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Application of phosphate solubilizing fungi and various sources of P-Fertilizers toward P-Available and P Nutrient content of soybean (*Glycine max* L. Merrill) in andisol soil

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Abstract. Andisol is a soil formed from volcanic ash and has a problem with low P availability in the soil. The purpose of this research was to determine the effect of phosphate solubilizing fungi, various sources of P fertilizer and phosphate solubilizing fungi interactions to increase P availability and soybean plant growth in Andisol soil. The research was carried out at the Faculty of Agriculture Greenhouse and USU Soil Biology Laboratory, Medan 2018. This research used Factorial Randomized Block Design (RBD) with 2 Treatment Factors and 3 replications. The first factor is phosphate solubilizing fungi, namely; M0 (without application of PSF), M1 (5g *Talaromyces pinophilus*), M2 (5g *Aspergillus terreus*), M3 (2.5g *Talaromyces pinophilus* + 2.5g *Aspergillus terreus*). The second factor is various sources of P fertilizer, namely; P0 (Without application P), P1 (0.78g TSP), P2 (1g SP36) and P3 (1.3g RP). The research results showed that the application of phosphate solubilizing fungi and P fertilizer could increase the availability of P as much as 1.4-15.4%, plant dry weight as much as 21.6-42% and plant P content as much as 1.3-8.9%. The best treatment was the interaction of *Talaromyces pinophilus* with SP36.

1. Introduction

Andisol that develops from acidic (liparite) parent material has a high Aluminium (Al) content. This causes the problem to Andisol soil, regarding the availability of phosphorus (P) in the soil because of the P bound on the surface of soil colloids which causes P nutrients in the soil to be unavailable to plants [1]. Andisol land area in Indonesia is estimated at $\pm 5,395,000$ ha or $\pm 2.9\%$ of the land area in Indonesia and the largest is in Sumatera Utara Province ($\pm 1,062$ ha) followed by East Java province (± 0.37 ha) [2].

Phosphate (P) is the nutrient needed by plants for photosynthesis, metabolism, root development, the formation of flower, fruit, and seeds. P nutrient is an essential nutrient needed by plants in large quantities. In a soil, P availability rarely exceeds to 0.01% of the total P contained, therefore it is necessary to make an effort to reduce P bound in the soil so that it can be available to plants [3].

Increasing the availability of P in Andisol soil can be done by applying microbes that play a role in the supply of P nutrients in plants such as fungi and bacteria phosphate solubilizing. The research results of



Marbun *et al* [4], Ritonga *et al* [5] and Sembiring *et al* [6] stated that the application of phosphate solubilizing microbes can increase the availability of P in Andisol soil affected by Sinabung eruption.

Soybean (*Glycine max* (L.) Merrill) is one of the food crops commodities which is important in improving community nutrition. This is based on its benefits as a source of vegetable protein, vitamins, minerals, fats and iron which is important for humans. Soybean cultivation in Andisol soil can be hampered due to the high P bound so that P uptake is very low which has an impact on plant growth. If soybean plants lack P, it can inhibit the plant growth, fruit ripening, and chlorophyll biosynthesis, so that plants experience discoloration (become darker / darkening) and pods filling are less optimal [7].

The efforts to increase soybean productivity in andisol soils can be done by fertilizing and applying phosphate solubilizing fungi to increase P available and soybean plant growth.

2. Materials and Methods

This research was carried out in Greenhouse of the Laboratory of Soil Biology, and the Research and Technology Laboratory of the Faculty of Agriculture, University of Sumatera Utara, Medan 2018. The materials used were the inoculums of *T. pinophilus* and *A. terreus* fungi which were the collection of USU Soil Biology Laboratory, Andisol with soil characteristics: pH H₂O 4.9, C-Organic 4.5%, N-total 0.57%, P-total 0.33%, P-available 33.68% and CEC 23.77%, soybean seeds as indicator plants, P fertilizer with a predetermined dose, and polybags as containers of soil and planting material.

This research used a Factorial Randomized Block Design consisting of 2 factors with 3 replications. Factor I: phosphate solubilizing fungi (M), namely; M0 (without application of PSF), M1 (5 g *T. pinophilus*), M2 (5g *A. terreus*), M3 (2.5g *T. pinophilus* + 2,5g *A. terreus*). The second factor is various sources of P fertilizer (P), namely; P0 (Without P application), P1 (0.78 g TSP), P2 (1 g SP36) and P3 (1.3 g RP).

Andisol that had been dried air was put in a 5 kg polybag. Application of phosphate solubilizing fungi was carried out one week after planting with each dose of 5 g / plant by making a ditch around the planting hole and then inserting the phosphate solubilizing fungi then covered with soil. While the application of P fertilizer and basic fertilizer was carried out two days before planting. A sampling of soil and plants to be analysed were taken at the end of the vegetative period. Parameters observed were planted dry weight (gr), P available and plant P content.

Statistical Analysis: data from the research on significant effect treatments were continued by Duncan's Multiple Range test with a level of 5%.

