Effect of DOM (dissolved organic matter) derived from litter of *Acacia mangium* and *Eucalyptus pellita* on soil N_2O emissions

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Abstract
To investigate the effects of dissolved organic matters (DOM) and particulate organic matters (POM) on soil N_2O emissions, soils with added DOM or POM obtained from the leaf litters at different decomposition degrees of two species (*Acacia mangium* and *Eucalyptus pellita*) were incubated under a wet condition for 7 days. Soil with added DOM showed greater N_2O emission than control, while POM addition seemed to have no effects on N_2O emission at least in a 1-week incubation. *A. mangium* DOM caused greater N_2O emission than *E. pellita* DOM probably because *A. mangium* DOM with low CN ratio provided larger amount of readily mineralizable N substrate for microbial N_2O production. Among two different decomposition degrees of litter, DOM from more decomposed litter had less N_2O emission than that from fresh litter. These results suggest that the function of DOM and POM of leaf litter as N_2O production substrate is quite different from each other, and the former is also different among species and decomposition stages, implying the importance of DOM quality (CN ratio and bioavailability of dissolved organic C) to control N_2O emission.

Key Words
Soil incubation, legume, tropic, forest litter, plantation.

Introduction
Fast growing tree species such as Acacia and Eucalyptus are important for industrial plantation expanding in Southeast Asia. Soil of Acacia plantation rich in nitrogen, however, emits nonnegligible amounts of N_2O (Arai *et al*. 2008), which is the third important GHGs following to CO_2 and CH_4 (IPCC 2007). Soil N_2O is mainly produced through microbial nitrification and denitrification processes which need substrates such as inorganic N and organic C in addition to the suitable condition of O_2 and temperature (Firestone and Davidson 1989). Large parts of these substrates are provided from litter likely in the forms of dissolved organic matter (DOM, $< 0.45\ \mu$ m) and fine particulate organic matter (POM, $> 0.45\ \mu$ m) leaching from litter layer with rainwater. Because of high precipitation, which is reported to accelerate production of DOM (Cleveland *et al*. 2006), the substrate for N_2O emission in the humid tropics might be largely supplied in the forms of DOM and POM in addition to incorporation of organic matter by soil fauna. But there are few reports explaining the effect of litter species and decomposition degrees of these organic matters on N_2O emission in tropical area. In this study, we demonstrated the effect of DOM and POM from leaf litter of different tree species and decomposition degrees on N_2O emission under a wet soil condition to clarify the mechanism of N_2O emission from soil in tropical plantation area.

Materials and methods
Sampling
Leaf litters were collected from 6-year-old *A. mangium* and 4-year-old *E. pellita* stands in South Sumatra Province, Indonesia (3° 48'S, 103° 55"E) in September 2008. Air-dried leaves of 2 species were devided into two decomposition degrees; relatively fresh leaves (L1) and relatively decomposed leaves (L2). A part of the litter samples were milled for CN analysis. For incubation experiment, soil was collected from 0-5 cm depth of 0-year-old *A. mangium* plantation in September 2007 (3° 47'S, 103° 55'E). It was air-dried and passed through 2mm stainless steel sieve. The soils are Acrisols (International Society of Soil Science (ISSS) Working Group RB, 1998) with a parent material of Tertiary sedimentary rocks. Total C and N of incubation soil were 37.3 mgC/g and 3.0 mg N/g and pH was 4.74.

DOM and POM extraction from litters
Each air-dried litter sample was pre-sprayed with distilled water to make the water contact close to field condition. Ten times distilled water (w/w) was added to the leaves and the suspension was kept at 5 ^{o}C in the

dark for 24 hrs with occasional shaking. The suspension was passed through 53 μ m sieve and subsequently filtered through 0.45 μ m membrane filters (cellulose acetate, Toyo) to obtain DOM (< 0.45 μ m) and POM (0.45 - 53 μ m). These fractions were immediately freeze-dried.

Incubation and gas sampling

For each treatment, air-dried soil corresponding to 20 g on an oven dry basis was placed in a 250ml glass bottle and the soil was pre-incubated at 60% WHC (water holding capacity) for 2 days to stabilize the microbial activity. Pre-incubation and the next incubation were carried out at 25 ^{o}C in the dark in four replications. DOM and POM equivalent to 2 mgC/g soil were added with distilled water to adjust the water content to 100% WHC. Bottles without organic matter addition were also set up as control. The bottles were incubated for 7-day and the soil water content was adjusted occasionally to 100% WHC. Gas was sampled from the headspace of each incubation bottle at 0 and 30 min after sealing the bottle with a rubber topper equipped with a septum. Gas sampling was conducted at 0, 0.5, 1, 2, 3, 5 and 7days. We measured N_2O and CO_2 concentration by using gas chromatographs (GC-14B, Shimazu, Kyoto, Japan) equipped with an electron capture detector and with a thermal conductivity detector, respectively. Gas fluxes were calculated from the linear increase of gas concentration in the bottle headspace during 30 min.

Statistics analysis

All statistical analyses were performed using SPSS 10.0 (SPSS Inc., Chicago, USA). Kruskal-Wallis test and thereafter Mann-Whitney test were used to determine significant differences of among the treatments. Statistical significant differences were set at P values < 0.05.

