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Indigenous Peat Soil Phosphate Solubilizhing Microbe Inoculation And Amelioration On Carbon Emission

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Abstract.

The un-right peat soil management will cause excessive CO_2 emissions that affected to the Global climate. Research related to learning of MPF induction in peat-lands and the application of ameliorant at oil palm nurseries to CO_2 emissions released has been implemented on farmers' nurseries at Kampar District in June 2013 till March 2014. Using a Factorial Randomized Block Design with 3 replications. As a first factor, MPF inoculation (control; *Burkholderia gladioli* and *Penicillium aculeatum*) while the second factor was Ameliorants (Control, Oil Palm Empty Fruit Bunch (TKKS) Compost, 4 kg TKKS compost/polybag and 25% recommended dosage, 4 kg TKKS compost/polybag and 50% recommended dosage, 4 kg TKKS compost/polybag and 75% recommended dosage, 4 kg TKKS compost/polybag and 100% P recommended dosage, 25% recommended dosage, 50% recommended dosage, 75% recommended dosage , 75% recommended dosage P and 100% recommended dosage P. Measurement of CO_2 emissions was done using a closed chamber and an Infrared Gas Analyzer tool. The collected data is tabulated and analyzed using SPSS. The results showed that the MPF inoculation and the combination of ameliorant and P fertilizer did not affect the CO_2 emissions increased.

Keyword: Compost, *Burkholderia gladioli*, *Penicillium aculeatum,* CO_2 emission

1. Introduction

Limited productive soil causes agricultural expansion activities leading to sub-optimal soils such as peat soils. The results of the Research Center for Palm Oil show that peat soils have the potential for oil palm development because these plants are tolerant of the nature of peat, especially in the depth of the layer less than 4 meters with the level of hemic to saprist maturity. The level of oil palm productivity in peatlands ranges from 20.25-23.74 t ha^{-1} TBS (Barchia, 2006) with a yield of 23 per cent or 11.27 per cent lower than mineral soils (Wahyunto *et al.*, 2013).

In 2010 the total area of oil palm in peatlands was 701,868 hectares in Kalimantan and 500,000 ha in Riau (Wahyunto and Ani, 2011). Peatland was chosen mainly by Estate because of its relatively sparsely populated population so that the possibility of land-use conflicts is relatively small. One of the problems in developing peatlands is related to the high carbon content of weathering of peat raw material. Improper management causes the release of large amounts of carbon. The results showed that on oil palm plantations replanting led to carbon loss in the form of CO_2 emissions of 56 t ha^{-1} $years^{-1}$ (Wahyunto *et al*., 2012). Each gram of peat soil contains 180-600 mg of carbon ten times higher than mineral soil (Agus and Subiksa, 2008). Each hectare of peatland has a carbon potential equivalent to 8.07-13.58 million t CO_2 per year (Mulyani and Noor, 2011). It was further stated that in stable conditions carbon deposits will increase every year but in disturbing conditions such as the presence of land clearing activities for oil palm plantations causing carbon loss in the form of CO_2 and CH_4 emissions. Fertilization applications caused an increase in plant metabolism and soil biota to produce CO_2. The high concentration of CO_2 in the air causes climate change which indirectly affects agricultural production in a broad sense. An increase in temperature of more than 2°C can threaten humans because it causes scarcity of clean water caused by a decrease in groundwater level, flooding and drought so that the management of peatlands needs to be considered carefully, P fertilization on the growth of oil palm seedlings and reducing CO_2 emissions in peat soils. The potential microbes (MPF) using to reduce the costs of production inputs and environmental pollution. Istina *et al*. (2015) results that indigenous phosphate solubilizing microbes can be used to increase peatland productivity. The research purposed to determine the effect of indigenous phosphate solubilizing microbe inoculation and ameliorant combination on CO_2 emissions increasingly at oil palm nurseries

