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Phosphate solubilizing microbes and coffee skin compost to increase Robusta coffee plant growth in Andisol of Mount Sinabung Area

Mariani Sembiring*, T. Sabrina and Mukhlis Mukhlis

University of Sumatera Utara, Faculty of Agriculture, Padang Bulan, Medan 20155, Indonesia
**Corresponding author:* mariani.sembiring29@yahoo.com, marianisembiring@usu.ac.id

Abstract

Sembiring, M., Sabrina, T. & Mukhlis, M. (2020). Phosphate solubilizing microbes and coffee skin compost to increase Robusta coffee plant growth in Andisol of Mount Sinabung Area. *Bulg. J. Agric. Sci., 26 (4)*, 766–771

Coffee plants need high phosphorus nutrients for growth and fertilization. Andisol has a very low P availability which ranges from 1.17 to 2.54 ppm. The efforts that can be made to increase the availability of P are by the use of phosphate solubilizing microbes and coffee skin compost. The purpose of this research was to obtain the right type of phosphate solubilizing microbes and coffee skin organic matter in increasing the availability and growth of coffee plants on Andisol affected by the eruption of Mount Sinabung. This research used Factorial Randomized Block Design (RBD) consisting of 3 replications. Factor I: (Phosphate Solubilizing Microbes) M0 = without application, M1 = 6 g *Burkholderia cepacia*, M2 = 6 g *Talaromyces pinophilus*, M3 = 3 g *Burkholderia cepacia + 3 g Talaromyces pinophilus*. Factor II: Coffee Skin Compost, K0 = Without Coffee Skin Compost, K1 = 75 g, K2 = 150 g, K3 = 225 g and K4 = 300 g. Parameters observed were plant height, plant P content using spectrophotometry, plant N content using Kjeldahl titration method, plant K content using flame photometry and plant dry weight (g). The results obtained from the interaction of phosphate solubilizing microbes and coffee skin compost can increase plant height up to 35%, plant dry weight up to 32.17%. The best treatment for increasing plant growth is *T. pinophilus* combined with 150 g/plant coffee skin compost (M2K2).

Keywords: Andisol; coffee skin compost; coffee plants; P Available; phosphate solubilizing microbes

Introduction

Coffee is one of the annual crops that has high economic value and plays an important role as a source of foreign exchange. Coffee plants need high amounts of P nutrients. The optimal provision of nutrients at the nursery stage is needed for root growth and plant development (Richardson, 2001; Hayat et al., 2010; Ahemad et al., 2009; Vikram & Hamzehzarghani, 2008), while the capacity of soil to provide nutrients for plants is limited, especially Andisol soil. P fertilizer is sourced from non-renewable minerals whose availability is limited and can become depleted so that the price of P fertilizer increases (Isherwood, 2000). P nutrient deficiency can inhibit plant growth and production because P affects the root growth and absorption of nutrient elements (Raghothama, 1999; Borling et al., 2001; Hao et al., 2002).

Andisol soil which is affected by the eruption of Mount Sinabung has a low pH. The research results of Sembiring et al. (2017a); Sinaga et al. (2015); Fatmala et al. (2015) stated that the pH of Andisol soil affected by the eruption of Mount Sinabung ranges from 3.7 to 4.7 which falls into the very acidic category. The low pH of the soil affected by the eruption of Mount Sinabung resulted in the low availability of P in the soil, this is related to the ability of microbes that are able to live in it will also be low. Microorganisms are an important component in P mobilization in the soil (Richardson, 2007; Oberson & Joner, 2005). Several species of fungi

and bacteria are able to increase P availability (Leggett et al., 2001; Velazquez & Trujillo, 2007).

Increasing the availability of P in the soil can be done with the application of phosphate solubilizing microbes and organic materials that are able to produce organic acids. According to Sembiring et al. (2017b; 2017c) the application of *Talaromyces pinophilus* can increase the availability of P by 9.63 – 49.78% in Andisol soil. Marbun et al. (2015) application of phosphate solubilizing bacteria/fungi and organic matter can increase P uptake and plant growth in Andisol soil affected by the eruption of Mount Sinabung. Gupta et al. (2012) stated that *Burkholderia* can increase nutrient absorption by plants. The research results of Sembiring et al. (2017a); Masdariah et al (2019) stated that *Burkholderia cepacia* application can increase plant dry weight and p available in Andisol soil affected by Mount Sinabung eruption.

