

# Increased phosphate fertilization efficiency through microbial phosphate solubilization to boost growth of mustard (*Brassica juncea* L.) in Andisol affected by Sinabung eruption

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## Abstract

Andisol is a land formed by volcanic ash and has a problem in the availability of phosphate (P), as a result the use of P fertilizer becomes ineffective. Andisol affected by the eruption of Mount. Sinabung has pH 4.83 which can affect the availability of P in the soil. The purpose of this research was to determine the effect of Microbial phosphate solubilizer application and SP36 (fertilizer) dose to the efficiency of P fertilizing and growth of mustard (*Brassica juncea* L.) in Andisol land affected by the eruption of Mount. Sinabung. This research used factorial randomized block design with 2 factors and 3 replications. The first factor was Microbial phosphate solubilizer: without application (M0), 30 mL *Burkholderia cepacia* (M1), 30 mL *Talaromyces pinophilus* (M2). The second factor was SP 36 with five levels *i.e.* P0 = 0%, P1 = 25% = 50% P3, P4 = 75%, and P5 = 100% of the recommended dose (0g, 0.325g, 0.65g, 0.975g and 1.3 g). The measured parameters were soil pH, P-total, P-available, P uptake, plant height, shoot dry weight. The research results showed that *Talaromyces pinophilus* with SP36 25% of the recommended dose improved the efficiency of P fertilizing and the growth of mustard in Andisol affected by the eruption of Mount. Sinabung.

**Key words:** Andisol, growth of mustard, microbial phosphate solubilizer and SP36 fertilizer

## Introduction

Andisol is formed by volcanic ash material which is dominated by amorphous mineral and it can be developed into a fertile land for successful cultivation of agricultural crops. The soil contains minerals with high P retention (> 85%). This results in the low availability of P in the soil and availability is reduced by the presence of P entrapment on the surface of colloidal making it unavailable to plants (Tisdal *et al.*, 1995; Shoji and Takahashi, 2002)

Research results of studies conducted by Sembiring *et al.* (2015; 2016a) and Balitbangtan (2014) indicated that Andisol in Namantera, Karo District are affected by the eruption of Mount. Sinabung and contains very high total P content (3462.27 ppm) and only 3% of P-total is in available form. It showed the retention of P in Andisol. Due to these reasons, the P fertilizing on Andisol become less efficient.

Phosphorus (P) is a macro nutrient needed by the plant for proper growth and development. P contained in plants play a role in the process of photosynthesis and respiration, stimulates root development and increases fruit growth and several physiological process (Yuliprianto, 2010; Sanchez, 1992; Havlin *et al.*, 1999)

Mustard (*Brassica juncea* L.) is one of many vegetable crops cultivated in the Karo highlands. The crop requires N application for vegetative growth and development. Nevertheless, mustard also requires P and other nutrients, although in smaller amounts, for several metabolic processes. Therefore, as a part of fertilization to mustard plants, P fertilizer are still being used by the farmers to meet the nutrient requirements of mustard.

One of the alternatives that can be used to reduce the P fertilizer requirement is by increasing P-availability in Andisol through use of microbial phosphate solubilizer (MPS). These microorganisms are capable of dissolving the phosphate in the soil by excretion of organic acids that increases soil P availability. The results

of Sembiring *et al.* (2015; 2016a; 2016b) indicate that the use of MPS can improve the P-availability by 30-35.42 % and the production of potato tubers up to 50.66% in Andisol affected by the eruption of Mount Sinabung.

Based on the above facts, experiments were conducted to study the role of MPS and SP36 in improving efficiency of P fertilization required for growth of mustard on Andisol affected by Mount Sinabung eruption.

## Materials and methods

This research was conducted at the Faculty of Agriculture, University of Sumatra Utara, Medan in 2016. Materials used in this research were Andisol of Kutarayay Village, Naman Teran with soil characteristic; pH H2O 4.21, C-Organic 4.7%, N 0.61%, total P 0.14%, P available 66.26 ppm and CEC 26.77 (me/100g). Mustard seeds as an indicator plant, inoculums of *Burkholderia cepacia* and *Talaromyces pinophilus*, isolated from Andisol affected by the eruption of Sinabung.

