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The increasing of phosphorus availability and corn growth (*Zea mays* L.) With the application of phosphate solubilizing microbes and some sources of organic materials on andisol

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Abstract. Andisol is a soil that develops from volcanic ash material, dominated by amorphous aluminium silicate and Al-humus complex. This research was carried out at the Greenhouse and Laboratory of Soil Biology, Faculty of Agriculture, University of Sumatera Utara, Medan. This research used a randomized block design with 2 treatment factors and 3 replications. The first factor was Phosphate Solubilizing Microbial (PSM), namely: without application (M_0), 5 g of *Mycorrhiza* (M_1), 5 gr of *Talaromyces pinophilus* Fungi (M_2), 5 g of *Burkholderia cepacia* Bacteria (M_3). The second factor was organic matter, namely: without application (K_0), 180 g of cow dung (K_1), 180 g of chicken manure (K_2) and 180 g of OPEFB (Oil Palm Empty Fruit Bunch) compost (K_3). The research results showed that the administration of phosphate solubilizing microbes and several sources of organic matter could increase the soil pH by 0.61-29.12%, P-available by 1.46-112.64%, plant height by 5.41-19.25% and canopy dry weight by 11.34-65.57%. In general, the best treatment was the application of *Mycorrhiza* with OPEFB (Oil Palm Empty Fruit Bunch) compost.

1. Introduction

Andisol is a soil that develops from volcanic ash and is widely used for agriculture of horticultural crops, especially vegetables and plantation crops such as tea [1]. The problem found in Andisol soil is low phosphate availability for plants so that the efficiency of fertilization is also low [2].

Phosphorus (P) is a nutrient which determining the growth of agricultural crops. P has always been a limitation for plant growth in Andisol soil because the supply is always low. P is bound by aluminium and non-crystalline iron materials and become unavailable for plants [2] affects various metabolic processes such as cell division and development, energy transport, transduction, macromolecular biosynthesis, photosynthesis and plant respiration [3]. Plants take P from soil solution in the form of $H_2PO_4^-$ ion which is dominant in acid soils and HPO_4^{2-} which is dominant in alkaline soils [4].

Corn plant (*Zea mays* L.) is one of the food crop commodities that has a strategic role in agricultural development and the Indonesian economy because it has the potential in the needs of food, feed, and industrial raw materials. The efforts to increase corn production can be carried out with an intensification program in the form of effective and efficient fertilization program. Therefore, to improve fertilization efficiency and increase plant growth, it is necessary to develop soil biotechnology; one example of it is the use of microbes and the use of organic matter.



One way to increase plant growth and P availability in Andisol soil is by utilizing phosphate solubilizing microbes and organic matter because it produces organic acids that can chelate metals in the soil so that phosphate becomes available to plants. Phosphate solubilizing microorganisms are microorganisms that have the ability to extract phosphates from insoluble forms into forms that available to plants. In the research of [5-6]. Stated that the *Burkholderia cepacia* application increased P available by 5.04-35.42%, and the application of *Talaromyces pinophilus* (30 ml/plant) and cow dung (100 g/plant) could increase P uptake and potato plant growth and production in the Andisol soil in Sinabung area.

2. Materials and Methods

This research was conducted at the Greenhouse and Laboratory of Soil Biology, Faculty of Agriculture, Universitas Sumatera Utara, Medan in April-August 2018. The soil used in this research was Andisol soil as much as 5.9 kg of air-dry soil/polybag with 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%, corn plants, *Mycorrhiza* inoculant, *B. cepacia* bacteria and *T. pinophilus* fungi which were collection of Soil Biology Laboratory and basic fertilizers of Urea, KCL and SP36 respectively 3.6 g, 1.2 g and 0.9 g per plant.

This research used a randomized block design (RBD) with 2 treatment factors and 3 replications. The first factor was the phosphate solubilizing microbes (M), namely: without application of PSM (M₀), 5 g of *Mycorrhizae*/plant (M₁), 5 g of *Talaromyces pinophilus* fungi/plant (M₂), and 5 g of *Burkholderia cepacia*/plant (M₃). The second factor was several sources of organic matter (K), namely: without application (K₀), 180 g of cow dung/plant (K₁), 180 g of chicken manure/plant (K₂), 180 g of OPEFB compost/plant (K₃).

