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Indigenous Phosphate Solubilizing Microbe on Peat Soil Productivity Enhance at Riau Province

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Abstract: ***Combination of OPEFB compost ameliorant and P fertilization significantly influences the availability of P nutrients on soil even though the total is not significantly different. This indicates that the provision of ameliorant alone is still not able to increase the availability of nutrients, especially P content on peat soils. This can be understood because the P nutrients in peat soils are available in minimal quantities, even the presence of organic acids that bond the P elements causes P in peat soils is un-available. So it needs to be added in volume high enough to meet the needs of plants growth. The addition of 75% P nutrient from the recommended dose gives P available is not significantly different from 100% recommended dose, this indicates that fertilization of 75% of the recommended dose can increase the availability of P nutrient in peat soils. Table 4 also indicates that phosphate solubilizing microbe inoculation contributed to the increasing P nutrients available, although not yet signed. Phosphate solubilizing microbe activities by excreting organic acids that wet the environment and release P bonds.***

Keywords: soil nutrients, compost, Burkholderia gladioli, Penicillium aculeatum

1. Introduction

The area of peatlands in Indonesia covers 14,905,574 hectares spread mainly in Sumatra, Kalimantan and Papua [16] with very high levels of soil variability, both in terms of peat thickness, maturity and fertility, causing not all land peat is suitable for agriculture, and only 80 per cent of it is suitable for agriculture, including oil palm plantations. The Research Center for Palm Oil mentions that peat soils have the potential for oil palm development because these plants are tolerant on peat soil, especially in the layer depth less than 3 meters with the level of hemic to saprist maturity. In 2010 the total area of oil palm in peatlands was recorded at 307,515 hectares in Kalimantan and 1,395,737 ha in Riau and 1,727 ha in Papua [21]. Peatland was chosen mainly by large plantations because of its relatively sparsely populated population so the possibility of land-use conflicts is relatively small.

Problems with oil palm development on peatlands include the gap in productivity between large plantations and smallholder plantations which cover 40 per cent of the total land area and the level of soil fertility. The level of oil palm productivity in peatlands ranges from 12-18 t ha -1years-1 fresh fruit [17], [11]. 27 per cent lower than at mineral soils [22]

The development of oil palm plantations in peat soils is limited by the irreversible of soil acidic, acidic to highly acidic soil reactions, nutrient availability with low base saturation and high organic acid content, especially derivatives of phenolic acids that are toxic to plants and microorganisms [1]. To find out the high yielding, the wise soil management need must done including the application of ameliorant, the addition of phosphate fertilizer and the utilization of soil biological potential that plays a role in increasing nutrient availability in a sustainable manner that supports plant growth [9] and increases efficiency production inputs through a phosphate dissolution mechanism. Phosphate solubilizing microbes play a role in soil fertility because this type of microbe can perform the mechanism of phosphate dissolution by excreting some low molecular weight organic acids such as oxalate, succinate, fumarate and malate. This organic acid will react with phosphate-binding agents such as Al^{3+}, Fe^{3+}, Ca^{2+}, or Mg^{2+} to form a stable organic chelate that can release phosphate ions bound and can be absorbed by plants [8]. The availability of P nutrients in peat soils is low [3] because it's availability in organic form (phospholipids) [7] however the P nutrient can be dissolved by the enzyme phosphatase

The research showed that phosphate solubilizing microbes adaptable well in various types of soil that were deficient in P nutrient including at peat soil, however, environmental factors could influence the adaptability and ability to dissolve phosphate so that non-indigenous inoculant applications could have different effects on P. nutrient availability. Furthermore, the results showed that ameliorant can increase soil pH which is the main obstacle of peat soils, improve soil stability, decrease the concentration of phenolic acids, strengthen cation and anion bonds so that it can conserve nutrients derived from fertilizers and reduce the occurrence of peatland degradation [6]. For this reason, it is necessary to study the contribution of indigenous phosphate solubilizing microbes with their combination with ameliorant on peat soil productivity.