The experiment was laid out in factorial randomized block design with three replications. The first factor was MPS with 3 levels of treatment, *i.e.*, M0: without application (Control), M1: 30 mL of *Burkholderia cepacia* and M2: 30 mL of *Talaromyces pinophilus* (inoculum/plant). The second factor was SP-36 (P) fertilizer *i.e.* P0: recommended dose 0%, P1: recommended dose 25% (0.325g SP36/5 kg of soil), P2: recommended dose 50% (0.65g SP36/5 kg of soil), P3: recommended dose 75% (0.975g SP36/5 kg of soil), P4: recommended dose 100% (1.3g SP36/5 kg of soil) and Urea fertilizer application 2g, KCl 1g/5 kg of soil.

The application of MPS with population  $11 \times 10^8$  cfu/mL was performed 1 week after the plants started growing. Soil and plant samples were taken when the plant were 30 days old. Soil

parameters include soil pH by Electrometric method, P-total (%) by extract method with 25% HCl, P-available (ppm) by Bray II method. Plant parameters included plant P Uptake (mg/plant) with wet digestion method, plant height (cm) and shoot dry weights (g).

**Statistical analysis:** Significance of treatments was tested by ANOVA and treatment means were compared with LSD ( $P=0.05$ )

## Results and discussion

Statistical analysis of the data on soil and plant parameters as a response of MPS and multiple doses of SP36 fertilizer application on Andisol affected by the eruption of Mount Sinabung indicated significant effect of treatments on various parameters studied.

Applications of *B. cepacia* with 100 % recommended dose (M1P4) recorded increase in pH value by 12% as compared to control (Fig. 1, Table 1). Musarrat and Khan (2014) reported that MPS produced organic acids in the process of dissolving bound phosphate in the colloid surface and organic acid which reduces the soil pH. However, after the completion of the dissolution process, phosphoric acid is not produced organically and soil pH rises up along with increased availability of P. In addition, the application of SP36 fertilizer recommended dose could help increasing the pH of the soil through mineralization of  $P_2O_5$  giving rise to  $HPO_3^{2-}$  and  $H_2PO_4^-$ . The total P content of Andisol affected by Mount Sinabung eruption is already quite high ( $> 0.100\%$ ). This is the impact of volcanic material eruption of the volcano's crater which contained compounds useful for agricultural. According to Tampubolon *et al.* (2014), the volcanic ash from the eruption of Sinabung is able to contribute few nutrients for the plant growth, one of which is P in high quantity.

Available P is the form of available phosphate in the soil and can be absorbed by plants. Based on the results of analysis, the available P in Andisol with MPS application and multiple doses of SP36 fertilizer gave no significant effect. Plants usually absorb P in the form of inorganic ( $HPO_4^{2-}$ ,  $H_2PO_4^-$ , and  $PO_4^{3-}$ ). From the data obtained P uptake from the plant with *T. pinophilus*

application gave the best results with 37.65 mg/plant. This value is 14 % higher than control and 80 % higher when compared with *B. cepacia* application. This suggests that *T. pinophilus* has good ability in increasing the availability of P. Sembiring *et al.* (2015) reported that *T. pinophilus* application can increase plant nutrient uptake by 5.28%.

Based on the results, the plant's height by MPS applications showed different results and the best results were in the treatment *T. pinophilus* application (M2) (22.41 cm). Musarrat and Khan (2014) observed that the dissolution of P by phosphate solubilising fungi is larger than phosphate solubilising bacteria due to the capability of fungal hyphae to bind the P mineral particles in the soil despite the longer distance. The total amount of P absorbed by the plants is directly proportional to the dry weight of the plant canopy. Application of *T. pinophilus* (M2) increased 9.92 % shoot dry weight as compared with control and 54.78 % higher than the application of *B. cepacia* (Fig. 4). Sembiring *et al.* (2015) and Ritonga *et al.* (2015) stated that the application of *T. pinophilus* in Andisol affected by the Mount. Sinabung eruption can increase P uptake and shoot dry weight of the potato crop.