Phosphate solubilizing microbes (5 g/polybag) and organic matter (180 g/polybag) were applied around the planting hole and then incubated for 2 weeks with the number of *Mycorrhiza* spores as much as 103 spores/10 g of soil, *T. pinophilus* fungi 32 x 10⁻⁸ CFU/g and *B. cepacia* 15 x 10⁻⁸ CFU/g. While the application of basic fertilizer was carried out singly 2 days before planting i.e. Urea (3.6 g/plant), KCL (1.2 g/plant) and SP36 (0.9 g/plant). A sampling of soil to be analysed was done after the incubation was completed, while for the plants analysed, it was done at the end of the vegetative period. Parameters observed were soil pH after incubation, P-available after incubation (ppm) with P-Bray II method, plant height in last vegetative period (cm) and canopy dry weight (g) which was weighed with analytical scales.

3. Results and Discussion

Based on the analysis of variance, it showed that the application of phosphate solubilizing microbes had a very significant effect on soil pH while the application of several sources of organic matter had a very significant effect on soil pH, P-available, canopy dry weight and the interaction of both had no significant effect on soil P-available.

Table 1 show that it can be seen that the application of phosphate solubilizing microbes can increase soil pH. The highest pH value was found in *Mycorrhiza* treatment, which was 5.74 and the lowest was in the treatment of *B. cepacia* bacteria, which was 5.30. The increase in soil pH was caused by the presence of phosphate solubilizing microbes which can chelate the metals that cause soil acidity such as Al and Fe [7]. stated that phosphate solubilizing microbes secrete a number of organic acids including formic acids, acetate, propionate, lactonate, glycolate, fumarate, lactate, and succinate. The research results of [8] also showed that the highest soil pH value was in *B. cepacia* application treatment as much as 10 ml. In the P-available parameter, *T. pinophilus* fungi treatment increased P-Available by 9.72% compared to the control. This is consistent with the research of [5-6] which stated that phosphate solubilizing microbes can increase P-available by 14.47-47.71% in Andisol soil affected by Mount Sinabung Eruption. For plant height parameters, the highest value was found in the treatment of *T. pinophilus* fungi, namely 207.38 and the lowest in *B. cepacia* bacteria treatment was 205.43. This is consistent with the research results of [9] which showed that the application of *T. pinophilus* can increase plant height by 1.26% compared to controls. *Mycorrhiza* treatment increased canopy dry weight by

7.1%, followed by *T. pinophilus* by 2.53% and *B. cepacia* by 0.14% [10] stated that organic acids will react with phosphate binders such as Al^{3+} , Fe^{3+} , Ca^{2+} or Mg^{2+} to form stable organic chelates so that they are able to liberate bound phosphate ions so that they affect the effective phosphate dissolution so that P becomes available and absorbable by plants to increase plant growth.

Table 1. Soil pH value, P-available value, plant height and canopy dry weight.

Treatment	Soil pH	P-Available (ppm)	Plant height (cm)	Canopy dry weight (g)
Phosphate Solubilizing Microbes (g)				
Control (M ₀)	5.29b	57.39	205.41	61.08
<i>Mycorrhiza</i> 5 g (M ₁)	5.74a	55.34	205.71	65.44
<i>T. pinophilus</i> 5 g (M ₂)	5.31b	62.97	207.38	62.63
<i>B. cepacia</i> 5 g (M ₃)	5.30b	59.98	205.43	61.17
Organic Matter (g)				
Control (K ₀)	5.03d	50.43bc	192.13c	48.98c
cow dung 180 g (K ₁)	5.38b	55.53b	211.90ab	68.89ab
Chicken manure 180 g (K ₂)	5.36bc	33.48d	212.19a	71.15a
OPEFB Compost 180 g (K ₃)	5.87a	96.24a	207.70abc	60.29abc
M	**	NS	NS	NS
K	**	**	*	**
M x K	NS	NS	NS	NS

