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The effect of phosphate solubilizing microbes and chicken manure in increasing the P availability and growth of Green Beans (*Phaseolus radiatus* L.) on Andisol

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Abstract. The availability of P in Andisol is low because phosphate is absorbed by allophane, Al and Fe minerals on the colloidal surface so that it is not available for plants. This research aim was to determine the effect of phosphate solubilizing microbes and chicken manure in increasing P availability and the growth of green beans (*Phaseolus radiatus* L.) plants on Andisol. This research was carried out at the Greenhouse and Laboratory of Soil Biology, Faculty of Agriculture, Universitas Sumatera Utara, Medan. This research used a randomized block design with 2 treatment factors and 3 replications. The first factor is phosphate solubilizing microbes (PSM), namely: (M0) without application, (M1) 5 gr mycorrhiza, (M2) 5 gr *Burkholderia cepacia* bacteria, (M3) 5 gr *Talaromyces pinophilus* fungi. The second factor is the dose of chicken manure, namely: (A0) 0 gr, (A1) 80 g, (A2) 120 g and (A3) 160 g. The results showed that the administration of phosphate solubilizing microbes and chicken manure could increase P-available by 10.78-50.82%, total leaf area by 8.63-65.18%, plant dry weight by 2.46-58.25% and plants P content by 24-99%, the best treatment was the interaction of *T. pinophilus* fungi with a dose of 160 gr/ plant chicken manure.

1. Introduction

Andisol is one of the lands used in the cultivation of plants both horticultural, plantation and forest plants. The main problem in Andisol is the low of P availability due to amorphous clay content in Andisol, especially allophane, little silica, and Al and Fe hydrate oxides with a broad specific surface causing high P retention of >85% so that plants cannot absorb P optimally [1]. This was evidenced by the research of [2]. Andisol in Kutarakyat Village, Namanteran Subdistrict, Karo District in three different land use profiles (forest land, annual crops and seasonal crops) having a retention value of P by 92.94% - 99.91%.

Phosphorus (P) is macronutrients that play an important role in various processes such as photosynthesis, assimilation, and respiration. In addition, phosphorus also plays a role in cell division, stimulates initial growth in roots, plant ripening, fruit formation and seed production [3]. Plants need phosphorus elements in the form of H_2PO_4^- , HPO_4^{2-} and PO_4^{3-} [4]. However, in acid soils, the solubility of Al and Fe becomes high so that phosphate ions will soon be bound to form P compounds which are less available for plants. At pH above neutral, P is also less available for plants because it is bound by Ca into a less available compound [5].



Green beans (*Phaseolus radiatus* L.) is one of the food crops that are cultivated by farmers and consumed by the public because they contain high nutrients and vitamins. Green beans require high P nutrients after N to support their growth. However, the cultivation of green beans in Andisol has a problem because of the high P retention so that the availability of nutrients is very low which has an impact on the metabolic process and plant growth.

Increasing the availability of P and plant growth on Andisol can be done by using phosphate solubilizing microbes (PSM) and the addition of organic matters such as chicken manure. Phosphate solubilizing microbes and chicken manure can change the form of phosphate which is not available (absorbed) to become available by producing organic acids. In Sembiring and Fauzi [6] and Sembiring *et al.* [7] researches, it was found that phosphate solubilizing microbes can increase 47.71% P-available, 69.84% P uptake and 68% potato production on Andisol affected by the eruption of Mount Sinabung. The same thing was also found in Tamad's [8] research, that the application of phosphate solubilizing microbes increased P soluble from 30 ppm to 195 ppm in Andisol.

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 to August 2018. The soil used in this research was Andisol with the 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%, green beans, pikovskaya media, empty palm oil bunches compost, Mycorrhizal inoculant, *Burkholderia cepacia* bacteria and *Talaromyces pinophilus* fungi are the Laboratory of Soil Biology collections, chicken manure and urea base fertilizer, KCl, and SP36, respectively 0.36 gr, 0.4 gr and 0.28 gr/plant.

This research used a randomized block design (RBD) with 2 treatment factors and 3 replications. The first factor was Phosphate solubilizing microbes (M) with 4 levels, namely: (M0) without application of PSM, (M1) 5 gr of mycorrhiza/ plant, (M2) 5 gr of *B. cepacia* bacteria/plant, 5 gr of *T. pinophilus* fungi/plant. The second factor was chicken manure dose (A) with 4 levels, namely: (A0) without application of chicken manure, (A1) 80 g/plant, (A2) 120 g/plant, (A3) 120 g/plants.

