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THE EFFECT OF PHOSPHATE SOLUBILIZING BACTERIA AND ORGANIC FERTILIZER ON PHOSPHATASE, AVAILABLE P, P UPTAKE, AND GROWTH SWEET CORN IN ANDISOLS

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ABSTRACT

An experiment has been conducted at green house of Agriculture Faculty, Universitas Padjadjaran, Jatinangor West Java, Indonesia elevated at ± 782 m above sea levels. The aim of this experiment was to find out the effect of phosphate solubilizing bacteria and organic fertilizer on phosphatase, P available, P uptake and growth up of sweet corn on Andisols from Lembang, West Java Indonesia. Randomized Block Design (RBD) was used in this experiment with twelve treatments and three replications. The treatments were three isolates (Bacillus mycoides, Bacillus macerans and`Pseudomonas pseudoalcaligenes)with combine organic fertilizer were cow manure fertilizer and green manure. The result shows that phosphate solubilizing bacteria and organic fertilizer increased soil phosphatase and P-available significantly. The treatments did not have a significant effect on the growth of sweet corn on Andisols. Isolate of P. pseudoalcaligenes combined with green manure gave the highest to soil available P.

Keywords: Andisols, phosphate solubilizing, phosphatase, sweet corn

1. INTRODUCTION

Andisol is the potential soil as a medium for plant growth because it has a high content of organic matter. However, Andisol has constraints such as acidity and low P availability. The low availability of P is due to the strong bonding of P elements to the soil colloids and the high P retention of> 80%. P retention is a problem, especially in acid soils with contains of alofan (Tan 2008). This high P retention resulted in inefficient use of P fertilizer. To overcome the problem of P on Andisol, continuous handling is required through the use of soil microbes that play a role in the transformation of P in the soil. The soil microbes is known as phosphate solubilizing bacteria (Whitelaw 2000).

The phosphate solubilizing bacteria increase soil P-available through the activity of its phosphatase enzyme which converts P-organic to P-inorganic so it becomes available to the plant through P mineralization and secretes of organic acids that convert the insoluble P into P dissolves in the soil. Fitriatin et al (2008) reported that the isolation of *Bacillus macerans* and leaf compost was able to decrease P-organic by 65,33 mg $kg^{-1}$to 18,33 mg kg^{-1}than control. The phosphate solubilizing microbes producing phytohormone increased soil P and yield of maize on Untisols (Fitriatin et al 2014).

The synthesized organic acids include lactic acid, formate, glycolic, citrate, acetate, malate, ketogluconate, and succinate. The αketogluconic acid is an acid having high relative solubility to the inorganic P-compound. This acid is capable of replacing the position of P-orthophosphate in the compound of Al-P and Fe-P so that phosphate is released into the soil solution and becomes a form available to the plant (Rao 1995).

The ability of phosphatase-producing phosphatase and organic fertilizers can increase the availability of phosphorus in the soil through the process of mineralization of organic P into P inorganic and P dissolution (Stevenson 1986). Phosphate solubilizing bacteria can also increase soil phosphatase activity, available P, P uptake and growth of sweet corn (*Zea mays* var. SaccharataSturt) on Andisols.

2. MATERIALS AND METHODS

The experiment used three isolates of P dissolution and the production of phosphate enzyme. The isolates were (Bacillus mycoides, Bacillus macerans and `Pseudomonas pseudoalcaligenes). The materials were used sweet corn, Andisol soil, cow manure and green manure in the form of leaf nuts (Lamtoro / Leucaena leucocephala, pig nuts / Vicia faba L., soybean / Glycine max) and Crotalaria trichotoma) Which was composted for three weeks, basic fertilizers ie Urea, TSP and KCl, various materials for enzyme phosphatase and P available (Bray I)

Greenhouse experiments were held at Greenhouse Faculty of Agriculture, Padjadjaran University in Jatinangor. The experimental design used in this experimental stage was the Randomized Block Design of the factorial pattern with three replications. The treatments consisted of a combination of isolate types (without isolates, isolates 1 (Bacillus mycoides), isolate 2 (Bacillus macerans) isolates 3 (*Pseudomonas pseudoalcaligenes)* as well as organic fertilizer treatment. The response variables analyzed in this experiment were: soil phosphatase and available P (Bray I).

3. RESULTS AND DISCUSSION

Soil Phosphatase

Table 1 shows that the inoculation of three isolates of phosphate solubilizing bacteria and the organic fertilizer in Andisols had a significant effect on soil phosphatase in both four and eight weeks after planting (WAP). Soil phosphatase at 4 MST increased almost 50% in combination treatment of *B. mycoides* and green manure compared with control. While at 8 WAP, the increase of phosphatase a reached 54% in combination treatment of *P. pseudoalcaligenes* with green manure compared with control. This shows that the application of PSB isolate and green manure can increase soil phosphatase. In general, the application of green manure can increase the soil phosphatase higher than cow manure, it is suspected because the nutrient content as well as C / N from green manure is higher so it can provide better substrate for microbial growth which can further increase its enzyme activity . According to Saparatka (2003) and George et al

(2002), phosphatases are influenced by: soil moisture, temperature, aeration and structure, pH, inorganic colloidal content and organic colloids.