2. Material and Methods

The study was carried out in Kampar District in 2014 using a randomized factorial design with 3 replications. As the first factor is phosphate solubilizing microbe (control, *Burkholderia gladioli* and *penicillium aculeatum*) while the second factor is a combination of ameliorant (control, Palm Oil Empty Fruit Bunch Compost (OPEFB), 4 kg OPEFB /polybag + 25% fertilizer P recommendation, 4 kg OPEFB/ polybag + 50% fertilizer P recommendation, 4 kg OPEFB /polybag + 75% fertilizer P recommendation, 4 kg OPEFB / polybag + 100% fertilizer P. Soil planting media for oil palm seedlings taken from peat soils with saprist maturity;

planting media was put into 8 kg non-perforated polybags for control and amelioration treatment, polybags filled with soil and oil palm empty fruit bunch compost (OPEFB) with a ratio of 1:1. And given recommended fertilization at 16 weeks after the seedlings are planted on polybags and treated P application of fertilizer is given by spreading on a polybag and mixed into the soil, while the application of microbial phosphate solubilizing microbes much as 109 CPU was done by splashing isolates into the soil around the roots in the afternoon. The parameters observed include: nutrient content of N, P, K, Ca, Mg before and after application on the planting media of oil palm seedlings

3. Results and Discussion

Characteristics of saprist peat soil in Riau are included in the eutrophic peat group formed in the basin behind the river with a depth of less than 200 cm, including the Histosol order, the Sapris sub-order, the Haplosapris group and the Typic Haplosapris sub-group [19]. The results of the Peat soil analysis before the experiment as shown in Table 1

Table 1: Peat soil nutrient content before treatment

Parameter		Soil Analysis
pH	:	3
C (%)	:	37,35
N (%)	:	1,83
C/N	:	20
P2O5 (Pbray) ppm	:	22,8 ppm
K (ppm)	:	175,4
P2O5 HCl 25 %	:	59,22 mg/100 g
K2O HCl 25 %	:	42,84 mg/100g
Mg	:	3,05 cmol/kg

Source: Lembang Soil Laboratory of Vegetable Crop Research Institute 2014

Based on the results of laboratory analysis, it can be seen that the peat soil of the research site has a very acidic pH; soil N nutrient content is classified in very high (> 0.75) [18]; with a moderate C / N ratio (11-15); high P (> 40 mg / 100 g soil); high K (> 20 mg / 100 g of soil), but the availability for plant growth un-maximally.

The degree of the soil (pH) acidity of greatly affects the availability of nutrients, plant growth and other potential microbes and affects the efficiency of fertilization. N, P, K,S, Ca and Mg nutrients are available at pH 5 to 7 (neutral) while fertilization micronutrients are abundant at acidic pH. At low pH the solubility of high Fe and Al that influences the higher P bonding process in the form of Al-P or Fe-P bond that cannot be absorbed by plants; it means that even though the peat soil of the site location had a high total P nutrient status, because of the presence of all it is not available to plants [6].

The peat soil of planting media has a high organic C content (37.35%) that derived from the remnants of plants which have encounter weathering although it is not yet optimal. The higher the organic matter, the lower the soil's pH. The degree of the soil acidity (pH) is influenced by the type of fertilizer used, soil CEC, organic matter and weathering. The use of inorganic nitrogen fertilizer can continuously reduce the pH by the nitrification process that produces 2 H^+. Nitrogen application in Haplustalf and Hapludalf showed a decrease in pH respectively (4.4 and 4.9) compared to controls (5.3 and 5.6). On the other hand, [5] states that P fertilization the used of rocks phosphate increasing of the compost pH value, but the used of TSP has no real effect on pH changes. The process of absorption of nutrients by plant roots in the form of cations will release H^+ as a source of soil acidity. In addition, the microbial decomposition process produces CO2 which will react with the soil to produce H^+. Preliminary research results indicate that the addition of OPEFB compost as ameliorant can increase soil pH from 3 to 5.2; increasing available P from 22.8 to 99.5 ppm and increasing soil P potential from 59.22 to 482.18 mg /100 g of soil. This increase in pH was caused by the pH of the OPEFB compost reaching 9.02, and macro/micronutrients contained in it. This fact can improve soil chemical performance which will have an impact on soil fertility, microbial and plant growth. The results of the field research showed that the application of indigenous phosphate solubilizing microbe and the OPEFB compost ameliorant and/or P fertilizer could influence the chemical characteristics of the soil. (Table 2)

Table 2: Soil nutrient content after application of indigenous phosphate solubilizing microbe and Ameliorant combinations

