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Interactive comment on "Responses of nitrous oxide emissions to nitrogen and phosphorus additions in two tropical plantations with N-fixing vs. non-N-fixing tree species" *by* W. Zhang et al.

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Responses to the comments:

Reviewer #3 (Anonymous Referee #3) Received and published: 16 April 2014

This study manipulates nitrogen and phosphorus addition levels to examine the responses of N2O emission in tropical plantation with N fixing and non-N fixing tree species. The research method and data collected are solid, and the phenomenon basically makes sense. I think it's an interesting study for us to investigate the competition between plant and microbial in using and transforming nitrogen. But I still have some concerns regarding the discussion of underlying mechanisms.

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Reply: Thank you very much for your constructive comments. We found some of your comments were responded in the last revision. Anyway, according to your comments we have done a thorough checking and made the necessary changes to improve the manuscript, especially in the Discussion section. Please find as follows our responses to all comments.

1) In P1421 L20-25, the authors stated that P addition increased soil available N content in AA plantation in the first year. What's the reason if no significant change in mineralization and nitrification was found in P addition treatment? It conflicts with the authors' argument that NP-addition decrease N2O emission in AA because P addition relieved P shortage and stimulated N uptake by plants (P1428 L10-15). I would like to see authors' opinion on this issue. I am thinking the different N-min and nitrification rates in two years may help to explain this phenomenon.

Answer: Thank you very much for the comments. We are so sorry that we had not made a clear explanation here. For the first experimental year, actually there was no significant statistical difference in soil available N (NO3- and NH4+) contents between P-addition treatments and the controls of the AA plantation ($p = 0.09$ and 0.47, respectively for NO3- and NH4+). The unsupported conclusion of "P-addition tended to slightly increase soil available N (NH4+ and NO3-) contents in the first year" should not been shown in the paper, because the words of "tended to slightly" in this conclusion is confused. We have now changed the sentences from "For the AA plantation, P-addition tended to slightly increase soil available N (NH4+ and NO3-) contents in the first year, especially in HP treatment plots (Table 1). By contrary, for the EU plantation, P addition significantly decreased soil available N (NH4+ and NO3-) contents in the second year (Table 1; all $p < 0.05$), while did not in the first year." to "In the second experimental year, soil NO3- content decreased significantly following P-addition in the EU plantation ($p = 0.05$), but not significantly in the AA stand (Table 1 and 3; $p = 0.39$)." in this revision. (Please see the Page 9, Lines 220-222). After the correction, it does not conflict with the conclusion that NP-addition decrease N2O emission in AA because P-addition together likely relieved P shortage and stimulated N uptake by plants. (Please see the Page 14, Lines 401-403).

2) In the control plot, soil C/N ration in AA plantation is larger than EU (Table 1). How could you confirm EU is limited by N availability? I am wondering if EU is more limited by P availability than AA, and none of these sites is limited by N. I found litter mass increase in MP addition but declined in HP, while litter mass decreased in both MN and HN additions in EU (table 2). Is it because restricted plant growth or stimulated mortality/turnover in N addition? P addition reduced N2O emission from EU plantation, which is likely because alleviation of P limitation stimulates plant growth and N uptake. But I cannot find evidence to support the argument made in this paper ("Alleviation of P limitation resulting from P-addition might restrict the stress of N limitation, and then reduced soil N2O emission from the EU plantation."). Is there any productivity measurement? Or maybe the authors have other data to convince me. BTW, this sentence is pretty awkward, and needs to be rephrased.