2. Material and methods

The study was carried out on oil palm nurseries using saprist peat soilin Kampar District. Materials used include oil palm seedlings aged 16Week after planting, ameliorant oil palm empty fruit bunches that having a pH of 9.02 with a moisture content of 46.6% and organic C 21.54% inoculants of Phosphate Solubilizing Microbe, N, P and K fertilizers; Insecticides, and fungicides, while the equipment used is polybags, rags, shovels, hoes, electric scales, measuring cups, pipettes, Infrared Gas Analyzer (IRGA) and other aids. This study used a factorial randomized block design with 3 replications. The first factor was MPF isolate (3 levels) and the second factor was combination of ameliorant and fertilizer dosage (10 levels). The first factor were:

k : Control
l : Bulkholderia gladioli isolate with a density of 109 ml $cell^{-1}$ suspension of $polybag^{-1}$ as much as 15 ml
m : Penicillium aculeatum isolate with a density of 109 ml $cell^{-1}$ suspension of $polybag^{-1}$ as much as 15 ml

While the combination of ameliorant and P fertilizer dosages include

a : Control
b : 4 kg TKKS compost/polybag
c : 4 kg TKKS compost /polibag dan 25 % P recommended dose
d : 4 kg TKKS compost /polibag dan 50 % P recommended dose
e : 4 kg TKKS compost /polibag dan 75 % P recommended dose
f : 4 kg TKKS compost /polibag dan 100 % P recommended dose

g : 25 % P recommended dose
h : 50% P recommended dose
i : 75 % P recommended dose
j : 100 % P recommended dose

Table 1. Fertilizer recommended dosages and time application

Weeks	Fertilizer dosages (g/seedling)							
	N	P					K	Mg
		100%	75%	50%	25%	Control		
16	1,139	0,917	0,688	0,458	0,229	0	0,554	0,402
18	1,594	1,283	0,963	0,642	0,321	0	0,774	0,563
20	2,278	1,833	1,375	0,917	0,458	0	1,106	0,804
22	2,278	1,833	1,375	0,917	0,458	0	1,106	0,804
24	2,278	1,833	1,375	0,917	0,458	0	1,106	0,804
26	3,644	2,933	2,200	1,467	0,733	0	6,271	7,638
28	3,644	2,933	2,200	1,467	0,733	0	6,271	7,638
30	3,644	2,933	2,200	1,467	0,733	0	6,271	7,638
32	4,556	3,667	2,750	1,833	0,917	0	7,839	8,04
34	4,556	3,667	2,750	1,833	0,917	0	7,839	8,04
35	4,556	3,667	2,750	1,833	0,917	0	7,839	8,04
Total	34,167	27,499	20,626	13,751	6,874	0	46,976	50,411

In the control, each polybag was contains 8 kg of peat soil, while in the combination the ameliorant ratio between TKKS compost ameliorant and peat is 1: 1 (4 kg of peat soil: 4 kg of TKKS compost). Each of the 16-week-old oil palm seedlings planted on a perforated polybag containing peat media and oil palm empty fruit bunch (TKKS) compost that has been watered to field capacity and given a planting hole with a diameter of 14 cm. Before the seedlings are planted into the planting hole, the fertilizer is given according to the recommended dosage. The seedling fertilizer were 0.569 g Urea + 0.58 g TSP + 0.276 g KCl +0. 201 g Kieserit. Fertilization of seedlings in the main nursery (main nursery) is done 2 weeks after planting by using a single fertilizer sprinkled around the plant and immersed into the soil at the recommended dosage, while inoculation is carried out in the afternoon by pouring inoculant suspension according to the treatment dose into the plant root area.