The results of this research are expected to identify the best microbes and doses of coffee skin compost to increase the availability of P which can stimulate the growth of Robusta coffee plants grown in Andisol soil in the area of Mount Sinabung.

Materials and Methods

The research was carried out in Kuta Rayat Village, Karo District from March to September, 2017.

The ingredients used were Robusta coffee plants aged 1 month, *Burkholderia cepacia* (8.2×10^9/g) and *Talaromyces pinophilus* (8.1×10^9 /g). The research used Factorial Randomized Block Design with 3 replications consisting of: Factor I: Phosphate Solubilizing Microbes M0 = without application, M1 = 6 g *B.cepacia*, M2 = 6 g *T. pinophilus*, M3 = 3 g *B. cepacia* + 3 g *T. pinophilus*. Factor II: Organic Matter from Coffee Skin Compost, namely K0 = without coffee skin, K1 = 75g, K2 = 150 g, K3 = 225 g, K4 = 300 g. This research used a polybag filled with 5 kg of Andisol soil. Application of coffee skin compost in accordance with the treatment and basic fertilizers in the form of Urea (3 g), SP36 (5 g) and KCl (5 g) was carried out a week before planting. The application of phosphate solubilizing microbes was carried out 2 weeks after planting which was applied around the plant roots. Soil and plant analysis were done after the plants were 5 months old after planting.

The Parameters observed were plant height, plant P content using spectrophotometry, plant N content using Kjeldahl titration method, plant K content using flame photometry and plant dry weight (g).

***Statistical analysis**:* to see the effect of treatment in general, the F test was conducted on F 5% using ANOVA and followed by the Least Significant Difference (LSD) Test P = 0.05 (Gomez & Gomez., 1984).

Results and Discussion

Based on the results of observations and statistical analysis, it showed that the application of phosphate solubilizing microbes and coffee skin also their combinations toward plant height parameters can be seen in Table 1 and Table 2.

Table 1. Plant height (cm) for 5 months of research

Treatment	Plant height				
	I	II	III	IV	V
Phosphate Solubilizing Microbes (g)					
Control/without application(M0)	16.39	17.49	20.31ab	23.79	28.39a
B. cepacia (M1)	16.31	17.33	18.69a	23.33	28.26a
T. pinophilus (M2)	16.39	17.49	19.30a	24.09	29.20a
B. cepacia + *T. pinophilus* (M3)	16.72	17.71	19.52a	24.53	30.21ab
Coffee Skin Compost (g)					
Control/without application(K0)	16.14a	17.03a	18.70a	22.49a	27.48a
75 g (K1)	15.73a	16.52a	18.44a	23.47a	28.63a
150 g (K2)	16.33a	17.59a	19.12ab	24.28a	29.46ab
225 g (K3)	16.79ab	17.67ad	19.83abc	24.55ab	29.60abc
300 g (K4)	17.28bc	18.72bc	21.20cd	24.89bc	29.91bcd
M	NS	NS	*	NS	*
K	*	**	**	*	**
M x K	*	**	**	*	*
CV, %	5.22	5.39	7.53	8	6.07

*.**significant at p≤0.05, 0.01 and NS Not significance. Means in columns followed by a common letter are not significantly different at the level 0.05 level by LSD

Table 2. Plant dry weight (g) and nutrient content of N, P, K from the coffee plants

