学位論文の要旨

Abstract of Thesis

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学位論文題目 Title of Thesis（学位論文題目が英語の場合は和訳を付記）

Evaluation of nitrous oxide and carbon dioxide emissions from manure compost-amended soil
堆肥施用土壌からの一酸化二窒素および二酸化炭素排出速度の評価

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Nitrous oxide (N_2O) is an important greenhouse gas, which depletes the ozone layer and has a strong greenhouse effect (Zhu *et al*., 2014). In agricultural soil, compost application either enhances N_2O emission by increasing the supply of nitrogen (N) and carbon (C) available for microorganisms or reduces it by promoting N immobilization (Lim *et al*., 2018; Westermann *et al*., 2021; Wright *et al*., 2008). Emissions of N_2O and carbon dioxide (CO_2) from compost-amended soil can be affected by different compost and soil properties. Interactions between manure compost and soil properties on N_2O and CO_2 emissions have not been clearly known. Studies discussing the effects of ammonium N (NH_4^+-N) additions on N_2O and CO_2 emissions from manure compost-amended soil are not sufficiently determined. Moreover, in existing process-based biogeochemical models of N_2O emissions, different sets of parameters are included in different mathematical equations for nitrification and denitrification. Most of these models have been developed to represent the effects of mineral N fertilization on N_2O emissions (Del Grosso *et al*. 2008). There is a lack of understanding on how to represent nitrification and denitrification in manure compost-amended soil in model equations. Therefore, this thesis aimed at

1) determining N_2O and CO_2 emissions from two soils amended with different manure composts and the relative abundances of key functional ammonia-oxidizing genes,
2) investigating N_2O and CO_2 emissions from manure compost-amended soil at different NH_4^+-N rates and the relative abundances of denitrification-related genes, and
3) developing mechanistic models for N_2O emissions from upland and paddy soils amended manure compost.

To achieve these objectives, cattle manure compost (CC) or mixed compost (MC) (mixture of cattle, poultry, and swine manure) were amended with Kochi (upland) or Ushimado (paddy) soils and emissions of N_2O and CO_2 were determined in aerobic incubation experiments. Kochi soil showed

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higher total N and C, and mineral N contents compared with Ushimado soil. Among manure compost types, MC was susceptible to decomposition, while CC was resistant.

Results showed:

1) cumulative N_2O and CO_2 emissions were significantly higher in MC-amended soil than those in CC-amended soil, which were attributable to higher NH_4^+-N content and faster N mineralization due to the low C/N ratio. Emissions of N_2O and CO_2 were higher in MC- or CC-amended Kochi soil (70% water holding capacity: WHC) due to higher N, C, and clay contents and higher water-filled pore spaces (WFPS) than those in Ushimado soil at the same WHC. The application of CC increased N_2O emissions only from fertile Kochi soil. Emissions of N_2O until day 15 were mainly regulated by the activities of AOB *amoA* functional genes;
2) in both Kochi and Ushimado soils with CC and no compost, raising NH_4^+-N rates from 160 to 200 (mg-N kg^{-1}) increased N_2O emissions by stimulating nitrification. Increasing NH_4^+-N rates from 200 to 400 generally decreased N_2O and CO_2 emissions by suppressing microorganisms by osmotic stress and limited C availability, except for N_2O emissions in MC- and CO_2 emissions in CC- and no compost-amended Ushimado soil. Emissions of N_2O were positively related to copy numbers of the *narG* gene only in Kochi soil with higher N and C contents and higher WFPS than those in Ushimado soil; and
3) a linear model for N_2O emissions in nitrification or denitrification is composed of an equation of consumed NH_4^+-N or nitrate N contents. In addition, N_2O emissions showed a steady state with NH_4^+-N contents (>100 mg-N kg^{-1} for MC- and <79 mg-N kg^{-1} for CC-amended soils) during nitrification. The linear model for N_2O emissions in nitrification reproduced N_2O emissions well in both Kochi (upland) and Ushimado (paddy) soils. The model for N_2O emissions in denitrification reflected N_2O emissions only in Kochi (upland) soil. The model for N_2O emissions from respiration during denitrification was a function of CO_2 emissions and was applicable in both soils.

This thesis provides a better understanding of effects of properties of compost and soil, their interactions, and influences of different NH_4^+-N rates on N_2O and CO_2 emissions from manure compost-amended soil. The findings of this study can be used in compost management strategies with mitigating N_2O and CO_2 emissions such as the selection of appropriate compost types in agricultural soil. The mechanistic models in our study can be used to predict N_2O emissions from manure compost-amended soil and improved under field in future.