Conference Paper

The Application of Phosphate Solubilizing Microbes Biofertilizer to Increase Soil P and Yield of Maize on Ultisols Jatinangor

Betty Natalie Fitriatin[1], Pujawati Suryatmana[1], Anny Yuniarti[1], and Noor Istifadah[2]

[1]Department of Soil Sciences, Agriculture Faculty, Universitas Padjadjaran
[2]Department of Plant Pests and Diseases, Agriculture Faculty, Universitas Padjadjaran, Jl Raya Bandung Sumedang Km 21, 45363, Jatinangor, Jawa Barat

Corresponding Author:
Betty Natalie Fitriatin
betty.natalie@unpad.ac.id

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Abstract

Ultisols has problems of low availability of nutrients, especially phosphorus. To improve soil phosphate and P fertilizer efficiency, it is necessary to develop biofertilizer such as phosphate solubilizing microbes. Phosphate solubilizing microbes (PSM) have the capability of dissolving soil phosphorus which have been adsorbed and can mineralize organic P to become inorganic P, hence increasing the avalibility of P in the soil. Phosphate solubilizing bacteria (Pseudomonas mallei and Pseudomonas cepacea) and phosphate solubilizing fungi (Penicillium sp. and Aspergillus sp) were selected based on their ability to dissolve P. The experiment was conducted at Jatinangor, West Java Indonesia to study the application of PSM biofertilizer to increase soil P and yield of maize. Experiment used a Randomized Block Design (RBD) in factorial pattern, consisting of two factors with three replications. The first factor consisted of PSM biofertilizer, which were; without PSM, 5 L ha-1 of PSM and 50 kg ha-1 of PSM. The second factor was P fertilizer with five levels (0%, 25%, 50%, 75% and 100% dosage of recommendation). The results showed that the application of PSM biofertilizer increased soil phosphate and yield of maize on Ultisol Jatinangor. The dosage of P inorganic fertilizers was reduced by 50%.

Keywords: ultisol, maize, biofertillizer, phospate-solubilizing bacteria.

1. Introduction

Ultisols is widely spread in Indonesia. This soil has probems for planting as has a high acidity, low macro nutrients, low organic matter content and low soil microbial activity. Ultisols soil has a high P content but largely unavailable to plants. Low P availability due to fixation of P by Al or Fe on Ultisols [1]. Many efforts to improve the productivity of Ultisols, one of them with fertilizer into the soil in the form of synthetic fertilizers or natural fertilizers. However, many obstacles encountered by this fertilization. One of

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them is a residual effect of fertilizers that can pollute the environment. This fertilizer residues also have a negative impact on the environment.

Some free-living microbes in the soil has the ability to dissolve P soil is bound to be available, so that the plants are able to absorb P [2]. Phosphate solubilizing microbes are a group of soil microbes that have the ability to extract P from bonding with Al, Fe, Ca, and Mg, so as to dissolve P which are not available to the plants become to available to plants. This happens because these microbes secrete organic acids that can form stable complexes with cations binder P in the soil [3].

Phosphate solubilizing microbes (PSM) play an important role in influencing the growth of plants, in addition to a fixed P release can also produce the enzyme phosphatase [4, 5] and can produce phytohormones [6, 7]. Phosphatase enzyme released by these microbes can make mineralization of organic P into P inorganic [4, 8, 9].

The purpose of the research to determine of the PSM formulation which superior to increase the availability of soil P and the growth and yield of maize on Ultisols. The result is expected to support sustainable agriculture. Using biofertilizer and biostimulan serves as an alternative to overcome the problems of Ultisols are quite widespread in Indonesia.

2. Materials and Methods

Phosphate-solubilizing microbes biofertilizer were contains P-solubilizing bateria (PSB) and P-solubilizing fungi (PSF). *Pseudomonas cepaceae* and *P. mallei* are isolates from maize rhizosphere while *Aspergillus niger* and *Penicillium* sp. are isolates from paddy rhizosphere. Formulation of liquid biofertilizer were mass cultured in 2% molase + NH4Cl of 0.05% broth medium while formulation of solid carrier biofertilizer were cultured in mixture of compost and peat with ratio of 1: 1. P fertilizer was super phosphate (36% P_2O_5) as fertilizer treatments.

The application of PSM biofertilizer were mixed with cow manure (2 t ha^{-1}) two days before planting. Super phoshate, Urea, and KCl fertilizer was applied at planting. Experiment design was used randomized block design factorial design with three replications composed of two factors:

I. Formulation of biofertilizers (H), consists of three levels i.e.:
   h_0= without biofertilizer
   h_1 = liquid biofertilizer (5 L ha^{-1})
   h_2 = solid carrier biofertilizer (50 kg ha^{-1})

II. Fertilizer of super phosphate (P) consists of five levels, i.e.:
   p_0 = without super phosphate
   p_1 = super phosphate 25 kg ha^{-1}

TABLE 1: Soil available P of Ultisols and P-uptake of maize at the end of the vegetative period.