Treatment	Soil nutrient averages						
	C (%)	N (%)	C/N (%)	P (ppm)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)
Peat soil	27,87	2,62	11	476	6748	27,45	42,19
Compost OPEFB	28,64	2,52	11	864	6505	27,16	40,48
Compost OPEFB+25% P	28,44	2,75	10	679	6108	32,00	40,90
Compost OPEFB+50% P	28,68	2,52	11	818	6532	34,67	45,41
Compost OPEFB+75% P	28,26	2,69	11	919	6473	28,42	40,77
Compost OPEFB+100% P	29,19	2,70	11	1058	5271	27,74	34,47
Burkholderia gladioli	28,40	2,67	10,7	691	6367	29,47	31,55
Penicillium aculeatum	29,35	2,77	10,6	840	6197	28,47	29,47

Source: Soil Laboratory of Lembang Vegetable Crop Research Institute, 2014

Twenty weeks after treatment (Table 2) showed that carbon content (C) of the soil media ranged from 27.87 to 29.35%; a decrease average about 23.42% compared with the soil C content before treatment; with a range between the treatment of *Penicillium aculeatum* inoculation and control were 21.42 to 25.38%. These results indicate that the use of indigenous phosphate solubilizing microbes can reduce carbon losses compared to unfertilized peat. Table 2 also indicates that the use of peat soil without fertilization causes a decrease in carbon content, as well as the application of compost and inorganic fertilizer. The decrease in peat carbon content occurs because of the release of carbon into CO_2 into the air. According to [12], peatlands have large reserves of C and are a source of CO_2 emissions released into the air. It was further stated that the peat C content was determined by the rate of decomposition. The faster the rate of peat decomposition, the faster the decrease in C.

The average reduction in the amount of carbon in peat which was ameliorated by OPEFB compost was 22.35%, while the addition of the dose of P fertilizer on peat gave a lower carbon reduction of 23.68%. OPEFB Compost application reduces soil carbon content. This is related to the increase in soil pH which results in the activity of microbial degradation that can work well to decompose using organic peat as an energy source [23] with the consequences of the release of carbon in the form of CO_2 into the air. The results of this study also indicate that a decrease in soil C content in P fertilizer treatment. It's showing the C content is influenced by P fertilization, but in general is more influenced by the addition of organic matter. The results of the study showed that the application of oil palm empty fruit bunches and P fertilization showed that the higher the dose of P fertilizer, the higher the soil C content.

Nitrogen content has increased average of 47.65% with a range between 37.70-60.11%. The addition of 75% P fertilizer on peat showed an increase in N percentage (60.11%) of 2.93% and on compost amelioration and compost amelioration + 50% P amounted to 37.70% i.e. 2.52% compared to N content before treatment. This means that the addition of P fertilizer to a dose of 75% can increase soil N content. P nutrients needed by plants for growing and production include supporting root development. Table 2 also indicates that amelioration and fertilization of oil palm seeds increase the nutrient content of K, Ca and Mg. This indicates that the amelioration and fertilization activities increase the nutrient content of N, P, K, Ca and Mg because OPEFB compost has a fairly complete nutrient content both macro and micronutrients that can help to increase nutrient availability and crop production [20].[10] improve Mg / K balance and increase in CEC [4]. Also, OPEFB compost has a high pH that can increase soil pH performance. The results showed that the degree of soil acidity (pH) is closely related to the availability of nutrients and organic acids that are toxic to plants such as phenolic acids and their derivatives. This is in line with [15] which states that the addition of ameliorant containing polyvalent cations such as Fe; Al; Cu and Zn will reduce the influence of organic acids.

Soil pH

The results of the soil analysis before treatment indicated that the peat used as a growing medium had a high acidity level, with a low N nutrient status, moderate P and high K despite being mature peat. Statistical analysis showed that there was no interaction between the application of phosphate solubilizing microbial inoculation and the combination of OPEFB compost ameliorant and P fertilizer to the degree of acidity (pH) of the soil, but independently the combination of OPEFB compost ameliorant and P fertilizer showed significant differences in soil pH (Table 3).