Tabel 1.Soil phosphatase at four and eight weeks after planting (WAP) as affected by phosphate solubilizing bacteria and organic fertilizer

Treatments	Soil phosphatase (µ NP/g soil/h)	
	4 WAP	**8 WAP**
a = control	0.10 a	0.45 abc
b = cow manure	0.19 ab	0.23 a
c = green manure	0.38 ab	0.45 abc
d = *B. mycoides*	0.45 ab	0.71 bc
e = *B. mycoides* + cow manure	0.27 ab	0.41 abc
f = *B. mycoides* + green manure	**0.57 b**	0.52 abc
g = *B. macerans*	0.35 ab	0.73 bc
h = *B. macerans* + cow manure	0.24 ab	0.43 abc
i = *B. macerans* + green manure	0.35 ab	0.40 abc
j = *P. pseudoalcaligenes*	0.36 ab	**0.84 c**
k = *P. pseudoalcaligenes* + cow manure	0.29 ab	0.33 ab
l = *P. pseudoalcaligenes* + green manure	0.29 ab	0.33 ab

Note : Data in a column followed by different letters were significantly different ($P < 0.05$) based on Duncan test

P-available

The result of experiment showed that application phosphate solubilizing bacteria combined with organic fertilizer increased P available soil either at 4 MST or 8 MST (Table 2). Based on statistical analysis showed that *P. pseudoalcaligenes* combined with green manure gave the

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highest to soil available P compared with other treatments. This is presumably due to the apparent correlation between P dissolution with the quality of organic matter added to the soil. The result of nutrient content analysis of green manure was higher than cow manure.

Table 2.P-available at four and eight weeks after planting as affected by phosphate solubilizing bacteria and organic fertilizer

Treatments	P-available (ppm)	
	4 WAP	**8 WAP**
a = control	6.00 a	7.33 a
b = cow manure	8.00 a	11.00 ab
c = green manure	8.00 a	12.33 bc
d = *B. mycoides*	14.00 bc	16.00 cd
e = *B. mycoides* + cow manure	15.67 cd	16.67 cd
f = *B. mycoides* + green manure	15.67 cd	17.00 cd
g = *B. macerans*	19.67 d	17.33 cd
h = *B. macerans* + cow manure	14.67 bcd	18.67 d
i = *B. macerans* + green manure	10.00 ab	16.33 cd
j = *P. pseudoalcaligenes*	14.33 bcd	17.67 cd
k = *P. pseudoalcaligenes* + cow manure	16.67 cd	16.00 cd
l = *P. pseudoalcaligenes* + green manure	16.00 cd	**24.67 e**

Note : Data in a column followed by different letters were significantly different ($P < 0.05$) based on Duncan test

In general the available P content of soil is higher at eight weeks after planting than four weeks after planting. This was consistent with the results of the soil phosphatase analysis showing that phosphatase activity is higher at eight weeks after planting than four weeks after planting. Thus there is a correlation between the activity of phosphatase and the solubility of soil P. According to Saparatka (2003), the phosphatase ability of hydrolyzing phosphate ester can increase soluble P in the soil. With respect to the availability of P for crops, the inorganic P form which plays an important role in the availability of P is a secondary inorganic P form of unstable Al, Fe, and Ca phosphate compounds. The inorganic P will become available to the plant when there is a change in environmental conditions in the soil

Plant Growth

Phosphate solubilizing bacteria and organiz fertilizer did not increase growth of sweet corn significantly (Table 3). The growth of the plant visually looks the same and evenly, also does not show symptoms of nutrient deficiency. Similar plant growth is presumed that nutrient availability from organic fertilizers has been available for plant metabolism activities.

According to the results of the soil analysis, these Andisols are acid soils (pH H2O 5.2 and pH KCl 4.9). Both the problem of acidity and disruption of the availability, absorption and disturbance of plant nutrients that grow on acid soil is fixed to the existence of Al.

Soil acidity is due to the high concentration of H^+ ions, according to Tan (2008)the source of soil acidity usually comes from humus or organic matter, clay mineral, Al silicates, Fe and Al hydroxides, and others.

Table 3.Growth of sweet corn at eight weeks after planting as affected by phosphate solubilizing bacteria and organic fertilizer

Treatments	Plant height (cm)	Plant dry weight (g)
a = control	283,42 a	94.02 a
b = cow manure	264,70 a	52.19 a
c = green manure	298,03 a	66.52 a
d = *B. mycoides*	254,15 a	53.43 a
e = *B. mycoides* + cow manure	289,63 a	88.87 a
f = *B. mycoides* + green manure	321,23 a	91.81 a
g = *B. macerans*	310,98 a	73.12 a

h = *B. macerans* + cow manure	290,13 a	76.87 a
i = *B. macerans* + green manure	280,88 a	66.95 a
j = *P. pseudoalcaligenes*	265,35 a	45.28 a
k = *P. pseudoalcaligenes* + cow manure	302,98 a	92.52 a
l = *P. pseudoalcaligenes* + green manure	254,35 a	103.77 a

3. CONCLUSION

The result shows that phosphate solubilizing bacteria and organic fertilizer increased soil phosphatase and P-available significantly. The treatments did not have a significant effect on the growth of sweet corn on Andisols. The phosphate solubilizing bacteria *P. pseudoalcaligenes* combined with green manure gave the highest to soil available P.

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