Application of chicken manure and basic fertilizer were done 2 days before planting while the application of phosphate solubilizing microbes a week after planting with the number of mycorrhizal spores of 118 spores/ 10 g soil, *T. pinophilus* fungi 36×10^8 CFU/ gr and *B. cepacia* bacteria 17×10^8 CFU/ gr. A sampling of soil and plants to be analysed at the end of the vegetative period. The parameters that observed were P-available (ppm) with P-Bray II method, total leaf area (cm²) by gravimetric method, plant dry weight (gr) weighed with analytical scales and plant P content (%) with wet titration method.

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, showed that the application of phosphate solubilizing microbes significantly affected the total leaf area and P content of plants while the application of chicken manure significantly affected P-available, total leaf area and P content of plants.

Table 1 show that it can be seen that the application of *T. pinophilus* fungi was able to increase P-available as much as 8.45% from the control. P-solubilizing microbes will produce organic acids. Furthermore, these organic acids will react with phosphate binders such as Al³⁺, Fe³⁺, Ca²⁺, or Mg²⁺ to form stable organic chelates which are able to free bound phosphate ions [5]. This is also in line with the research of Sembiring *et al.* [9-11] that phosphate solubilizing microbes can increase P-available by 14.47% - 64.79% in Andisol affected by Mount Sinabung Eruption.

Table 1. P-available, total leaf area, plant dry weight and plant P content value due to the application of phosphate solubilizing microbes and chicken manure.

Treatment	P-available (ppm)	Total Leaf Area (cm ²)	Plant Dry Weight (gr)	Plant P Content (%)
Phosphate solubilizing microbes (gr)				
Control (M0)	148.52	832.78b	5.75	2.82b
Mycorrhiza5 gr (M1)	150.18	989.28ab	6.09	3.33ab
<i>B. cepacia</i> 5 gr (M2)	145.67	939.68ab	6.06	3.35ab
<i>T. pinophilus</i> 5 gr (M3)	161.08	1078.55a	6.97	3.72a
Chicken manure (A)				
0 gr (A0)	122.84b	883.22b	5.84	2.79b
80 gr (A1)	151.16a	884.87b	5.72	3.37ab
120 gr (A2)	166.07a	1105.50a	6.8	3.52a
160 gr (A3)	165.40a	966.71ab	6.52	3.53a
M	NS	*	NS	*
A	*	*	NS	*
M x A	NS	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

The increase of P-available was in line with the increase in total leaf area, plant dry weight and plant P content. The highest application was found in *T. pinophilus* fungi, which was able to increase the total leaf area by 29.51%, plant dry weight by 21.21% and plant P content by 31.91%. With high P availability, it can stimulate root growth and expand the absorption area by roots so that plants can absorb P elements optimally which can be used in metabolic processes and plant growth. This is in accordance with the literature of [3] which stated that the main function of P in plants is as an energy transfer obtained by photosynthesis and carbon metabolism. In addition, phosphorus also plays a role in cell division, stimulates initial growth in roots, plant ripening, fruit formation, and seed production. In addition, according to the research results of [12] in which *T. pinophilus* inoculation can increase plant dry weight as much as 1.27% - 2.37% and P uptake of plants as much as 7.41% - 14.41% in oil palm sprouts on saline soil. In addition, [13] also stated that *T. pinophilus* fungi increased P uptake by 21.99% and corn growth by 12.91%.

Based on the Table 1, it is known that the application of chicken manure has a significant effect on P-available, the total leaf area and P content of plants. P-available parameters and the highest total leaf area were found at 120 gr/ plant chicken manure dose. As for the highest P content of plants was at a dose of 160 gr/plant. This increase was due to the decomposition process of chicken manure that produces organic acids which are able to free P elements that are absorbed in acidic Andisol. This is in accordance with [14] which stated that the influence of organic matter on the availability of phosphate nutrients in the soil through organic acids that can bind metals such as Al, Fe and Ca from the soil solution, then form complex compounds that it is difficult to dissolve. In addition, the decomposition rate of chicken manure is fast and contains nutrients where a good decomposition rate will increase the concentration of nutrients in the soil, especially N, P and K and other elements, and improved soil structure. Thus, the roots of plants will develop well and the roots can absorb more nutrients [15].

The interaction between phosphate solubilizing microbes and chicken manure had no significant effect on P-available, total leaf area, plant dry weight and P content of plants, but there was an increase,

where treatment of *T. pinophilus* fungi with 160 gr dosage of chicken manure/ plant increase P-available by 50.82% from the control. The higher dose of chicken manure combined with the phosphate solubilizing microbes, the higher P-available is (Figure 1). This is in accordance with the research of Ritonga *et al.* [16] that the application of phosphate solubilizing fungi combined with chicken manure increases the availability of P by 69% in Andisol affected by the eruption of Mount Sinabung.