Measurement of CO_2 emissions is done by using a hood that serves to capture gas emissions released by peat. Gas concentrations are measured using IRGA software. Calculation of CO_2 gass concentrations using the USEPA equation

E =dc/dt x mW/mV x t x {273,2/(273+T)

Remaks :

E = fluks CO_2 (mgm^{-2} hour^{-1})

Dc/dt = changes in CO2 concentration per time (ppm menit^{-1})

t = containment height (cm)
mW = molecular weight CO_2 (g)
mV = molecular volume CO_2 (22.41 liter)
T = Temperature in the chamber (º C)
22.41 liter is volume 1 mol gass at the standart pressure

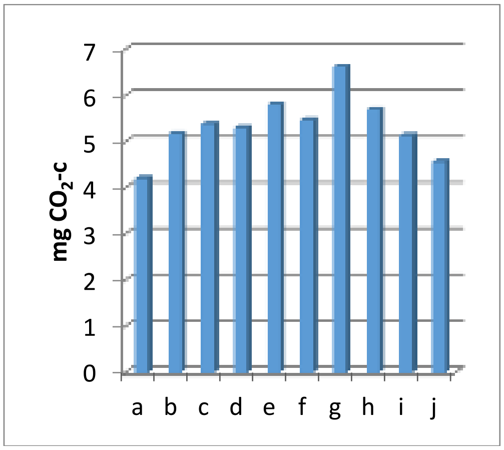
Figure 1 the CO_2 emission measurement methods using IRGA. Dark chamber (left), and IRGA equipment (right)

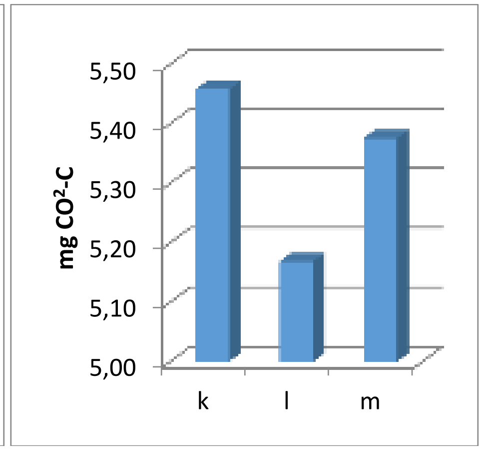
Observation data were collected and analyzed using Anova variance at α 0.05 level. To find out the effect between treatments doe to Duncan's multiple range test (DMRT) was at 5% using SPSS software

3. Result and discussion

Agricultural land causes high concentrations of CO_2 in the air include soil pH, soil carbon content, nutrient availability, water, temperature, root respiration and other environmental factors (Wahyunto *et al*., 2005; Knorr *et al*., 2009; Sukarman *et al*., 2011). Statistical analysis showed that amelioration treatment, P fertilization and MPF inoculation on saprist peat soils affected respiration and CO_2 emissions at 4 weeks after treatment, but were not significantly different until 20 weeks after treatment and had a downward trend (Figure 2). This indicates that peatland management through MPF inoculation and the combination of TKKS ameliorant and P fertilizer does not affect CO_2 emissions. In Figure 2 it can be seen that respiration at 25% P fertilization showed a significant difference with the control even though it was not significantly different from other treatments. The addition of ameliorant in the form of fertilizer and its combination with compost indicates higher respiration compared to without ameliorant. The addition of P fertilizer to ameliorated peat shows that the higher dose of P fertilizer given, the higher the respiration, although there is a decrease if the dose is increased up to 100%.

Figure 2 Effect of MPF inoculation and combination of ameliorant TKKS compost and P fertilizer on oil palm seedling growing media on soil respiration. a = control, b= TKKS compost, c= combination of TKKS compost and 25 % P fertilizer , d= combination of TKKS compost and 50 % P fertilizer, e= combination of TKKS compost and 75 % P fertilizer, f= combination of TKKS compost and 100 % P fertilizer, g= 25 % P fertilizer, h= 50 % P fertilizer, i= 75 % P fertilizer, j= 100 % fertilizer P, k= control for MPF, l= isolate Burkholderia gladioli and m= Penicillium aculeatum isolate

