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# Adding Compost to Oil Palm Planting Holes can Increase the Diversity of Soil Fungi without Significantly Affecting the Gas Emissions on Wetlands

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## ABSTRACT

Inorganic fertilizer has long been used in improving soil fertility and enhancing crop production in Indonesia, especially for estate crops like oil palm (*Euis guenensis*). However, the use of inorganic fertilizers is ought to stimulate methane formation in soil and successive greenhouse gas emissions to the atmosphere and suppress the development of particular microbes of wetlands' soils. As the one of the alternative in oil palm cultivation is to use compost. The objectives of this study were to determine the effects of applying combined compost on gas emissions and diversity of soil fungi in oil palm field on wetlands. For these, grass compost with inorganic fertilizer (WC), oil palm empty fruit bunches compost with inorganic fertilizer (OPEPB), and the inorganic fertilizer without compost (CF) were tested. The emissions of $CH_4$, $CO_2$ and $N_2O$ were collected from the oil palm planting holes by closed chamber method. Soil samples were also taken and used for determination of fungi characteristic and diversity. The results of this research showed no statistical different in $CH_4$, $CO_2$ and $N_2O$ emissions from WC, OPEPB and CF plots. Meanwhile, the genera of soil fungi that were found on the sites after applying combining compost, viz *Aspergillus, Bipolaris, Gonatobotrys, Gonatorrhodiella, Oidiodendron, Penicillium, Rhynchosporium, Rhizopus, Trichoderma,* and *Trichocladium*. It could be concluded that the use of compost increased the diversity of soil fungi without significantly effect on gas emissions from oil palm field on wetlands.

**Keywords**: gas emissions, fertilizer, diversity, and soil fungi

## INTRODUCTION

Inorganic fertilizer has long been used in improving soil fertility and enhancing crop production in Indonesia. However, the use of inorganic fertilizers is ought to stimulate methane formation in soil and successive greenhouse gas emissions to the atmosphere (Mambu, 2012). Li et al (2012) reported the application of nitrogen fertilizers in 210 kg $ha^{-1}$ increased the $CH_4$ emissions around 13-66% in wetland paddy field. Wihardjaka and Abdurachman (2007) also reported the addition of K fertilizers increased the $CH_4$ emissions at non-wetland paddy field. Moreover, Hickman et al (2011) reported the use of inorganic fertilizers in plenty can stimulate $N_2O$ emission.

Oil palm plant is a plant that is cultivated widely in Indonesia thought it

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needs large amount of fertilizers. Out of seven million ha of oil palm plantations, about half are owned by farmer or so called house-hold oil palm field (Noor, 2010). Due increased price coupled with high demand competition with oil palm companies, house-hold oil palm farmers are unable to afford in inorganic fertilizer. One of the alternatives to overcome this constrain is the use of composting wastes that are largely available in oil palm field on wetlands.

Sampanpanish (2012) described that the $CH_4$, $CO_2$ and $N_2O$ emissions from wetland paddy field that has been applied inorganic fertilizers were 1.79, 534.11, and 1.21 $mg.m^{-2}.d^{.}$, respectively. Meanwhile, the gas emissions in the field that has been applied organic fertilizers were 1.35, 377.35, and 0.88 $mg.m^{-2}.d$ for $CH_4$, $CO_2$ and $N_2O$, respectively. The application of compost generally improves the abundant and diversity of soil microbes, such as bacteria and fungi. Pe'rez-Piqures et al (2006) reported the application of compost has an affected sort of bacteria and soil fungi. However, there are few studies on the effect of waste compost on fungi diversity while keeping low greenhouse gas emissions. Thus, the objectives of this study were to determine the effect of applying combined compost on gas emissions and diversity of soil fungi in oil palm field on wetlands.

## MATERIALS AND METHODS

### Study site

The expriement was conducted at Gampa Asahi sub-district, Rantau Badauh district, Barito Kuala regency, South Kalimantan-Indonesia. The classification of soil on this swampy area has characterized as acid sulphate soil.

### Preparation and application fertilizers

Compost that used in this experiment was prepared previously by Mawar (2014). The sort of organic fertilizers that used in this research were oil palm empty fruit bunch compost and grass (fern species *Stenochlaena palustris*) compost. Inorganic fertilizer was also applied as comparison and compost supplement. Twelve planting holes each sizing 60 x 60 x 60 cm were prepared two weeks prior to fertilizer application. Four holes were filled with inorganic fertilizers at the rate of 250 kg $ha^{-1}$ N, 250 kg $ha^{-1}$ SP36 and 150 kg $ha^{-1}$ KCl (consider as CF plot hereafter). The rest of the holes were filled with either oil palm empty fruit bunch compost (considered as OP EFB plots hereafter) or grass compost (considered as WC hereafter) at the rate of eight ton $ha^{-1}$. Urea, SP36 and KCl fertilizers were also applied to OPEF and WG to reach the same N, P and K doses to CF plots. Furthermore, oil palm plants that has been nursed for 18 month were planted at the same day with fertilizer applications.