3. Results and Discussion

Based on the analysis of variance results, it showed that the application of phosphate solubilizing fungi significantly affected the soil pH and P available of the soil while the application of P fertilizer significantly affected the soil pH and the interaction of both gave a significant effect on the plants P content.

Table 1 show that it can be seen that the application of phosphate solubilizing fungi can increase soil pH. The treatment of *T. Pinophilus* fungi had the highest pH of 6.09 and the lowest was without application as much as 5.73. In the P-available parameter, the treatment of *T. Pinophilus* + *A. terreus* fungi can increase P-available by 5% compared to the control. The treatment of *T. Pinophilus* fungi increased the plant dry weight by 12.1% compared to the control. In plant P content, the highest treatment was at *A. terreus* which can increase P content by 8.3%. With the application of phosphate solubilizing fungi, it can increase the soil P-available so that plant growth increase, this is because the application of phosphate solubilizing fungi can produce organic acids that can chelate Al and Fe so that P is available for plants. This is in accordance with the literature of Subba Rao [8] which stated that in its activity P solubilizing microbes will produce organic acids, including citric acid, glutamate, lactic succinate, glyoxalate, malate, flumarate, tartaric and α -ketobutyrate. The research results of Sembiring *et al* [9], Sembiring and Fauzi [10], Sembiring *et al* [11]

stated that *T. pinophilus* can increase plant growth, plant dry weight by 13.92-61.8% and P uptake of plants by 7.41-14.41%.

Table 1. The value of Soil pH, P available, plant dry weight and plants P content

Treatments	Soil pH	P available	Plant dry weight (gr)	Plant P content (%)
Phosphate Solubilizing Fungi				
Without PSF (M0)	5.73b	126.61b	8.31	2.53
<i>T. Pinophilus</i> (M1)	6.09a	132.95ab	9.32	2.59
<i>A. terreus</i> (M2)	5.93ab	137.09ab	8.68	2.84
<i>T. Pinophilus</i> + <i>A. terreus</i> (M3)	5.93ab	138.71a	8.72	2.81
P Fertilizer				
Without P Fertilizer (M0)	5.71b	127.27	8.38	2.81
TSP (M1)	5.99ab	136.11	9.18	2.93
SP 36 (M2)	6.02a	137.22	8.77	2.85
RP (M3)	5.96ab	134.76	8.7	2.58
M	*	*	NS	NS
P	*	NS	NS	NS
M x P	NS	NS	NS	*

Note: Numbers followed by the same notation on the same line show no significant difference according to Duncan's Multiple Range Test at the 5% level

NS = Not Significant

* = Significant

Based on Table 1, it can be seen that the application of phosphate solubilizing fungi can increase soil pH. The treatment of *T. Pinophilus* fungi had the highest pH of 6.09 and the lowest was without application as much as 5.73. In the P-available parameter, the treatment of *T. Pinophilus* + *A. terreus* fungi can increase P-available by 5% compared to the control. The treatment of *T. Pinophilus* fungi increased the plant dry weight by 12.1% compared to the control. In plant P content, the highest treatment was at *A. terreus* which can increase P content by 8.3%. With the application of phosphate solubilizing fungi, it can increase the soil P-available so that plant growth increase, this is because the application of phosphate solubilizing fungi can produce organic acids that can chelate Al and Fe so that P is available for plants. This is in accordance with the literature of Subba Rao [8] which stated that in its activity P solubilizing microbes will produce organic acids, including citric acid, glutamate, lactic succisate, glyoxalate, malate, flumarate, tartaric and α -ketobutyrate. The research results of (Sembiring *et al* [9], Sembiring and Fauzi [10], Sembiring *et al* [11] stated that *T. pinophilus* can increase plant growth, plant dry weight by 13.92-61.8% and P uptake of plants by 7.41-14.41%.

Based on Table 1, it was known that the application of several sources of P fertilizer can increase the pH of the soil where the highest pH was obtained at SP 36 treatment of 6.02 and the lowest without the application of P fertilizer at 5.71. The TSP treatment was able to increase P available by 6.6%, plant dry weight by 9.5% and P content by 4.2% compared with no P fertilizer treatment. This increase was due to the P content in fertilizers that can be absorbed by plants that increase plant growth. The results of Purba [12] research stated that the application of TSP fertilizer increased P uptake by 48% and canopy dry weight by 38% in corn crops.