The applications of SP36 fertilizer with 100 % recommended dose gave the best results *i.e.* 66.65 mg/plant and significantly different from the control *i.e.*, 4.98 mg/plant. This showed that the higher SP36 dosage given, the higher P uptake value, but this increasing value is not always directly proportional to the increasing P dosage. Sembiring *et al.* (2015; 2016b) reported that SP36 fertilizer application can increase P uptake and growth of potato plants by 86.6 5 %. Fig. 2 depicts pattern of P uptake in MPS application with multiple doses of SP36.

Higher P uptake of plants improves growth and plant height also as phosphorus has an important influence on the metabolic processes in plants. Phosphorus compounds in the plant tissues play role in the process of cell division, stimulating early growth on root, ripening crops, transporting energy in cells, forming fruit and producing seed (Yuliprianto, 2010). Fig. 3 depicts the

Table 1. The mean of soil pH, P-total, P-available, P uptake of plants, plant height and shoot dry weight of plants

Treatment	Soil pH	Total P (%)	Available P (ppm)	P uptake (mg/plant)	Plant height (cm)	Shoot dry weight (g)
MPS (M)						
Control (M0)	4.04	0.144	54.25	32.76	19.67a	2.45a
<i>B. cepacia</i> 30 mL (M1)	4.05	0.135	54.55	20.84	15a	1.23b
<i>T. pinophilus</i> 30 mL (M2)	4.14	0.141	51.28	37.65	22.41b	2.72a
SP36 fertilizer (P)						
0g (P0)	3.98	0.138	50.50	4.98b	10.84c	0.46b
0.325g (P1)	4.02	0.144	58.85	20.88b	16.05bc	1.93ab
0.65g (P2)	4.12	0.139	50.58	35.81ab	21.7ab	3.47a
0.975g (P3)	4.07	0.142	56.02	23.76ab	20.01ab	1.43b
1.3g (P4)	4.18	0.137	50.85	66.65a	26.53a	3.38a
M	NS	NS	NS	NS	*	*
P	NS	NS	NS	*	*	*
M x P	*	NS	NS	*	*	*

Figs in columns followed by different letters indicate a significant effect at  $P=0.05$ .

NS not significant. \*F test significant at  $P=0.05$

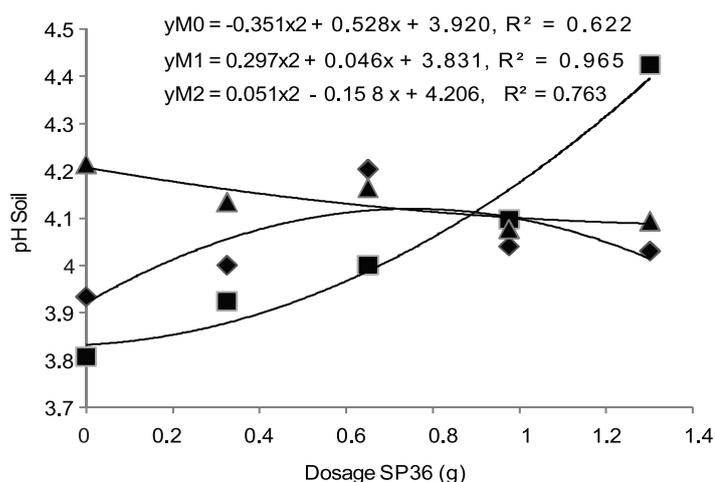


Fig. 1. The relationship between microbial phosphate solubilization and SP36 Fertilizer on pH Soil. M0(♦)= Without application (Control), M1(■)= *B.cepacia*, M2(▲)=*T.pinophilus*.