### Soil and gas sample collection

Gas collection carried out by close chamber method as described by Hadi et al. (2012). The interval of gas sampling was 2, 7, 12 minutes after the chambers closure. The sample samples were transeferred to laboratory and used for determination of $CH_4$, $N_2O$ and $CO_2$. Gas sample was collected every two weeks for 3.5 months. In addition, gas concentrations were quantified by gas chromatography of GHG 450 types Shimadzu. Then gas sample was



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calculated based on the formula below (Hadi et al 2005):

$$\mathbf{F = k.h.\Delta c / \Delta t\ (273 / T)}$$

Whereas, the F refer to gas emissions rate (mg $N_2O$ $m^{-2}h^{-1}$) ($gCO_2m^{-2}h^{-1}$) ($gCH_4m^{-2}h^{-1}$); k refer to constant volume gas conversion into weight ($CO_2$ and $CH_4$ = 0.536, $N_2O$ = 1.250); h = the height chambers in meter; $\Delta c/\Delta t$ refer to changes of the gas concentration (ppm) per unit of times (hours) and T refer to the temperature in chambers ($^oK$).

Soil sampel was collected from the oil palm planting hole. The sample was collected for three times, viz the initially before applied the waste compost, the middle after applied (35 days) and the last after applied (77 days). Soil sample was composite and taken up 0-20 cm in deep (Cappucino and Sherman, 2002). All samples was analyzed for diversity of soil fungi through characterization and identification. Identification of soil fungi covered the characteristic, such as morphology and microscopy. The characteristics of morphology were shape, color, size, pigmentation, and growth rate colony (Rohilla and Salar, 2012). Besides that, the microscopy characteristics consist of shape, color, spore location, position of the septa in mycellium, septa shaped into the spore, and morphology of conidiophore. The characteristics above was analyzed by dichotomous key of fungi.

### Research Design and Data Analysis

The reasearch design that used in this study was completely random block design in one factors, whereas the sort of compost as treatment. Types of compost were OP EFB, grass, and control. Every treatments consist of four groups. So the amount of combination every treatment i.e, 12 units design. Analysis of varians is used if the data gas emissions rate has fully assumed homogeneous and normality. Moreover, Duncan test (5%) is used if the analysis varians data showed the significantly, but the Kruskal Wallis is used if the data has not fully assumed of homogenous and normality (Mattjik and Sumertajaya, 2002).

## RESULTS AND DISCUSSION

### Gas Emission $CH_4$, $CO_2$, and $N_2O$

The emission of $CH_4$, $CO_2$, and $N_2O$ were varied with different treatments and fluctuated from time to time (Figure 1).

For example, the $CH_4$ emissions from OP EFB + inorganic fertilizers was 0.019 $gCH_4m^{-2}h^{-1}$ on the iniatially and become – 0.316 $gCH_4m^{-2}h^{-1}$ at the end of measurement. Contrastly, the emissions of $CH_4$ in the grass compost + anorganic fertilizers is showed increased from 0.012 $gCH_4m^{-2}h^{-1}$ at day zero become to 0.711 g $CH_4$ $m^{-2}$ $h^{-1}$ at day 77. The $CH_4$ emissions from inorganic fertilizer plot without compost decreased gradually up to the end of the observation (Figure 1C).

Reducing gas $CH_4$ on this study has correlated to the sort of microbes produced $CH_4$. Generally, the microbes that produced $CH_4$ is a group of methanogenic bacteria, meanwhile, the sort of waste compost that used is not ideally substrate for the bacteria. Therefore, the amount of $CH_4$ also decreased gradually.



