学位論文内容の要旨

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学位論文題名

Effects of long-term nitrogen fertilization on soil CO_2 and N_2O fluxes in a tropical peatland

（熱帯泥炭地における長期窒素施肥が土壌CO_2およびN_2Oフラックスに及ぼす影響）

The conversion of tropical peat swamp forest into oil palm plantation requires drainage and fertilization which typically accelerates the rate of peat mineralization and enhances soil CO_2 and N_2O emissions to the atmosphere. While effects of N fertilizers from cultivated tropical peatland are still limited, the understanding of this subject is essential to develop the mitigation approach for sustainable management of tropical peatland for agriculture.

Long-term field measurement was conducted (i) to quantify soil N_2O emissions by varying the rates of N fertilizers and identify key factors influencing the response of soil N_2O emissions under N fertilization (ii) to quantify the annual soil CO_2 emissions from different N rates and identify the regulatory factors affecting soil CO_2 fluxes over time, including temporal effect of ground water level (GWL) on CO_2 fluxes and (iii) to investigate the effect of N fertilizer on peat decomposition under different water-filled pore space (WFPS) via incubation study.

1. Soil N_2O Emissions under Different N Rates in an Oil Palm Plantation on Tropical Peatland.

A study was conducted in an oil palm plantation (*Elaeis guineensis* Jacq.) located in a tropical peatland in Sarawak, Malaysia from January 2010 to December 2013 and resumed from January 2016 to December 2017. Soil N_2O fluxes, GWL, WFPS, oil palm yield and nitrate (NO_3^-) were measured in four different N rates; control (T1, without N fertilization), low N (T2, 31.1 kg N ha^{-1}), moderate N (T3, 62.2 kg N ha^{-1}), and high N (T4, 124.3 kg N ha^{-1}). Although the effect of N application on annual cumulative N_2O emissions was only significant for T4, N application still has the potential to induce annual cumulative N_2O emissions when fertilizer rate more than 62.2 kg N ha^{-1} yr^{-1} N. Both GWL ($p<0.001$) and WFPS ($p < 0.01$) were significant predictors for all treatments

in which the effect of GWL on N_2O flux increased as the N rates increased. Increasing of WFPS (>70%) with decreasing in both N_2O flux and NO_3^- started in 2012 could be due to complete denitrification and reduction in gas diffusivity. N fertilization had no significant effect on annual oil palm yield (p = 0.994) but negative correlation between annual oil palm yield and both annual cumulative N_2O emissions and NO_3^- ($p < 0.05$) suggest that increased oil palm yield reduced NO_3^- in soil via N uptake, resulting in lower N_2O emissions.

2. Effect of long-term ground water level control and N fertilization on CO_2 fluxes from oil palm plantation on tropical peatland.

Study site and treatments were as in Study 1. Application of N fertilizer had no significant effect on annual cumulative CO_2 emissions in each year (p=0.448) as found by few studies in tropical peatland. Negative relationship between GWL and CO_2 fluxes and positive relationship between GWL on WFPS were found in year 2010 ($p<0.001$) and 2011 ($p<0.05$) imply that GWL was strongly affected both WFPS and CO_2 fluxes during the young phase of oil palm. Decreasing of CO_2 fluxes with the increasing in WFPS and decreasing in soil porosity with time indicate the importance of drainage and compaction of the peat. Positive correlation between CO_2 fluxes and N_2O fluxes were found ($p<0.01$), suggesting that N_2O emission increased with the increase of CO_2 emission by peat decomposition.

3. Incubation Study: Effect of Different N rates on Peat Decomposition Under Different Soil Moisture Level

It is known that oxidative peat decomposition dominates heterotrophic respiration but our field measurement only account for total soil CO_2 emission (sum of root respiration and microbial respiration). Thus, to investigate the effect of N fertilizer on peat decomposition, peat soil was incubated with four fertilization treatments; T1 (control- 0 mg N kg^{-1} soil), T2 (780 mg N kg^{-1} soil), T3 (1550 mg N kg^{-1} soil) and T4 (3110 mg N kg^{-1} soil) at two different WFPS; 50% and 80% WFPS. There was no significant effect of N fertilization on both cumulative CO_2 (p=0.5665) and N_2O emissions (p=0.5979), corresponding with results from field studies. Only N_2O emissions from fertilized treatments were significantly affected by soil moisture where cumulative N_2O emissions in 80% WFPS were significantly higher than 50% WFPS in fertilized treatments ($p<0.001$). In agreement with field measurements, N_2O fluxes was positively correlated with CO_2 fluxes in both 50% and 80% WFPS ($p<0.01$).