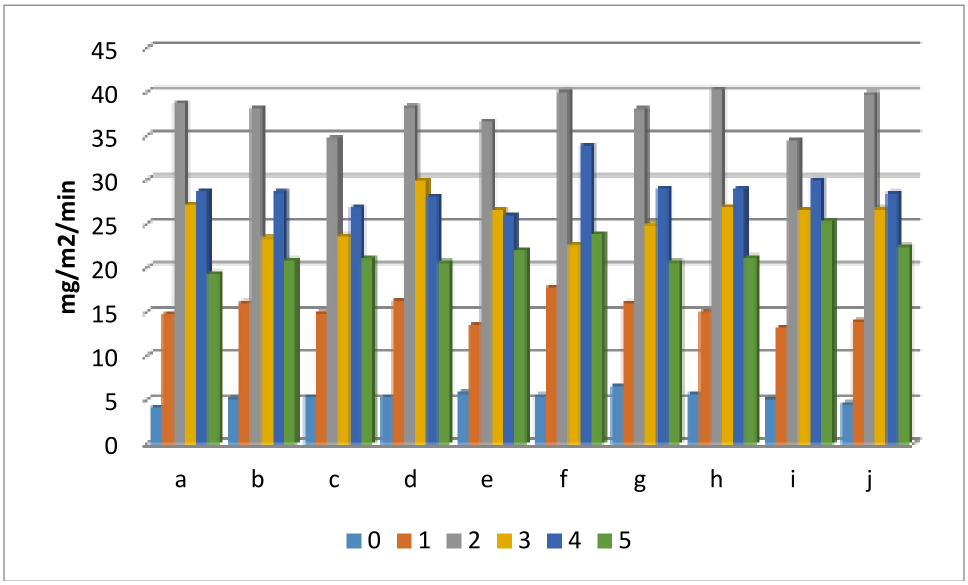




Peat soils which were no ameliorant applied, showed that the higher dose of P fertilizer makes lower respiration. The highest respiration occurs in the addition of a dose of 25 % P fertilizer. This condition caused by microbial activity, where the higher dose of P fertilizer microbial phosphate solubilizing microbe cannot work properly and the excess P fertilizer that is mobile is bound by soil organic acids so that respiration is reduced. Ameliorated peat soils showed an increase in respiration up to a 75% P fertilizer dosages increased. This was caused by changes in soil conditions, especially pH, which was more in line with microbial growth to inhibit the loss of P fertilizer and decomposition activities.

The results of statistical analysis of the CO_2 emissions released into the air in each treatment every month showed that the fluctuations with a downward tendency at 20 weeks after the highest treatment of emissions occurred in the third month (Figure 3). At the beginning of the observation, the addition of P fertilizer by 75% dosage to the ameliorated peat soils and showed no lower CO_2 emissions and significantly different from the amelioration of peat soil and 100% of P fertilizer dosage. This was probably due to the addition of P nutrients needed by microbes to carry out activities in the preparation of cells and phosphatase enzymes that play a role in stimulating root and microbial growth there by increasing CO_2 emissions.