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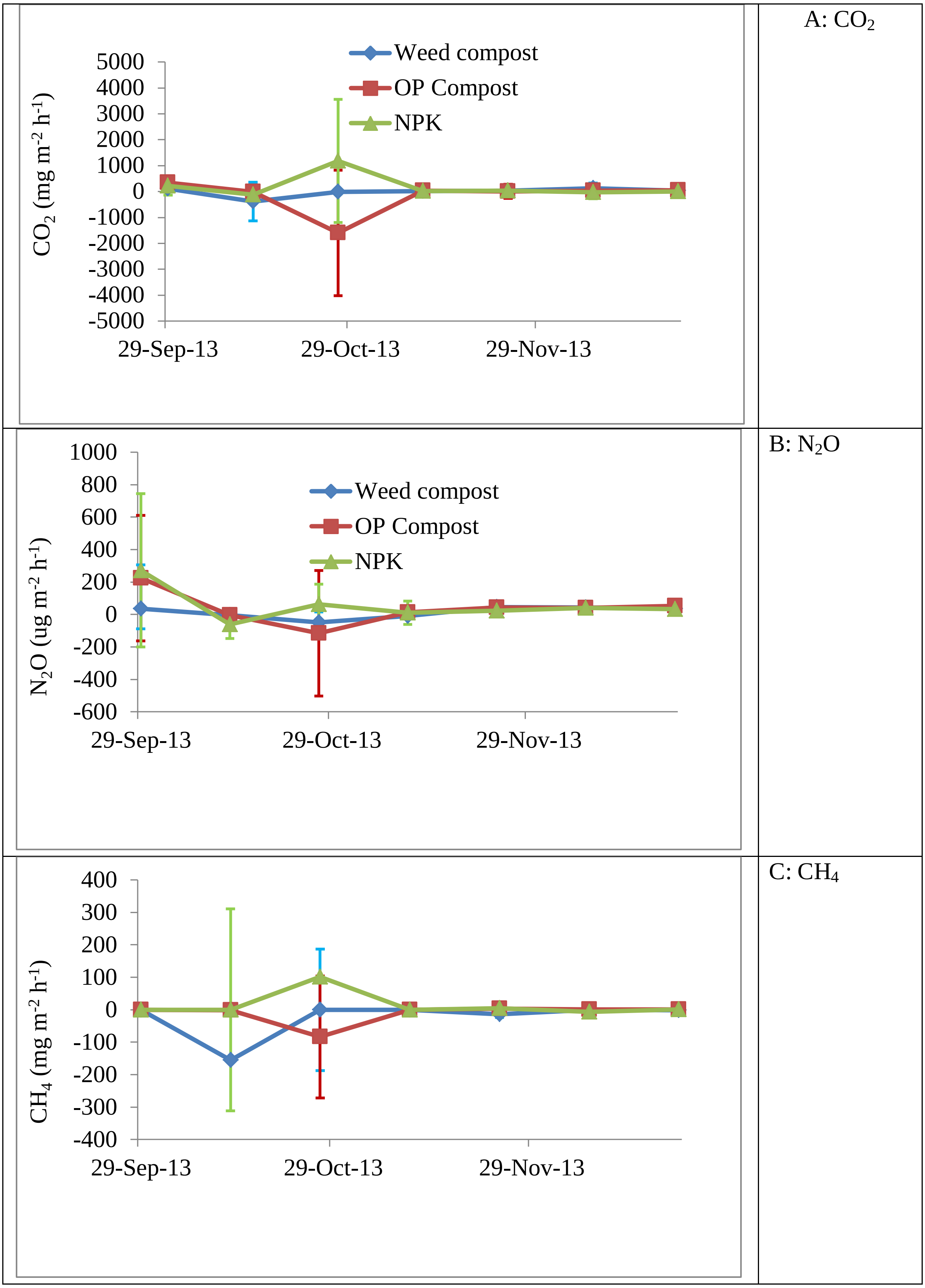


Figure 1. Temporal $N_2O$, $CO_2$ and $CH_4$ emissions from CF, OP EPB and WG plots.



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On this cases, the increasing of $CH_4$ in the oil palm planting hole that received combining fertilizers, grass compost + anorganic fertilizers is due to by the properties of grass compost that easily to degraded and decompesed by microbes, mainly by methanogenic bacteria to forming gas $CH_4$. According to Wihardjaka (2001), the emissons of plant that has recieved a straw compost is higher increased than a plant without its. The interaction of anorganic and anorganic fertilizers showed no effect of $CH_4$ emissions. In this cases, the forming of $CH_4$ depend on many factors, not only sort of fertilizers but also a redox potential, pH, temperature, kinds of plants, and anorganic matter in soil (Asri, 2010).

Table 1 showed the annual $CH_4$, $N_2O$ and $CO_2$ emissions from OP EFB, GW and CF plots, respectively.

Table 1. Annual $CH_4$, $N_2O$ and $CO_2$ emissions and their global warming potential

| | WG | OP EFB | CF |
|---|---|---|---|
| $CH_4$ (kg m$^{-2}$ year$^{-1}$) | -91.91 | -43.46 | 53.42 |
| $CO_2$ (kg m$^{-2}$ year$^{-1}$) | -75.41 | -723.27 | 640.90 |
| $N_2O$ (kg m$^{-2}$ year$^{-1}$) | 0.08 | 0.15 | 0.29 |
| GWP$^{*)}$ (kg $CO_2$ equ m$^{-2}$ year$^{-1}$) | -4.94 | -5.20 | 5.60 |

*): Global warming potential = 23 x $CH_4$ emission + 296 x $N_2O$ emission + $CO_2$ emissions

According to the ANOVA, there were no significant different in global warming potential from either WG, OP EFB or CF. This suggested that the replacement of inorganic fertilizer with waste compost on wetland did not have negative impact on environment, especially in viewpoint of greenhouse gas emissions.

