

Effect of *Burkholderia cepacia* and SP36 on available phosphate and potato production on Andisol impacted by Mount Sinabung Eruption, North Sumatera, Indonesia

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Abstract

Since 2013, Mount Sinabung has erupted and changed soil properties including microorganisms in the soil and affected the production of potatoes in Karo highland in Indonesia. *In vitro* screening of bacteria from surrounding horticulture land, their ability to dissolve phosphate showed that *Burkholderia cepacia* was the best bacteria. The aim of this study was to examine the capability of *B. cepacia* and P fertilizer on Andisol in improving soil P- available and production of potato (*Solanum tuberosum* L). The research design used was factorial randomized block with two factors. Factor I was the volume of *B. cepacia* inoculum, consist of 4 treatments; without *B. cepacia*, 10, 20 and 30 mL *B. cepacia* inoculum. Factor II was the dosage of SP36, consist of 3 treatments: 50, 75 and 100% from recommended dosage (9.75 g, 6.5 g and 13 g SP36/plant, respectively). The control was potato plant without applying *B. cepacia* but adding 7.8 g Urea, 10 g KCl and 13 g SP36 (100% suggested P fertilizer) which was applied twice with the same dosage. The results showed that application of *B. cepacia* application and P fertilizer dosage increased shoot dry weight 50.07-113.73%, soil P available 5.04-35.42%, P-uptake 34.47-163.28% and tuber yield 12.57-50.66% compared with control. The best treatment in increasing potato tuber yield was 20 mL *B. cepacia*/plant and 9.75 g SP36/plant.

Key words: Andisol, *Burkholderia cepacia*, potato, SP36, phosphate

Introduction

Phosphorus (P) is one of the main elements needed by plants and plays an important role in the metabolism (Goldstein, 1986; Sundara *et al.*, 2002; Wang *et al.*, 2009). The main source of P is rock, which is not renewable, making this resource limited. P is derived from the parent material which is mostly insoluble, except in certain circumstances. Andisol is one of the soil types that has problem with the availability of phosphate (Shoji *et al.*, 2002). The total P content in Andisol soil is relatively high, approximately 160-500 mg/100 g soil, but the amount of P that is available to plants is only about 1% of the total P present in the soil (Sanchez, 1992). Karo plateau is a horticulture center in North Sumatra, and the soil in this area is Andisol. It has volcanic ash and rich of minerals and contains Al and Fe in huge amount. The retention of P in Andisol soil in Kutarayat village, Karo plateau, or north of Mount Sinabung ranged from 95.04-99.44% (Mukhlis, 2014). According to Balitbangtan (2014) the volcanic ash materials of Mount Sinabung contained elements such as S (0.05-0.32%), Fe (0.58-3.1%), and Pb (1.5-5.3%) while, Cd, As, Ag and Ni were undetectable. The soil pH was 4.4-6.5 and the volcanic ash pH was 3.3-3.5.

Plants can only absorb P in the available forms. The P of soil becomes available through the secretion of organic acids produced by roots or microbes. Some soil bacteria such as phosphate solublizing bacteria have the ability to dissolve organic P into a soluble form of phosphate available to plants. Dilution effects are generally caused by the production of organic acids such as acetic acid, formic acid, lactic acid, oxalic acid, malic acid and citric acid that are produced by the microbes. The microbes also

produce amino acids, vitamins and growth promoting substance such as IAA and gibberellin acid that can improve plant growth (Richardson, 2001; Gyaneshwar *et al.*, 2002). *B. cepacia* is a bacterium that is capable of dissolving P into available forms that can be absorbed by plants (Babu-Khan *et al.*, 1995).

In Karo highland, potato (*Solanum tuberosum* L.) is one of the major horticultural crops and needs P in huge amount. For providing P nutrient for plants, phosphate solublizing bacteria were not taken into account. Therefore, the objective of this study was to measure the potential of the phosphate solublizing bacteria *B. cepacia* at various doses of SP36 fertilizer in improving the availability and production of potato crops in the Andisol soil impacted by the eruption of Mount Sinabung.

Materials and methods

The research was conducted in Kutarayat Village, Naman Teran District, Karo Regency (North of Mount Sinabung) with the following characteristics: pH H₂O 4.29, C 5.74%, N 0.56%, P total 2538.76 mg/kg, P available 81.49 mg/kg, 0.4%K, and CEC 46.29 me/kg. The materials used in this study were *B. cepacia* isolates, which were isolated from the rhizosphere of the potato plants affected by the eruption of Sinabung, and had been tested for their ability to dissolve phosphate.

This study used Factorial Randomized Block Design with two factors and 3 replications. Factor I was *B. cepacia* volume, consisting of treatments B1 = 10 mL, B2 = 20 mL and B3 = 30 mL of *B. cepacia* liquid inoculum/plant. Factor II was SP36 fertilizer dosage, consisting of treatments P1 = 50% of recommended dosage of P fertilizer (6.5 g/plant), P2 = 75% of recommended

dose of P fertilizer (9.75 g/plant), and P3 = 100% of recommended dosage of P fertilizer (13 g/plant). The control plant was without the application of *B. cepacia* but 7.8 g urea, 10 g KCl and 13 g SP36 (100% recommended P fertilizer) applied twice. Each treatment had 3 plots, and each plot had 5 plants.