Treatment	Plant Dry Weight (g)	Plant Nutrient Content		
		N, %	P,%	K,%
Phosphate Solubilizing Microbes (g)				
Control/without application (M0)	11.92a	2.29a	0.19	2.78a
B. cepacia (M1)	11.87a	2.49ab	0.18	3.06a
T. pinophilus (M2)	12.40a	2.39a	0.20	3.26bc
B. cepacia + *T. pinophilus* (M3)	12.79ab	2.49ab	0.20	3.18ab
Coffee Skin Compost (g)				
Control/without application (K0)	11.72A	2.38a	0.17a	2.84a
75 g (K1)	11.79A	2.34a	0.20a	2.97a
150 g (K2)	12.93BC	2.56ab	0.19b	3.11ab
225 g (K3)	11.95A	2.38a	0.21abc	3.33bc
300 g (K4)	12.84AB	2.40a	0.18a	3.11ab
M	*	*	NS	**
K	**	NS	*	**
M x K	*	*	*	**
CV, %	8.15	8.9	16.16	5.9

*.**significant at p≤0.05, 0.01 and NS Not significance. Means in columns followed by a common letter are not significantly different at the level 0.05 level by LSD

The application of phosphate solubilizing microbes significantly (P = 0.05) can increase the height of coffee plants. Observation of plant height in the 5th month of M3 treatment can increase plant height by 6.4% higher than without application (M0). The research results of Sembiring et al. (2018) stated that the application of phosphate solubilizing microbes can increase plant height and stem diameter of oil palm plants. Plant dry weight increased with the M3 application by 7.35% heavier when compared with no application. The results of research by Sitanggang et al. (2017); Sembiring et al. (2017c); Siswana et al. (2019); Silitonga et al. (2019) stated that the application of *T.pinophilus* can increase plant dry weight by 12.9%. P nutrient content have increased by 5.26%. The results of research by Li et al. (2013) stated that the *Burkholderia* application can increase the P available in soil, plant height and crop weight. Phosphate solubilizing microbes application can increase P solubility and plant growth (Gupta et al., 2012; Li et al., 2013; Zaidi et al., 2009; Khan et al., 2010; Das et al., 2013; Song et al., 2008). K nutrient content of plants with M2 (*T. pinophilus*) treatment increased by 17% when compared to without application (M0). The research results of Sembiring et al. (2018) stated that the application of phosphate solubilizing microbes can increase K content of plants. Saxena et al. (2013) stated that *Burkholderia cepacia* can increase crop production by 50–90% when compared to those without applications. Plant growth was increasing with the application of phosphate solubilizing microbes because phosphate solubilizing microbes produced phosphatase enzymes and organic acids also produced growth stimulating hormones so that absorption of nutrients and plant growth will increase. According to Viruel et al. (2011) and Souche et al. (2007) microbes can produce giberelin growth hormone and IAA which can increase plant growth.

The application of coffee skin organic matter can significantly increase plant height. Treatment of K4 (300 g) can increase plant height by 9.8% higher than control in the 1st month of observation. In the 5th month of observation, the K4 application is 8.8% higher than that without the application (K0). Observation of plant dry weight (g) with treatment K2 (coffee skin) application can increase plant dry weight by 10.32% higher than control. Plant nutrient content increased with the application of coffee skin compost. K2 treatment can increase plant nutrient content by 7.6%, P nutrient content increased by 23.53% and K nutrient content increased by 17.25% higher than without application (K0). The research results of Sembiring et al. (2017), Marbun et al. (2015) and Ritonga et al. (2015) stated that the application of organic ingredients can increase P available and plant growth.

The combined application of phosphate solubilizing microbes and coffee skin organic matter can increase plant height in the first month of observation; the best treatment was M3K4 can increase plant height by 15% higher than control. In 5th month observation, M2K2 application can significantly increase plant height by 35.77% compared to control (Figure 1). Plant dry weight increased in the

application of phosphate solubilizing microbes combined with coffee skin. M2K2 application can increase plant dry weight by 32.17% higher than control (Figure 2). Application of M1K2 can increase plant N nutrient content by 28.6% (Figure 3). M3K3 application can increase plant P content by 53% and K nutrient content increases in M3K2 application by 26% compared to control plants (Figure 4). Increased growth and nutrient content of plants with the applications of phosphate solubilizing microbes and organic matter was due to organic matter as a food source for microbes, so application of organic matter will increase the number and activity of microbes in the soil. Rao (2007) stated that organic matter can increase the population of organisms in the soil. The research results of Winarso et al. (2011) stated that the application of organic matter which contained humic acid and phosphate solubilizing bacteria could increase the pH and availability of P in Ultisol soil so that plant growth would increase.