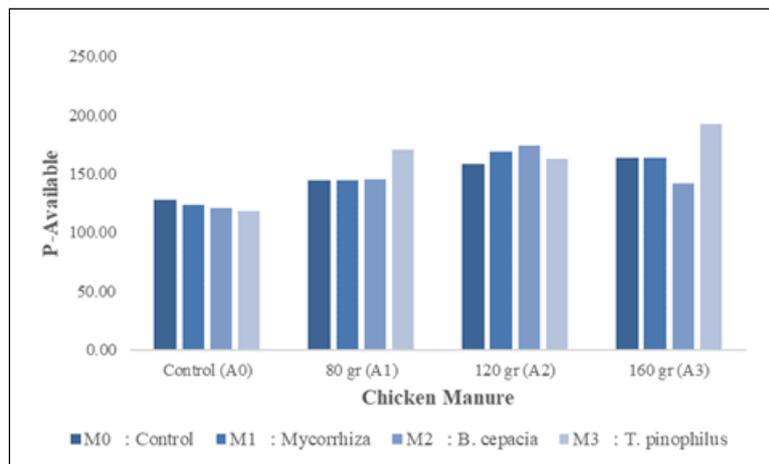


Figure 1. The interaction of phosphate solubilizing microbes with chicken manure against P-available in Andisol

The interaction between phosphate solubilizing microbes and chicken manure can increase the P content of plants in line with the value of P-available in the soil. The best treatment in increasing P content of plant in the treatment of *T. pinophilus* fungi with 160 gr/plant chicken manure dose was 99% of the control. There is an increase in P content of plants along with increasing doses of chicken manure in various phosphate solubilizing microbes (Figure 2). This is because plants are able to absorb P nutrients with increasing P-available and in accordance with the research of Marbun *et al.* [17] application of phosphate solubilizing fungi and chicken manure in Andisol affected by the eruption of Mount Sinabung increases the real P uptake from 5.15 g to 15.99 g.

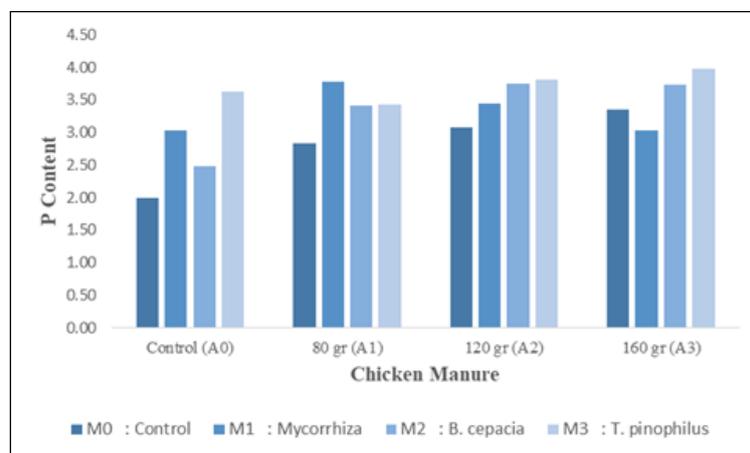


Figure 2. The interaction of phosphate solubilizing microbes with chicken manure on the P content of plant in green beans

4. Conclusions

The administration of phosphate solubilizing microbes can increase P-available (1.11-8.45%), total leaf area (12.83-29.51%), dry weight of plants (5.39-21.21%), P content of plants (18.08-31.91%) and the best treatment was in *T. pinophilus* fungi. The administration of chicken manure can increase P-available (23.05-35.19%), total leaf area (0.18-25.16%), plant dry weight (11.64-16.43%), plant P content (20.78-26.52%) and the best treatment was at dose 160 gr/ plant. The interaction of phosphate solubilizing microbes and chicken manure can increase P-available (10.78-50.82%), total leaf area (8.63-65.18%), plant dry weight (2.46-58.25%), plant P content (24-99%) and the best treatment was the interaction of *T. pinophilus* fungi with 160 g/ plant dosage of chicken manure.

