levels of P total in the soil. This is allegedly because of the planting media used in the form of dry acid soil of post-mining with clay texture. The retention of P is a problem especially in dry acid soil with clay texture containing Al and Fe oxides. Dry soil will reduce the uptake of P and the plants will lack of phosphorus. The symptoms of phosphorus deficiency are slow growth, dark green leaves and purple pigments on old leaves. This is in accordance with the research [2], which says in the soil P is available to plants less than 1% P total soil means more P that is not available to plants. The low availability of P is due to the strong bonding of P elements to the soil colloids and high P retention. The high uptake of P by plants infected with VAM is due to hypae VAM secrete the phosphatase enzyme so that the bounded P in the soil will be dissolved and available for the plant. In addition, the extremely soft hyphae size on the root hairs allows the hyphae to infilltrate the most delicate soil pores so that the hyphae absorb water under very low soil water conditions. The larger water uptake by plants which have mycorrhiza will also bring nutrients such as N, P, and K so that the nutrient uptake by plants will be increased [4]. VAM is able to help the plants absorb the nutrients both macro and micro, especially in a bounded form and not available for plants. The most popular effect of VAM is that plants absorb phosphorus in soil more and grow faster than plants that do not contain VAM. In addition to phosphorus, the hyphae also transport other nutrients to the host plants such as ammonium, calcium, sulfur, potassium, zinc, I and water [2].

3.2 Phosporus Concentrations on the plant tissues

The effect of giving VAM and LOF to the Phosphorus concentration on the soybean (Glycine max L.) plant tissues during 8 weeks after planting can be seen in the table below. The results show (Sig. ≥0,05).

Table 2. *The effect of giving VAM and LOF to the P total soybean plant tissue 8 weeks after planting (%)*

VAM	Liquid Organic Fertillizer		
	P0	P1	P2
M0	0.03±0.01^{ab}	0.03±0.01^{abc}	0.02±0.01^{a}
M1	0.03±0.00^{ab}	0.03±0.01^{abcd}	0.04±0.00^{abcd}
M2	0.04±0.01^{abcd}	0.03±0.00^{abc}	0.04±0.00^{abcd}
M3	0.04±0.01^{abcd}	0.05±0.01^{bcd}	0.05±0.00^{cd}
M4	0.04±0.00^{abcd}	0.05±0.00^{bcd}	0.06±0.02^{d}

Description: The numbers followed by the same letters on the columns and rows indicate no significant difference, whereas the different letters indicate significant difference at Duncan test with a 95% confidence level. Table 2 shows that with 40 grams of VAM and 20 ml of LOF (P2M4) show significantly different results to the treatment without VAM and LOF (control). The results show that the administration of VAM with a dose of 40 grams and 20 ml LOF (P2M4) dose is able to increase the P levels in plant tissue up to 0.57%. It is suspected that the increase in the dose of FMA is capable to increase the available P. However in this case there is no synergistic relationship between the dose of VAM and LOF in increasing the available P. VAM activity that is able to dissolve the fixed P through the enzyme phosphatase activity so that it can increase the available P for plants. In the report [3] suggests that in the optimum interactions, VAM symbiosis can provide a dominant path for the provision of P plant. Compost as a source of organic materials is able to give favorable conditions for VAM activity so that it can increase the available P and compost can produce the organic acids such as humic acid and dihydic acid where both are able to bind Al and Fe so that P becomes available. Mycorrhizae plays an important role in improving the tolerance of crops against the toxic metal elements and to the drought/less water conditions. The benefits of VAM also been reported to release P fixed by Al and Fe on acid soils by producing phosphatase enzymes so that P will be available for the plants. VAM is a symbiotic association between fungi and plant roots that forming a

complex interactional tangle. VAM plays a role in improving the physical properties, chemistry soil and biological soil, improving nutrient uptake, stimulating the growth of root plants from produced hormones, increasing the resistance of plants against drought, protecting roots from pathogen attacks, protecting plants from heavy metal poisoning, and releasing the fixed phosphate.The effect of giving increasing the resistance of plants against drought, protecting roots from pathogen attacks, protecting plants from heavy metal poisoning, and releasing the fixed phosphate.

3.3 The correlation value levels of P plant tissue and P soil total

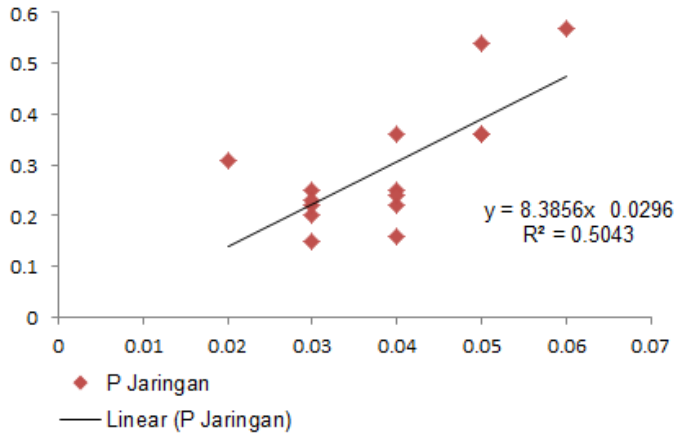

Figure 1*. The correlation of P soil and P plant tissue*

Based on the test results, it is known that the variable of total soil phosphate effect on the variable of plant tissue phosphate and its effect is positive because the value of the regression coefficient is 8,3856. While based on the R2 value of 71% which illustrates that the variable of P soil total levels and P plant tissue levels have a strong relationship. Which means if the soil total phosphate levels in the soil is higher it will increase the levels of tissue phosphate, vice versa. This is accordingly stated by [5] that on the soil having a high P absorption capacity, the use of P will be shorter, and vice versa if on the soil having a low absorption capacity (fixation) then the use of P will be longer. The ability of plants to absorb nutrients from the soil resulting in plants can absorb N and P well anyway. The higher uptake of N and P from the soil, the greater the uptake of P and N in plant tissue. In the report [8], that biofertilizer of rhizobium inoculant increased of soil nitrogen concentration, nitrogen concentration of plant component of Arachis hypogea in the soils post-coal mining. Similarly to the activity of the plant physiology, the higher the level of groundwater availability and the doses of N and P fertilizers are given, then the physiological process that expressed on the rate of plant photosynthesis are higher. This process is also clearly shown by the aspects of plant growth occurs. Accordingly, the dose and time of phosphate fertilizers administration should be considered [5]. Proper fertilization both dose and timing of administration in accordance with the plant needs can optimize the plant physiological processes. The optimal physiological processes can encourage the plants to give a growth response, yield, and optimum quality as well.

4 Conclusion

The results showed that the intraction of VAM as much as 40 grams and 20 mL of LOF (P2M4) gave the best result to the increased concentrstiond of phosphorus in plant tissue but did not show any increase in the phosphorus soil concentrations.

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