Table 3: Soil pH performance after treatment

Treatment	Soil pH	
Control	4,30	ab
Compost OPEFB	4,40	ab
Compost OPEFB +25% P	4,70	b
Compost OPEFB +50% P	4,70	b
Compost OPEFB +75% P	4,30	ab
Compost OPEFB +100% P	4,40	ab
25 % P	4,60	b
50 % P	4,30	ab
75 % P	4,20	a
100 % P	4,30	ab
Control	4,51	a
Burkholderia gladioli	4,35	a
Penicillium aculeatum	4,44	a

Note: Numbers followed by the same letter in the same column are not significantly different at 5% significance level according to Duncan's Multiple Range Test.

Table 3 shows that the higher the dose of P fertilizer administered the more the degree of acidity (pH) of the soil, although it was not significantly different between the levels of fertilizer fertilization and was higher when compared without fertilization.

Fertilization activities increased soil acidity by releasing H + ions which triggers an increase in soil acidity. This is in line with[11] which states that NPK fertilization can increase soil P and K nutrient content, but not significantly affect soil pH.

The increase of the media treated with ameliorant combination and 25% P fertilizer, OPEFB compost combination and 50% P and 25% P in acidity (pH) was significantly different from peat media without ameliorant and 75% P although the fellowship ameliorant combination treatments were not significantly different. This indicates that the addition of OPEFB compost causes an increase in negative charge on the surface of the colloidal soil which causes pH to increase [2]. Along with [6] mention that ameliorant can increase soil pH, improve soil stability and reduce phenolic acid concentration. Furthermore, [13] from her research stated that the use of OPEFB compost as ameliorant increased the pH of peat soils from 3.6 to 5.5.

A single inoculation of phosphate solubilizing microbes triggers an increase in the degree of soil acidity, although not significantly. This is due to organic acids that produce in phosphate solubilizing microbe metabolic activity [14] which were weeting the cells and their environment so that soil pH decreases. The results of the analysis showed that *Penicillium aculeatum* gave a higher pH performance compared to *Burkholderia gladioli*, it was suspected that the production of organic acids by *Burkholderia gladioli* was more than the production of organic acids by *Penicillium aculeatum*.

Soil Nutrien Enrichment

The results of the statistical analysis of the effect of phosphate solubilizing microbe inoculation and the combination of OPEFB ameliorant and P fertilizer dosages on P nutrient content in the soil are presented in Table 4.

Table 4: P Nutrient Content in Palm Oil Nurseries Media 20 Weeks after Treatment

Treatment	P Bray I		Nutrient	P (HCl)	
	---(ppm)---			mg/100 g soil	
Control	1.517	a	High	476	a
Compost OPEFB	1.569	a	High	1.045	a

Compost OPEFB +25% P	1.799	a	High	692	a
Compost OPEFB +50% P	2.113	a	High	772	a
Compost OPEFB +75% P	2.994	bc	High	780	a
Compost OPEFB +100% P	3.056	bc	High	864	a
25 % P	1.938	a	High	679	a
50 % P	2.832	b	High	818	a
75 % P	4.174	c	High	919	a
100 % P	3.635	bc	High	1.058	a
Kontrol	2.303	a	Tinggi	899	a
Burkholderia gladioli	2.427	a	Tinggi	691	a
Penicillium aculeatum	2.658	a	Tinggi	840	a

Note: Numbers followed by the same letter in the same column are not significantly different at 5% significance level according to Duncan's Multiple Range Test.

Table 4 shows that together there is no real interaction, but independently the combination of OPEFB compost ameliorant and P fertilization significantly influences the availability of P nutrients on the ground even though the total is not significantly different.

Combination of OPEFB compost ameliorant and P fertilization significantly influences the availability of P nutrients on the ground even though the total is not significantly different. This indicates that the provision of ameliorant alone is still not able to increase the availability of nutrients, especially P content on peat soils. This can be understood because the P nutrients in peat soils are available in minimal quantities, even the presence of organic acids that bond the P elements causes P in peat soils is un-available. So it needs to be added in volume high enough to meet the needs of plants growth. The addition of 75% P nutrient from the recommended dose gives P available is not significantly different from 100% recommended dose, this indicates that fertilization of 75% of the recommended dose can increase the availability of P nutrient in peat soils. Table 4 also indicates that phosphate solubilizing microbe inoculation contributed to the increasing P nutrients available, although not yet signed. Phosphate solubilizing microbe activities by excreting organic acids that wet the environment and release P bonds.

4. Conclusion

The application of indigenous phosphate solubilizing microbes increases the nutrient content of peat soils

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