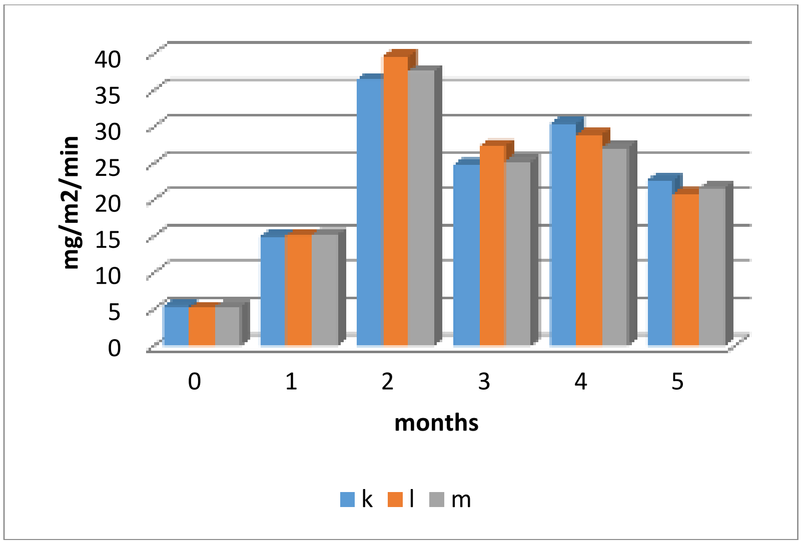
Figure 3 Histogram of CO_2 Emission on combinations of ameliorant and P fertilizer at 20 weeks after treatment: (0) CO_2 Emission at the first time (October), (1) CO_2 Emission 4 weeks after treatment (November), (2), CO_2 Emission 8 weeks after treatment (November), (3), CO_2 Emission 12 weeks after treatment (January), (4) CO_2 Emission 16 weeks after treatment (February), and (5) CO_2 Emission 20 weeks after treatment (March). a= control, b= TKKS compost, c= combination of TKKS compost and 100 % P fertilizer, d= combination of TKKS compost and 75 % P fertilizer, e= combination of TKKS compost and 50 % P fertilizer, f= combination of TKKS compost and 25 % P fertilizer, g= 100 % P, h= 75 % P, i= 50 % P, and j= 25 % P



Carbon dioxide emissions in nurseries fluctuated with a tendency to decrease tenth week after treatment. This is presumed by the presence of Fe in oil palm empty fruit bunch compost (1,223 ppm) which interacts with organic acids to form a stable Fe-organic complex that is difficult to be decomposed by microorganisms which result in inhibited activity and reduces CO_2 production. The results of this study were supported by Nelvia (2009) and Sabiham and Sukarman (2012) who stated that the addition of ameliorant containing Fe cation could reduce the toxic nature of organic acids and increase the stability of peat soils and reduce CO_2 emissions. The results of the laboratory analysis of oil palm compost showed that the Fe content in the compost used was 1,223 ppm. Besides, it is also caused by the reduction by photosynthesis activity of oil palm seeds to produce photosynthesis for plant growth and development (Kusumaningrum, 2008).

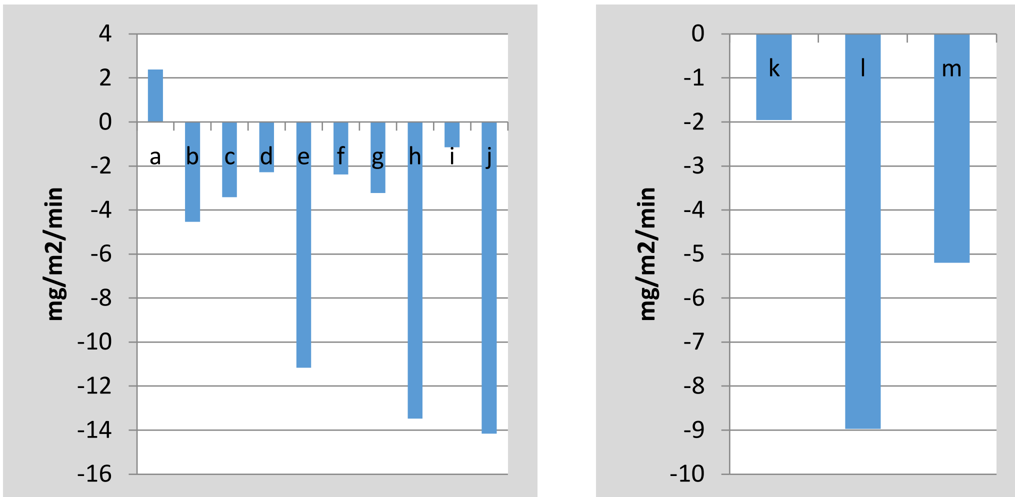
The results of the analysis of the MPF inoculation treatment showed a similar trend with the combination treatment of ameliorant and P fertilizer, which decreased (Figure 4). CO_2 emissions in the *Burkholderia gladioli* inoculation treatment contributed to average CO_2 emissions (26.40 mg/m^2/mg) followed by control (25.92 mg /m^2/mg) whereas the *Penicillium aculeatum* fungi treatment (25.41 mg/m^2/mg). This shows that microbial inoculation which was feared would contribute to CO_2 emissions through the mechanism of respiration did not occur. The results also showed a tendency that *Burkholderia gladioli* contributed lower CO_2 emissions than *Penicillium aculeatum*, presumably due to Burkholderia gladioli originating from a depth of 90-120 cm emitting less CO_2. The results of this study also indicate that the inoculation of phosphate solubilizing microbes and the combination of ameliorant and P fertilization have a positive effect on peat, increasing soil pH, soil nutrients and providing a good atmosphere for potential microbes and carrying out their activities even though it is not real.