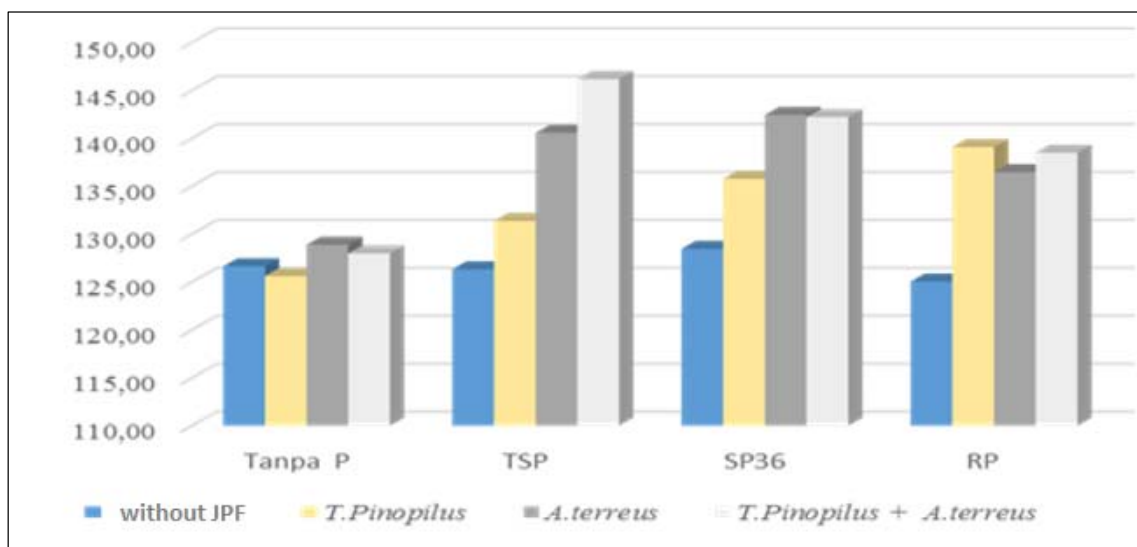


Figure 1. the interaction of phosphate solubilizing fungi with various of p fertilizers against p available in the soil

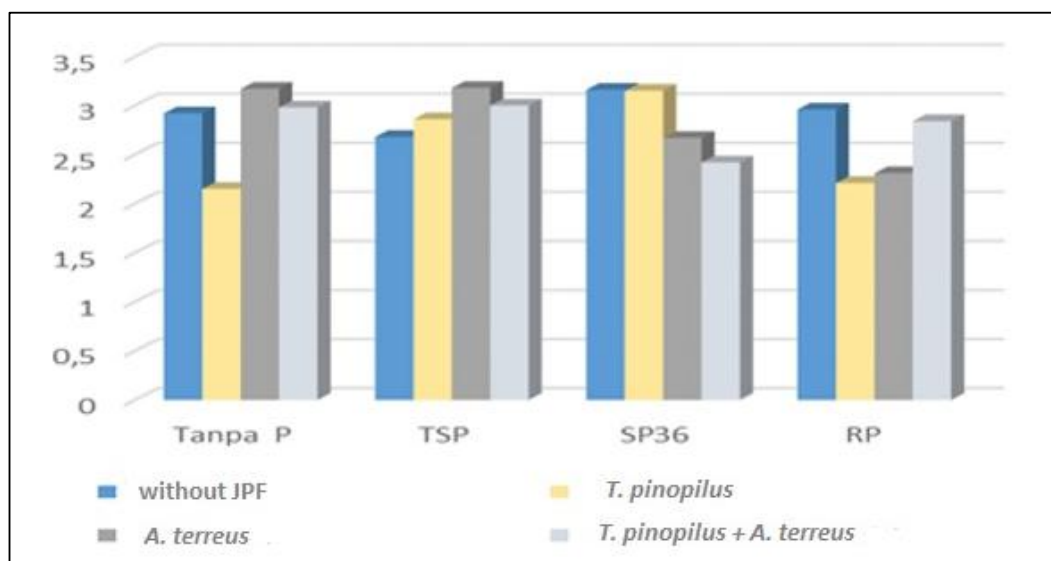


Figure 2. The Interaction of Phosphate Solubilizing Fungi with Various of P Fertilizers Against P available in Soil

The interaction of phosphate solubilizing fungi with various P fertilizers can increase soil pH, plant dry weight, P available and soil P content of plants. In the P-available parameter, the best treatment that increases the P content of plants is *A. terreus* with TSP by 15.4%. The relationship interaction of phosphate solubilizing fungi with various sources of P fertilizer to P-available can be seen in Figure 1. The treatment of *A. terreus* with TSP can increase plant P content by 8.5%. This is because plants are able to absorb P nutrients, with the increasing of P-available causing P content to also increase. A high enough of P content

in P fertilizer can affect plant growth and also affect the level of P in plants. The relationship interaction of the phosphate solubilizing fungi with various sources of P fertilizer on P content of soybean plants can be seen in Figure 2. The results of [13] research which stated that the application of phosphate solubilizing fungi was higher in increasing P uptake by 21.99% and the growth of corn (*Zea mays* L.) by 12.9 and the interaction of phosphate solubilizing fungi with TSP fertilizer were higher in increasing P uptake by 84.44%.

4. Conclusion

The application of phosphate solubilizing fungi can increase P-available by 5-9.5%, plant dry weight by 4.9-12.1% and plant P content by 11-12% and the best treatment was *Talaromyces pinophilus*. The application of various sources of P fertilizer increased P-available by 5.8-7.8%, plant dry weight by 4.6-9.5% and P content of plants by 1.4-4.2% with the best treatment was SP36 (1g). The interaction of phosphate solubilizing fungi and various sources of P fertilizer increased P-available by 1.4-15.4%, plant dry weight by 21.6-42% and plant P content by 1.3-8.9%, and the best treatment was the interaction of *Talaromyces pinophilus* with SP36.

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