## Diversity of Oil Fungi in Oil Palm Planting Hole

Sixteen isolates of soil fungi were characterized and identified. The amount of the genere are distributed in soil samples. Five isolates were characterized as genera of *Penicillium* and *Trichoderma* from the soil sample in previously. There are seven isolates were also characterized as genera of *Penicillium*, *Rhynchosporium*, *Trichocladium*, *Bipolaris*, *Trichoderma*, and *Oidiodendron* from the soil sample in the middle period. And than, four isolates were characterized as *Gonatorrhodiella*, *Gonatobotyrs*, *Rhizopus*, and *Aspergillus* from the soil sample which was collected on the end of period. Distribution of the soil fungi described in Table 2.

Addition of the waste compost is significantly increased the diversity of soil fungi. In this cases are demonstrated in Table 2 and 3. Especially in the combininig fertilizers ( OP EPB + anorganic fertilizers) was higly than the other treatments, meanwhile the diversity of soil fungi on the soil sample that was given anorganic fertilizers without compost are lowest than two types of combining fertilizers. Although that the diversity of soil fungi in this study is no correlation with the dynamics of gas emission. The phenomena are due to no specific fungi that has

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capacity to stimulate the gas emission production. The result is differently with the Jebaraj and Raghukumar (2010) explained the activity of fungi can affected the gas emission production.

## CONCLUSION & RECOMMENDATION

It could be concluded that the use of compost increased the diversity of soil fungi without significantly effect on gas emissions from oil palm field on wetlands. Therefore, the use of compost with combining chemical fertilizers are potentially to apply into the oil palm field on wetlands.

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Table 2. Diversity of soil fungi in oil palm planting hole during the application of fertilizers (combined compost)

| No | Soil sample sources | Isolates code | Genera |
|---|---|---|---|
| 1 | Initially (0- 7 days) | FA | *Penicillium* |
| 2 | | FI | *Penicillium* |
| 3 | | FK | *Penicillium* |
| 4 | | FL | *Trichoderma* |
| 5 | | FN | *Penicillium* |
| 6 | The middle (7-43 days) | FCt | *Penicillium* |
| 7 | | FGt | *Rhynchosporium* |
| 8 | | FHt | *Trichocladium* |
| 9 | | FKt | *Bipolaris* |
| 10 | | FMt | *Trichoderma* |
| 11 | | FOt | *Trichoderma* |
| 12 | | FSt | *Oidiodendron* |
| 13 | The end (63-77 days) | FGa | *Gonatorrhodiella* |
| 14 | | FPa | *Gonatobotrys* |
| 15 | | FUa | *Rhizopus* |
| 16 | | FXa | *Aspergillus* |

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Table 3. The representative in correlation between types of fertilizers (combined compost), gas emissions, and diversity of soil fungi

| **Type of fertilizers** | **Time of sampling** | **Gas emissions** | | | **Genera** |
|---|---|---|---|---|---|
| | | **$CO_2$ (g $m^{-2}$ $h^{-1}$)** | **$CH_4$ (g $m^{-2}$ $h^{-1}$)** | **$N_2O$ (mg $m^{-2}$ $h^{-1}$)** | |
| The combined fertilizers (grass compost + inorganic fertilizers) | Initially (0-7 days) | 8665.706 | 364.202 | -1382.37 | *Penicillium* |
| | The middle (7-63 days) | 1160.221 | 241.128 | 1411.279 | *Penicillium* *Rhynchosporium* *Trichoderma* |
| | The end (63-77 days) | 3682.497 | 65.625 | 14483.55 | *Penicillium* *Rhynchosporium* *Trichoderma* *Aspergillus* |
| The combined fertilizers (OP EFB + inorganic fertilizers) | Initially (0-7 days) | 64898.13 | -7.46069 | 2966.411 | *Trichoderma* |
| | The middle (7-63 days) | 4486.408 | -3.18719 | 12675.92 | *Trichoderma* *Penicillium* *Trichocladium* *Bipolaris* *Oidiodendron* |
| | The end (63-77 days) | -846.629 | -31.2936 | 19769.03 | *Trichoderma* *Penicillium* *Trichocladium* *Bipolaris* *Oidiodendron* *Gonatorrhodiella* *Rhizopus* |
| Inorganic fertilizers without compost | Initially (0-7 days) | 2888.06 | 2.105592 | 4348.57 | *Penicillium* |
| | The middle (7-63 days) | 630.493 | -14.98 | 9593.292 | *Penicillium* |
| | The end (63-77 days) | 2965.174 | -13.266 | 20104.2 | *Penicillium* *Gonatoboytrys* |

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