Treatments	soil available P (mg kg^{-1})	P-uptake (mg kg^{-1})
PSM Biofertilizer :		
- Without biofertilizer	3.45 a	8.18 ab
- Liquid biofertilizer (5 L ha^{-1})	4.79 a	9.88 b
- Solid carrier biofertilizer (50 kg ha^{-1})	4.82 a	7.31 a
P fertilizer (Super phosphate)		
- 0 kg ha^{-1}	4.51 a	5.35 a
- 25 kg ha^{-1}	4.49 a	8.77 b
- 50 kg ha^{-1}	4.85 a	8.51 b
- 75 kg ha^{-1}	3.95 a	10.45 b
- 100 kg ha^{-1}	3.95 a	9.20 b

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

p_2 = super phosphate 50 kg ha^{-1}
p_3 = super phosphate 75 kg ha^{-1}
p_4 = super phosphate 100 kg ha^{-1}

Pot experiment was made of two units, the first unit was used for observation until the end of the vegetative period to observe soil available P (Bray method) and P-uptake. The second unit was used for observation of the yield at the end of the generative period (harvest). All statistical analysis were perfomed using the SPPS 20. The data were analyzed through analysis of varians (ANOVA). To detect significance of differences ($P < 0.05$) between means a Duncan test was performed.

3. Results and Discussion

3.1. Soil available P and P-uptake

The available P concentrations in the rhizosphere soil of maize and P-uptake at the end of vegetative period are shown in Table 1. The application of PSM biofertilizer not significantly influenced soil P available. However, the study revealed that soil available P increased due to the application of P-solubilizing microbes biofertilizer on Ultisols. The application of solid carrier PSM biofertilizer increased soil available P by 39.7%. This is due to the role of inoculant carrier was mixture of peat and compost supported the growth of microbes. Formulation of biofertilizer influenced on ability of activity P-solubilizing microbes. Reference [7] reported that mixture of peat and compost as carrier gave the best effect on population of P-solubilizing microbe.

Increased soil available P Ultisols showed that PSM biofertilizer capable to dissolve P in the soil from fixation. This increase in solubility can occur as a response to the PSM activity on Ultisols that have a low P content. Similar result was reported in Reference [10] who observed that phosphate solubilizing bacteria (*Pseudomonas* sp.) able to increased available P concentrations on the P-deficient soil. Reference [9] also reported that phosphate solubilizing bacteria dissolve P was higher at low P medium.

Super phosphate fertilizer with range dosage 0 kg ha^{-1} up to 100 kg ha^{-1} not significantly influenced soil P available. The solubility of super phosphate due to the fertilization was not significantly. Super phosphate has rapid solubility that can be easy to up take by plant or lose in the soil. However, super phosphate fertilizer with 50 kg ha^{-1} gave better to increased soil available P. Reference [11] also reported that phosphate fertilizer with 50% recommendations dosage gave better effects on soil phosphate and maize yields.

The study revealed that P-uptake increased due to the application of phosphate-solubilizing microbe biofertilizer on Ultisols. The application of liquid PSM biofertilizer increased P-uptake by 20,8%. Reference [10] reported that phosphate solubilizing bacteria (*Pseudomonas* sp.) increased P content of plant and corn growth by 20% on the P deficient soil.

3.2. Yield of maize

The study revealed that yield of maize increased due to the application of P-solubilizing microbe biofertilizer (Table 2). The result showed that biofertilizer containing mixture *Pseudomonas cepaceae*, *P. mallei,* Aspergillus *niger* and *Penicillium* sp. increased yield of maize on Ultisols (11.4% up to 20.9%). We founded that these microbes produced organic acid and phytohormones [7]. Futhermore, application of P-solubilizing microbe increased P solubility that caused soil available P increased. Overall, enhancement of available P increased plant uptake and growth. Reference [10] showed that *Pseudomonas* sp as P-solubilizing bacteria. Increased the soil content of P and corn growth by 20%.

The result showed that P ferlilizer with super phosphate 50 kg ha^{-1} higher increased (9.5%) than another dose of super phosphate. Overall this suggested that aplication of PSM biofertilizer enhance P fertilizer efficiency.

4. Conclusion

Based on the results of this study, it can be concluded that the application of PSM biofertilizer *Pseudomonas cepaceae*, *P. mallei, Aspergillus niger* and *Penicillium* sp. increased soil phosphate and yield of maize on Ultisols. Solid carrier biofertilizer

Table 2: The effect of PSM biofertilizer and P fertilizer on yield of maize.

Treatments	Yield of maize (g plant^{-1})
PSM Biofertilizer :	
- Without biofertilizer	89.4 a
- Liquid biofertilizer (5 L ha^{-1})	99.6 ab
- Solid carrier biofertilizer (50 kg ha^{-1})	108,1 b
P fertilizer (Super phosphate)	
- 0 kg ha^{-1}	97.0 a
- 25 kg ha^{-1}	91.2 a
- 50 kg ha^{-1}	106.2 a
- 75 kg ha^{-1}	97.2 a
- 100 kg ha^{-1}	103. a

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

increased soil P-available was higher than liquid biofertilizer. Formulation of biofertilizer influenced on ability of activity P-solubilizing microbes.

The application of P-solubilizing microbes improved P fertilizer efficiency. Phosphate fertilizer 50 kg ha^{-1} super phosphate gave better effect on soil phosphate and maize yields. All this suggested that P-solubilizing microbe biofertilizer can be applied to reduce P fertilizer needed.

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