Figure 4 Histogram of CO_2 Emission on MPF isolate application at 20: (0) CO_2 emission at the initial time (October), (1) CO_2 emission 4 weeks after treatment (November), (2), CO_2 8 weeks after treatment (November), (3), CO_2 emission 12 weeks after treatment (January), (4) CO_2 emission 16 weeks after treatment (February), and (5) CO_2 emission 20 weeks after treatment (March) k= CO_2 emission on control, l= CO_2 emission on B. gladioli inoculation, dan m= CO_2 emission on P. aculeate inoculation



The observations showed that CO_2 sequestration occurred in all treatments except control treatments. Excessive CO_2 emissions will disrupt environmental stability and can cause pollution. Naturally, nature has formed a balance through the mechanism possessed by each component. Plants maintain climate balance through the photosynthesis process. Microorganisms support and stabilize changes, especially micro climate in the soil; through the mechanism of production and consumption of CO_2, CH_4 and nitrogen for their metabolic processes (Chatzipavlidis *et al.,* 2013). Based on the calculation of CO_2 emissions, the inoculation of *Burkholderia gladioli* can mitigate CO_2 emissions up to 7.01 mg /m^2/week or 336.48 mg / m2 / year, while Penicillium aculeatum is 3.24 mg / m2 / week or 155.52 mg /m^2/year compared to controls. Sequestration in microbes occurs through the mechanism of catalysis of CO_2 to HCO_3 and in *Bacillus pumilus*, HCO_3 will be converted into calcite (Komala and Khun 2014).

Figure 5. Histogram of of CO2 emission sequestration at 20 weeks after treatment. a= control, b= TKKS compost , c= combination of TKKS compost and 100 % P fertilizer, d= combination of TKKS compost and 75 % P fertilizer, e= combination of TKKS compost and 50 % P fertilizer, f= combination of TKKS compost and 25 % P fertilizer, g= 100 % P fertilizer, h= 75 % P fertilizer, i= 50 % P fertilizer, j= 25 % P fertilizer, k= control (no isolate), l= B. gladioli, and m= P. aculeatum



Phosphate Solubilizing Fungi inoculation especially *Burkholderia gladioli* and *Penicillium aculeatum* showed that CO_2 emissions which fluctuated and decreased in the 20^{th} week, this was allegedly due to CO_2 emissions related to the amount of carbon contained in the soil and the treatment of the soil. Plant growth that was not ameliorated is not good although it is not significantly different when compared to that amelioranted plant. Poor growth results in a lack of plant ability to absorb CO_2 so that CO_2 produced by root respiration and soil biological activities is emitted into the air. Conversely in plants that are not given ameliorant, their growth is better so that their ability to recapture CO_2 for photosynthesis and microbial metabolism is higher. CO_2 sequestration naturally can occur through biological mechanisms, namely photosynthesis, microbial activity and land management.

4. Conclusions

Phosphate Solubilizing Fungi inoculation and its combination with ameliorant in the form of Palm Oil Empty Bunches compost and P fertilizer was not significantly affect to increase carbon dioxide emissions on peat soils.

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