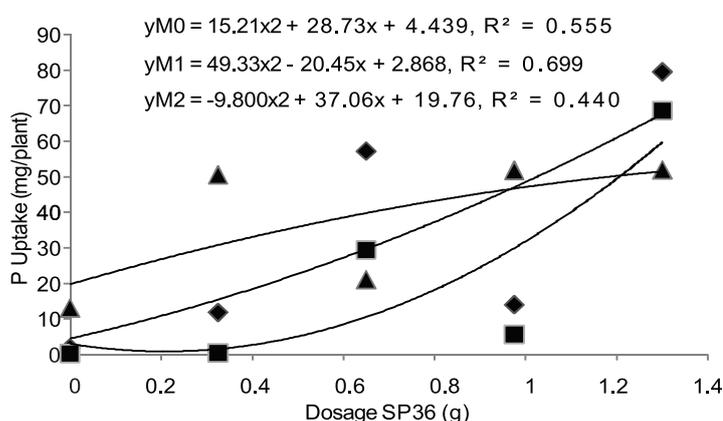


Fig.2. The relationship between microbial phosphate solubilization and SP36 Fertilizer on P Uptake (mg/Plant). M0(♦)= Without application (Control), M1(■)= *B.cepacia*, M2(▲)=*T.pinophilus*.

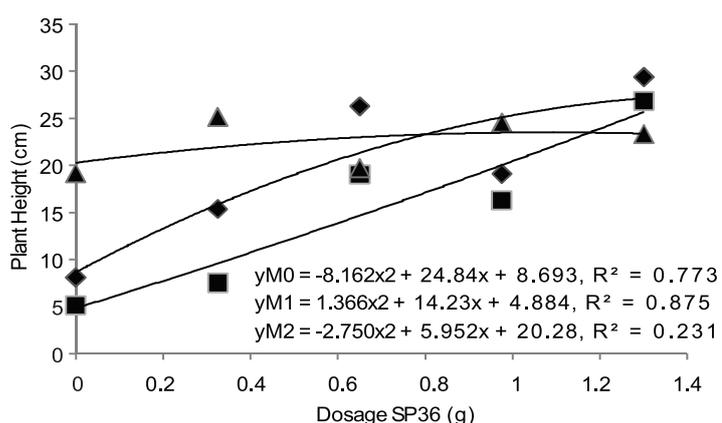


Fig.3. The relationship between microbial phosphate solubilization and SP36 Fertilizer on Plant Height (cm) M0(♦)=Without application (Control), M1(■)= *B.cepacia*, M2(▲)=*T.pinophilus*.

effect pattern of plant height in application of MPS with different doses of SP36.

The applications of SP36 fertilizer with 100 % recommended dose (MOP4) resulted highest uptake (79.45 mg/plant). Higher P uptake efficiency in this treatment enhanced P uptake by 16.62

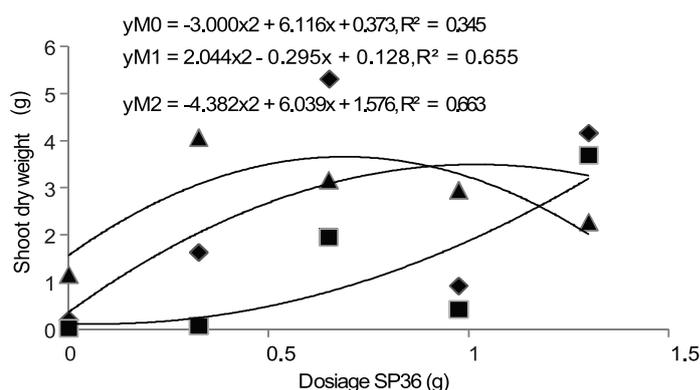


Fig.4. The relationship between microbial phosphate solubilization and SP36 Fertilizer on Shoot dry weight (g) M0(♦)= Without application (Control), M1(■)= *B. cepacia*, M2(▲)=*T. pinophilus*.

%, while the treatment of *T. pinophilus* application with 25% recommended dose (M2P1) improved P uptake up to 41.74 %. This suggests that high-dose of SP36 can increase P uptake but its use is not more efficient than the fertilizer at 25% of the recommended dose along with *T. pinophilus* application. Thus the used of inorganic P fertilizer can be reduced by 75% of the recommended dose.

Interaction between *T. pinophilus* with SP36 at 25% recommended dose can improve the efficiency of phosphate fertilizer in Andisol affected by the eruption of Mount. Sinabung. The provision of *T. pinophilus* with P fertilizer 25% recommended dose is the best treatment to improve the efficiency of phosphate fertilizer on Andisol affected by the eruption of Mount Sinabung.

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