Size of plot was 0.6 x 4.20 m, the distance between plots in the block was 30 cm, and the distance between blocks was 50 cm.

The base fertilizers applied were 7.8 g urea, 10 g KCl, P fertilizer application in accordance with the treatment dosage given one week after the plants growth. Plants were sprayed with insecticide with carbosulfan (3 mL/L a.i.) and fungicide Mankozeb (2 g/L a.i.) and weeding was done to prevent weed growth.

Inoculation of *B. cepacia* with population 20 x 10⁹ cfu /mL spreaded around potato roots 1 week after potato planted in the field. Soil and plant samples were taken 50 days after planting. For production parameter, samples were taken 3 months after planting (according to the criteria of the potato crop harvest). The parameters measured were: plant fresh weight measured at the end of the vegetative period, shoot dry weight measured at the end of the vegetative period, soil pH, available soil P by Bray II method, which was measured at the end of the vegetative period, plant P uptake, which was measured at the end of vegetative period and potato tuber yield.

Statistical Analysis: To determine the significant differences among the treatments, data was analyzed using Anova and means were compared with LSD ($P= 0.05$).

Results and discussion

The statistical analysis showed that application of *B. cepacia* affected P uptake and shoot dry weight significantly. Application of P fertilizer significantly affected P availability and shoot dry weight (Table 1)

Shoot dry weight of treatment 30 mL *B. cepacia* inoculum/plant was higher compared to other treatments. It was 80.95% higher compared to control. This indicated that application of *B. cepacia* increased potato growth. Solisbury and Ross (1995) suggested that P had a great

Table 1. The mean of pH, available P, shoot dry weight, plant P uptake and tuber yield

Treatment	Soil pH	Soil P availability (ppm)	Shoot dry weight (g)	Plant P uptake (mg/plant)	Potato tuber weight (g/plant)
Control	4.85	83.46	13.18	3.54	610
<i>B. cepacia</i> application					
10	4.73	92.29	15.54b	3.49b	617.04
20	4.29	83.44	23.01a	5.32a	770.05
30	4.43	95.54	23.85a	5.51a	631.07
F	NS	NS	*	*	NS
LSD	-	-	5.47	1.6	-
Fertilizer SP36					
6.5	4.27	89.46ab	18.63b	4.48	634.86
9.75	4.74	80.86b	24.60a	5.40	749.58
13	4.45	100.97a	19.17b	4.44	633.70
F	NS	*	*	NS	NS
LSD	-	15.55	5.47	-	-
CV%	5	17.2	26.28	25	33.6

Note: Figures in rows and columns followed by lower case letters indicate a significant effect on the level of $P=0.05$. * F value significant

effect on the development and growth of plants because P is an essential part of many kinds of phosphate sugar in nucleotides, such as DNA and RNA, as well as part of the phospholipids in the membrane.

Application of *B. cepacia* 30 mL, caused P availability (95.54 ppm) 14.47% higher than control (83.46 ppm). P uptake increased with application *B. cepacia*. The best treatment was 30 mL, 55.65% better than control. Kundu and Gaur (1980) found that seed inoculation of potato with *B. polymyxa* increased tuber yield and phosphate uptake of the crop. Tuber yield of treatment *B. cepacia* (20 mL) was higher compared to other treatments, increased tuber yield 26.24% higher when comparing to control. Gaur (1990) found that the *B. polymyxa* inoculation on potato seed tuber treatment increased potato yield by 52%. Phosphate solubilizing bacteria generates organic acids such as citric acid, malate, fumarate, glutamate, succinate, lactate, oxalate and beta - ketobutirat acid capable of dissolving P. Mechanisms of P dissolution are by releasing organic acids and chelate Al, Fe, Ca and Mg making P available for uptake by the plant (Subba Rao, 1999).

Application of 13 g SP36 increased available P, 20.98% higher than control. Highest shoot dry weight was with application of 9.75 g SP 36/plant when compared with other treatments and the weight was 86.65% higher than control. Potato tuber weight of treatment 9.75 g SP36 / plant was the highest production when compared to other treatments. The increase in crop tuber yield was 22.88% higher when compared with a control. Mukhlis (2014) found that application SP36 improved potato tuber weight up to 721 g/plant. Most P is closely related to starch, especially in cereal grains, and the starch in potato tubers was no exception (Marschner, 1986).

Interaction of *B. cepacia* treatment and P fertilizer dosage increased available P in treatment 10 mL *B. cepacia* and 13 g SP36 (35.42%) compared to control. Whereas, shoot dry weight was highest with 30 mL *B. cepacia* and 9.75 g SP36 (113.73%) as compared to control. The best potato tuber yield (919.03 g/plant) was with treatment 20 mL *B. cepacia* and 9.75 g SP36 mean while control' tuber yield only 610 g/plant. It was 50.66% higher than control. The experiment conducted by Malboobi *et al.* (2009) showed that the combinations of either *P. agglomerans* or *M. laevaniformans* strains with *P. putida* led to higher biomass and potato tuber growth in greenhouse and in field trials. They found that of all the three PSB, *P. agglomerans* significantly increased the growth and yield of potato plants by about 20-25%.