Answer: Thank you very much for the comments. For the question of "In the control plot, soil C/N ration in AA plantation is larger than EU (Table 1). How could you confirm EU is limited by N availability?", yes, soil C/N ratio in the control plot of AA plantation is larger than EU stand (Table 1). However in this revision, we did not say that the soil of EU plantation was limited by N availability. In the initial manuscript, we had proposed that the soil of AA was N-saturated and EU was N-limited. According to the comments of the last revision, we found that we could not confirm the soil is N-saturated for the AA or N-limited for EU plantation, because we did not have other direct evidences (productivity data, N fixation rate, N cycling and leaching rates, etc.) for proving this. We agree with your suggestion that both AA and EU plantations are not limited by N availability. Both AA and EU plantations are planted with fast growing tree species, the presence of leguminous trees may result in higher initial soil N contents (Arai et al. 2008; Konda et al. 2008) while EU plantation dominated by Eucalyptus spp. may not. Accordingly, we would like to suggest that the soil of AA as N richer than that of EU plantation, and have hypothesized that: (i) the promotion effect of N-addition on N2O emissions would be higher in the AA plantation due to its relatively higher initial soil N availability compared to the EU plantation, because of additional N input into the former via biological N fixation by leguminous trees. (Please see the Page 4, Lines 84-87). For “I am wondering if EU is more limited by P availability than AA, and none of these sites is limited by N. I found litter mass increase in MP addition but declined in HP, while litter mass decreased in both MN and HN additions in EU (table 2). Is it because restricted plant growth or stimulated mortality/turnover in N addition?”, we agree with your suggestion that the soils of both AA and EU plantations are not limited by N availability. But, we can not confirm that the soil of the EU is more limited by P availability than AA plantation. Because there was no statistical differences in litter mass among nutrient additions plots (Table 2; $p = 0.31$), and also no difference in litter mass between N-addition plots and the controls of the EU plantation (Table 2; $p = 0.07$). Moreover, we have no data of productivity measurement available now, and thus we can not confirm that it is restricted plant growth or stimulated mortality/turnover in N addition. In a pot experiment with maize (Zea mays L.), Baral et al. (2014) found that plant growth was significantly increased by P fertilization, and decreased mineral N availability in soil for microbial nitrification and denitrification, therefore reduced N2O emissions. However in our experiment, plant growth of the plantations (27-year) should not promptly response to nutrient additions in a short-term (1-2 year) experimental period. In the last revision, we had removed the awkward conclusion sentence of “Alleviation of P limitation resulting from P-addition might restrict the stress of N limitation, and then reduced soil N2O emission from the EU plantation.” from the Abstract and Discussion sections. Thus, the awkward conclusion sentence will not been shown in this revision. For the EU plantation, there were no changes in litter mass at the beginning of P-addition (1-2 years). However, the significant increase of litter P concentrations following P-additions was found. Due to affecting by stoichiometric relations with P, litter N concentration was significantly increased by P-additions (Table 2), which could likely decrease soil N availability, and then decreased N2O emissions. We had added the sentence to this revision: “Higher plant N uptake could lead to decrease N availability for microbial nitrification and denitrification that would be lost as N2O from the soil of EU plantation." to the Discussion section for the possible mechanism of P-addition decreasing N2O emission from the EU plantation. (Please see the Page 13, Lines 370-372). Reference: Arai, S., Ishizuka, S., Ohta, S., Ansori, S., Tokuchi, N., Tanaka, N., and Hardjono, A.: Potential N2O emissions from leguminous tree plantation soils in the humid tropics, Global Biogeochem. Cy., 22, GB2028, doi:10.1029/2007GB002965, 2008. Baral, B. R., Wuyper, T. W., and Van Groenigen, J. W.: Liebig's law of the minimum applied to a greenhouse gas: alleviation of P-limitation reduces soil N2O emission, Plant Soil, 374, 539-548, 2014. Konda, R., Ohta, S., Ishizuka, S., Arai, S., Ansori, S., Tanaka, N., and Hardjono, A.: Spatial structures of N2O, CO2, and CH4 fluxes from Acacia mangium plantation soils during a relatively dry season in Indonesia, Soil Biol. Biochem., 40, 3021-3030, 2008.

3) Figure 2 shows that P addition in EU plantation significantly decreased N2O emission, which is even smaller than control. However, P addition alone has no effect on AA's N2O release. The authors argue that it is likely because AA is an N fixing species and has higher initial soil N status. P addition may alleviate P shortage. But the pattern shown in Figure 2 looks not in line with this guess. The non-N fixing species has more response to P addition. How do you explain it?