References

- [1] Tan K H 2009 *Environment Soil Science Third Edition* (London: CRC Press)
- [2] Mukhlis, Nasution Z and Mulyanto B 2014 Effect of land use on the physical-chemical properties of andisols in Mt. Sinabung, North Sumatera, Indonesia *Malaysian Journal of Soil Science* **18** pp 51-60
- [3] Hanafiah A S, Sabrina T and Guchi H 2009 *Biologi dan ekologi tanah [Soil biology and ecology]* (Medan: Universitas Sumatera Utara)
- [4] Barchia M F 2009 *Agroekosistem tanah mineral masam (Acidic mineral soil agroecosystem)* (Yogyakarta: Gadjah Mada University Press)
- [5] Elfiati D 2005 *Peranan mikroba pelarut fosfat terhadap pertumbuhan tanaman [The function of microbial phosphate solvents against plant growth]* (Medan: Universitas Sumatera Utara)
- [6] Sembiring M and Fauzi 2017 Bacterial and fungi phosphate solubilization effect to increase nutrient uptake and potatoes (*Solanum tuberosum* L.) production on andisol Sinabung Area. *J. Agron.* **16** pp 131-37
- [7] Sembiring M, Elfiati D, Sutarta E S and Sabrina T 2017 Phosphate solubilization agents in production on andisol Sinabung Area *Asian Journal of Plant Sciences* **16** pp 141-48
- [8] Tamad, Ma'as A, Radjagukguk B, Hanudin E and Widada J 2013 Ketersediaan fosfor pada tanah andisol untuk jagung (*Zea mays* L.) oleh inokulum bakteri pelarut Fosfat [Phosphorus availability on andisols for maize (*Zea mays* L.) by phosphate solubilizing bacteria inoculant] *J. Agron.* **41** pp 112-14
- [9] Sembiring M, Elfiati D, Sutarta E S and Sabrina T 2015 Effect of *Talaromyces pinophilus* and SP36 on phosphate-available and potato (*Solanum tuberosum* L.) production on andisol impacted by Mount Sinabung eruption, North Sumatera, Indonesia *IJSBAR* **24** pp 382-88
- [10] Sembiring M, Elfiati D, Sutarta E S and Sabrina T 2016 Effect *Burkholderia cepacia* and SP36 on phosphate-available and potato (*Solanum tuberosum* L.) production on andisol impacted by Mount Sinabung eruption, North Sumatera, Indonesia *IJSBAR* **18** pp 223-35
- [11] Sembiring M, Alifa S and Bintang 2017b Phosphate fertilization efficiency through the use of microbial phosphate solubilization to boost growth of mustard (*Bassica juncea* L) in andisol affect by Sinabung eruption *Journal of Applied Horticulture* **19** pp196-99
- [12] Sembiring M, Jefri, Sakiah and Wahyuni M 2018 The inoculation of Mycorrhiza and *Talaromyces pinophilus* toward the improvement in growth and phosphorus uptake of soil palm seedlings (*Elaeis guineensis* Jacq) on saline soil media *Bulg J Agric Sci* **24** pp 617-22
- [13] Sitanggang V, Sembiring M and Fauzi 2017 Aplikasi mikroba pelarut fosfat dan beberapa sumber pupuk P untuk meningkatkan serapan P dan pertumbuhan tanaman jagung pada andisol terdampak erupsi Gunung Sinabung [Application of phosphate solubilizing microbes and sources of P fertilizer to increase P-Uptake and corn growth in andisols erupted Sinabung Mountain] *J. Agroekoteknologi FP USU* **5** pp 768-73
- [14] Damanik M M B, Hasibuan B E, Sarifuddin, Fauzi and Hanum H 2010 *Kesuburan Tanah Dan Pemupukan [Soil Fertility and Fertilization]* (Medan: USU Press)
- [15] Pangaribuan D H 2010 Analisis Pertumbuhan Tomat pada Berbagai Jenis Pupuk Kandang [Tomato Growth in Different Types of Manure] *Seminar Nasional Sains dan Teknologi III*

- [16] Ritonga M, Sitorus B and Sembiring M 2015 Perubahan bentuk P oleh mikroba pelarut fosfat dan bahan organik terhadap P-tersedia dan produksi kentang (*Solanum tuberosum* L.) pada tanah andisol terdampak erupsi Gunung Sinabung [Changes form of P by Phosphate solubilizing microbe and organic matter to availability P and production of potato (*Solanum tuberosum* L.) at andisol soil impacted Sinabung Mountain eruption] *J. Agroekoteknologi FP USU* **4** pp 1641-50
- [17] Marbun S, Sembiring M and Sitorus B 2015 Aplikasi mikroba pelarut fosfat dan bahan organik untuk meningkatkan serapan P dan pertumbuhan kentang pada andisol terdampak erupsi Gunung Sinabung [Phosphate solubilizing microbe and organic matter application to increase P uptake and potato growth at andisol impacted Sinabung Mountain eruption] *J. Agroekoteknologi FP USU* **4** pp 1651-58