Remarks: 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

Based on the table, it can be seen that the application of several sources of organic matter can increase soil pH. The highest value was found in the treatment of OPEFB compost organic matter sources, which was 5.87 and the lowest was on chicken manure treatment, which was 5.36 [11] stated that the increased in soil pH in the treatment which added by organic matter and P fertilizer was due to the added organic material that binds Al and forms complex compounds so that Al is not hydrolyzed again. This is in accordance with the research results of [12] where the highest pH value was found in the treatment of Chicken Manure, which was 4.57 and the lowest was in Paddy Straw treatment, which was 4.18. In the P-Available parameter, the OPEFB compost treatment increased P-Available by 90.8% compared to the control. This showed that the application of several sources of organic matter was able to increase P-available in the soil. In accordance with the research of [13] which stated that the addition of organic matter derived from crop residues and animal waste in addition to adding soil organic matter also contributes to the availability of N, P, and K nutrients. For plant height parameters, the highest value was found in the treatment of chicken manure organic matter sources, namely 212.19 and the lowest was on the treatment of OPEFB compost organic matter sources, namely 207.70, in the parameters of canopy dry weight, chicken manure was able to increase canopy dry weight by 45.26% followed by cow dung by 40.64%, and OPEFB compost by 23.09%. This is consistent with the results of [14] research which stated that the administration of soil organic matter in the form of chicken manure, cow dung, and compost significantly affects the content of phosphorus availability in the soil, where the highest average value for P-available was in 15 tons of chicken manure/ha treatment compared to controls.

Based on the picture, it can be seen that the interaction between the administration of phosphate solubilizing microbes and several sources of organic matter had no significant effect but tends to increase soil pH, P-Available, plant height and canopy dry weight of the plant. For the P-Available parameters, the best treatment was shown by *Mycorrhiza* treatment and OPEFB compost which

increased P-Available by 112.64% with the available P value of 104.58 compared to the control which was 49.18. This is consistent with the results of [9] which showed that *Mycorrhiza* had a significant effect on plant height of 1.15-3.37%, plant dry weight, P available and P uptake of plants because *Mycorrhizae* were able to symbiosis with plant roots to help to increase the plant growth. One effort to overcome the low phosphate availability in the soil is by utilizing a group of phosphate solubilizing microorganisms and organic materials. Microorganisms and organic matter, each of which can produce organic acids which chelate metals in the soil so that phosphate becomes available to plants. This is consistent with the results of [15] research which stated that singly, Phosphate Solubilizing Microbes (PSM) and its interaction with the organic matter had a significant effect on P-available and were not significantly different from the interaction of bacteria + phosphate solubilizing fungi with organic matter of cow dung.

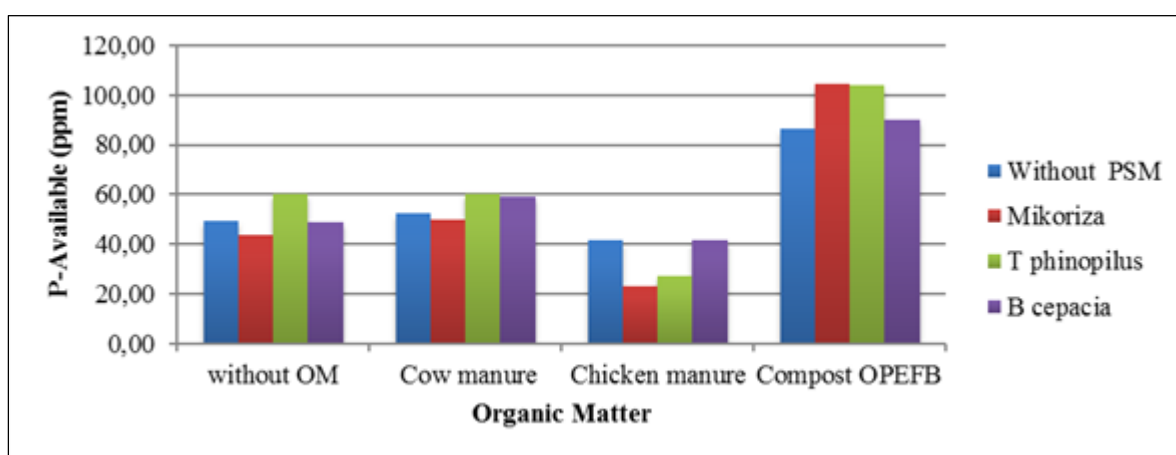


Figure 1. The interaction between the administration of phosphate solubilizing microbes and several sources of organic matter

4. Conclusion

Phosphate solubilizing microbe administration can increase soil pH, P-available, plant height, and canopy dry weight, and the best treatment was *Mycorrhizae*. The administration of some organic matter sources can increase soil pH, P-available, plant height, and canopy dry weight, and the best treatment was OPEFB (Oil Palm Empty Fruit Bunch) compost application. The interaction of several sources of organic material administration can increase soil pH by 0.61-29.12%, P-available by 1.46-112.64%, plant height by 5.41-19.25% and canopy dry weight by 11.34-65.57% and the best treatment was the application of mycorrhizae with OPEFB (Oil Palm Empty Fruit Bunch) compost.

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