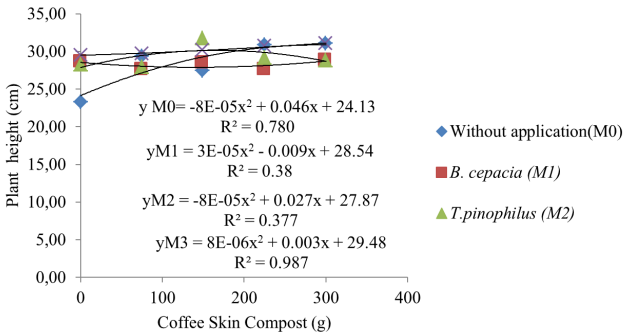

Fig. 1. Plant height (cm) in the application of Phosphate Solubilizing Microbes and Coffee Skin Compost (g)

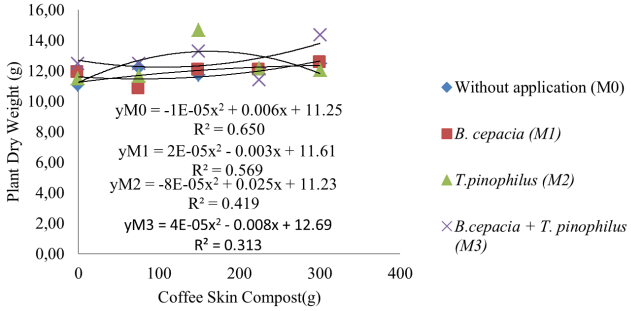

Fig. 2. Plant dry weight (g) in the application of Phosphate Solubilizing Microbes and Coffee Skin Compost (g)

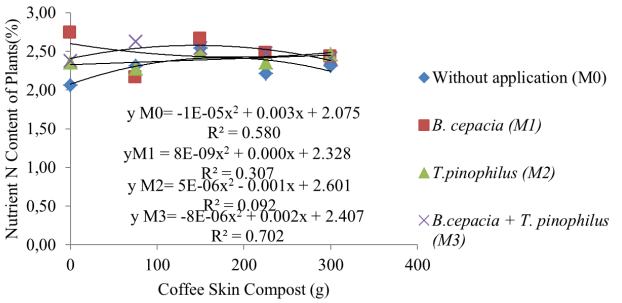

Fig. 3. Nutrient N Content of plants (%) in the application of Phosphate Solubilizing Microbes and Coffee Skin Compost (g)

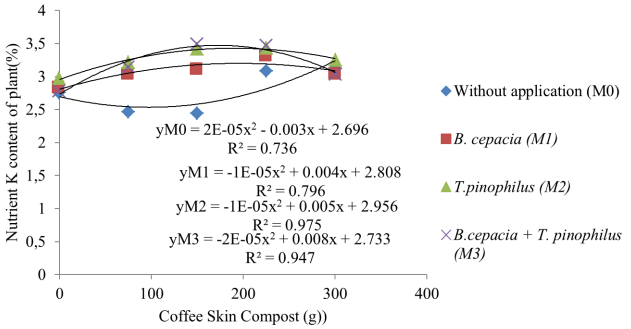

Fig. 4. Nutrient K content of plants (%) in the application of Phosphate Solubilizing Microbes and Coffee Skin Compost (g)

Conclusion

The application of phosphate solubilizing microbes can increase plant height growth up to 6.4%, plant dry weight to 7.35% and coffee plant nutrient content up to 17%. The application of coffee skin compost can increase plant height to 9.8%, plant dry weight to 10.32% and plant nutrient content increased to 17.25%. The interactions of phosphate solubilizing microbes and coffee skin compost can increase plant height up to 35%, plant dry weight to 32.17% and plant nutrient content increased to 53%. The best treatment for increasing plant growth was *T. pinophilus* combined with 150 g/plant coffee skin compost (M2K2).

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