Answer: Sorry that we did not make it clear in the text. We agree with you that Fig. 2 showed that non-N fixing species has more response to P addition: P addition in EU plantation significantly decreased N2O emission, which is even smaller than the control. However, P addition alone has no effect on AA's N2O release. Reasons for these different responses given in the text were as follows. For the EU plantation, the possible mechanism is "Higher plant N uptake could lead to decrease N availability for microbial nitrification and denitrification that would be lost as N2O from the soil of EU plantation." (Please see the Page 13, Lines 370-372). To make it clear, we had added more explanation with "For our EU plantation, the significant increases in P concentrations and decreases in N:P ratios of leaf litter proved that P-addition increased P

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uptake, as well as leading to faster N uptake by plants." in the last revision, (Please see the Page 1427, Lines 17-20 in the last revision) and also been showed in this revision (Please see the Page 14, Lines 380-382). For AA plantation, "P fertilization did not change N2O emission from the AA plantation soil. The mechanism is currently not clear". (Please see the Page 1427, Lines 20-21 in the last revision). Thus, we can tell from above (or the text in the last revision) we did not have any argue for AA plantation. The reason for this is currently not clear and we will further study in the future. (Please see the Page 14, Lines 382-385). It is a complex response of forest ecosystem to P addition. We have only tested the index of soil N2O emission after P addition, indicting the non-N-fixing species has more response to P addition than N-fixing species. Further study is necessary to identify and clear it.

4) In Figure 2, N addition alone in AA has increased N2O emission, and this increase declined in NP addition. However, P addition alone did not change N2O emission in 2-year measurement. The authors also pointed it out (P1427 L20-25), but didn't give clear explanation. Is it because P shortage of AA is more significant at high N input levels, or P addition alone does not stimulate plant N uptake at current N deposition rate? Do you have other data to test this?

Answer: For "However, P addition alone did not change N2O emission in 2-year measurement", the reason for this is currently not clear and we will further study in the future. (Please see the Page 14, Lines 382-385). We would like to suggest the possible mechnism as follows: Because that AA plantation has more initial available N for companying with plants uptake and utilizing P, soil N substrate did not significantly decrease after P addition, and thus no significant changes in N2O emission at the beginning of the experiment (1-2 years). In other word, this might be contributed that N availability in the AA plantation is enough to satisfy the increased N demand induced by P fertilization. Unfortunately, we can not confirm it because we have no direct evidences from the present study. We are so sorry that we did not have other data to test the question of "Is it because P shortage of AA is more significant at high N input levels, or P addition alone does not stimulate plant N uptake at current N deposition rate?". This will refer to a novel idea for continuing our research. The soil of AA plantation responded to N-addition greater than the EU stand, with a large and immediate loss of N2O emission. We had proposed the possible explanation was "The initial soil N status between both plantations contributed to the different responses of N2O emissions to N-addition." (Please see the Page 12, Lines 342-343 in this revision), and "Moreover, the rates of net N-mineralization and nitrification in the AA plantation were significantly increased following N applications." in this revision. (Please see the Page 13, Lines 346-348 of the revision). NP-addition decreased N2O emission compared to N-addition alone in the AA plantation. Repeated measures analysis indicated that there was a significant interaction of N- $\times$ P-addition on N2O emissions form the AA plantation. (Please see the Page 11, Lines 295-296). We had added the possible explanation "The main cause of this might be that most of added N was absorbed and utilized by the vegetation after relieving the P shortage by applied P together." in the last revision (Please see the Page 1428, Lines 11-13), and also shown in this revision (Please see the Page 14, Lines 402-403).

5) Table 4: I'd like to see the errors of emission factor among replicates in each treatment, and the significance levels of difference.

Answer: We have added the SE of N2O emission factors and annual mean N2O emissions among replicates to the Table 5, and given the different letters "a, b" represent as significant difference among the treatments. The necessary changes have been made in the Notes. (Please see the Page 28, Table 5 and Lines 648-651). In order to answer the comments of Anonymous Referee #1, we have added Table 4 for regression analysis between N2O fluxes and soil temperature and WFPS to this revision. The order of initial Table 4 has been changed to Table 5, and the Fig. 3 has been removed from this revision. We have also added a word "significantly" and p value to the sentence of "Compared to HN treatment, HNP-addition significantly decreased the N2O emission factor by 50% at the AA plantation (Table 5, p = 0.04).". (Please see the Page 15, Lines

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436 and 437).

6) Abstract: please indicate which species is N fixing and which is non-N-fixing in the beginning.

Answer: Thank you very much for the comments. We have inserted “N-fixing” and “non-N-fixing” into the parentheses following tree species of “Acacia auriculiformis” and “Eucalyptus urophylla”, respectively. (Please see the Page 2, Lines 15-16). We have also deleted the repeated phrase of “with N-fixing vs. non-N-fixing tree species” from the next sentence. (Please see the Page 2, Line 18).

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/11/C1987/2014/bgd-11-C1987-2014-supplement.pdf

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