Interaction of *B. cepacia* and the dosage of SP36 fertilizer exhibited maximum shoot dry weight in treatment 30 mL *B. cepacia* and 9.75 g SP36 fertilizer. The shoot dry weight of potato decreased with increasng SP36 fertilizer dosage for all *B. cepacia* inoculum volume (Fig. 1). The plant P uptake in treatment, 30 mL *B. cepacia* and 9.75 g SP36 was the highest compared to other treatments and it decreased with increasing dosage of SP36 except for treatment, 10 mL *B. cepacia* (Fig. 2). Treatment 20 mL *B. cepacia* and 9.75 g SP36 produced the highest tuber yield (919.03 g/plant), and

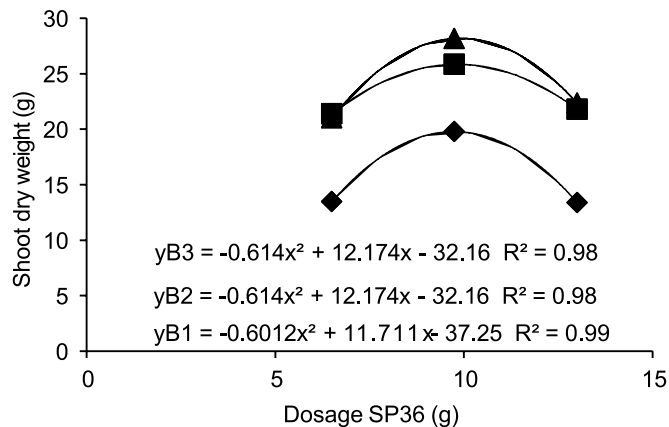


Fig. 1. The relationship between *B. cepacia* and SP36 Fertilizer on Shoot Dry Weight (g). B1(♦)=10 mL, B2(■)= 20 mL, B3(▲)= 30 mL

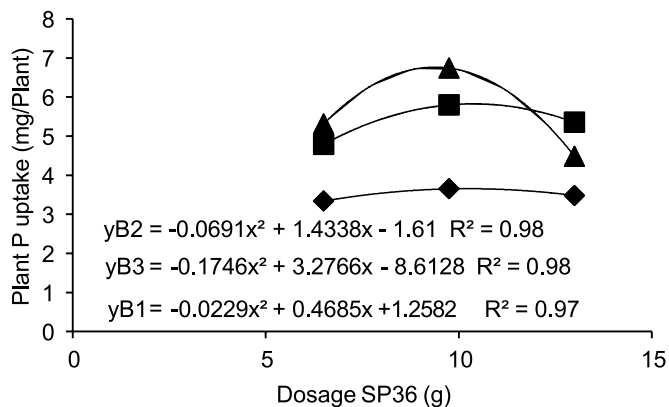


Fig. 2. The relationship between *B. cepacia* and SP36 Fertilizer on Plant P Uptake (mg/plant). B1(♦)=10 mL, B2(■)= 20 mL, B3(▲)= 30 mL

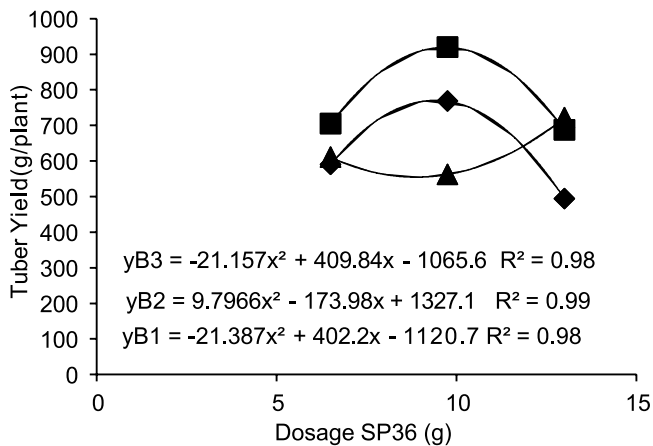


Fig. 3. The relationship between *B. cepacia* and SP36 fertilizer on potato tuber yield (g). B1(♦)=10 mL, B2(■)= 20 mL, B3(▲)= 30 mL

it decreased with increasing dosage SP36 except for treatment 30 mL *B. cepacia* (Fig. 3).

The study revealed that application of *B. cepacia* enhanced plant growth (17.9-80.95%), available P (10.58-14.47%), plant P uptake (50.28-55.65%), potato tuber yield (3.45-26.24%) compared to control. Application of P fertilizer increased plant growth (41.35-86.65%), available P (7.19-20.98%), plant P uptake (25.42-110%) and potato tuber yield (3.88-22.88%) compared the control. Applications of *B. cepacia* and SP36 increased shoot dry weight (50.07-113.73%), available P (5.04-35.42%), plant P uptake (34.4-163.28%) and potato tuber yield (12.57-50.66%) when compared with control. Best treatment was 20 mL *B. cepacia* / plant and 9.75 g SP36 / plant.

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