Table 1. The amount, and C and N concentrations in DOM and POM added soil.

Species	Decomposition degree	DOM				POM			
		Total (mg)	C (mg)	N (mg)	C/N	Total (mg)	C (mg)	N (mg)	C/N
A. mangium	L1	108	40	2.5	15.8	89	40	3.5	11.3
	L2	100	40	3.1	12.7	109	40	3.1	12.9
E. pellita	L1	93	40	0.6	63.9	127	40	2.5	16.0
	L2	97	40	1.2	34.1	151	40	2.6	15.2

Results

Addition of DOM to soil significantly increased N_2O emissions though POM did not compare with control (Figure 1 left). DOM from *A. mangium* L1 recorded the greatest cumulative N_2O emission (1.74 μ gN/gsoil), twice as high as the control (0.702 μ gN/gsoil). Comparing to DOMs from L1 of *A. mangium* and *E. pellita*, there were no significant differences in N_2O emission though their emissions were significantly greater than control (P < 0.05). DOM from *A. mangium* L2 showed significantly larger cumulative N_2O emission than control (P < 0.05) but that from *E. pellita* L2 did not. Comparing the decomposition degrees of litter, DOM from fresher litter had significantly greater effect on N_2O emission than that from decomposed litter (*A. mangium* L1 > *A. mangium* L2 > control, *E. pellita* L1 > control, P < 0.05). Cumulative CO_2 emission increased with the addition of DOM significantly (Figure 1 right, P < 0.05). DOM from *A. mangium* L1 was the highest in CO_2 emission (0.69 mgC/gsoil) among the all of DOM treated soils, and was more than twice as high as control (0.31 mgC/gsoil). Among the decomposition degrees, DOM from L1 caused significantly higher CO_2 emission than L2 in *A. mangium* but not in *E. pellita* (*A. mangium* L1 > *A. mangium* L2 > control; *E. pellita* L1, *E. pellita* L2 > control, P < 0.05). Though there were no significant differences in N_2O emission between soil treated POM and control, POM from *A. mangium* L1

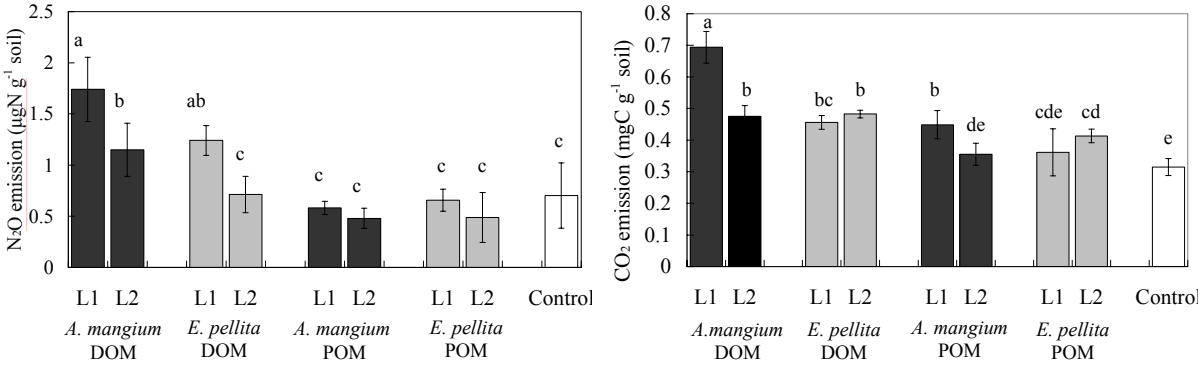

Figure 1. Cumulative emissions of N_2O (left) and CO_2 (right) during 7-day incubation from soil added with

DOM, POM and control. The vertical bars represent standard deviation (SD). Significant differences are indicated by different letters (Man-Whitney, p < 0.05).

and *E. pellita* L2 were significantly higher in cumulative CO_2 emission than control ($P < 0.05$). As a whole, N_2O emission tended to be higher in soils with added DOM from *A. mangium* rather than *E. pellita* and fresher litter than decomposed litter, and POM did not change N_2O emission significantly though some POMs accelerated CO_2 emission.

Discussion

DOM and POM showed completely different effects on N_2O production. Little N_2O emission and low C mineralization in POM added soil suggests that POM contains much recalcitrant organic matter which is more resistant against microbial utilization at least in 1 week of incubation. Higher N_2O emission from soils with added *A. mangium* DOM might be associated with the lower CN ratio of *A. mangium* DOM. This fact agrees with the results by Huang *et al*. (2004) suggesting the addition of lower CN ratio litter species increased N_2O emission. Coincidentally, the biodegradability of dissolved organic C often declines with decomposition of litter (Don and Kalbitz 2005). These facts can explain the reason why N_2O production from fresh litter DOM was higher than that from decomposed litter DOM though the CN ratio was higher in fresh litter DOM.

Conclusion

In the short term incubation under wet soil condition, the species and decomposition degrees of litter DOM affected N_2O emission while those of POM did not. These results suggest the importance of litter DOM supplied as substrates for N_2O production in the humid tropics.

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