論 文 の 内 容 の 要 旨

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論文題目　**Nitrogen loading from Japanese tea fields as estimated with a biogeochemical model: DNDC**
(生物地球化学モデル DNDC を用いた日本茶園からの窒素負荷の評価)

Chapter 1. Introduction

Japanese tea fields receive large amount of nitrogen (N) inputs from chemical fertilizers and organic matters. While N promotes the production and quality of tea leaves, surplus N can cause environmental problems by leaching into waterways or being emitted as a potent greenhouse gas: nitrous oxide (N_2O).

The Denitrification and Decomposition (DNDC) model was originally developed for estimating greenhouse gas emissions from U.S. agro-ecosystems. This model incorporates a suit of processes that describe soil hydrology, plant growth and biogeochemical reactions governing transport and transformation of C, N and water in plant-soil systems.

This thesis reports on an attempt to improve DNDC for estimating N_2O emissions and nitrate (NO_3-N) leaching from Japanese tea fields. I modified DNDC to extend its capacity to simulate agronomic and biogeochemical processes in the tea fields in Shizuoka and Kagoshima prefectures, the two major tea producing areas in Japan. I then estimated the N_2O emission and NO_3-N leaching from the tea fields across Japan by using the improved model, and assessed the efficacy of an alternative fertilization practice to mitigate N loadings.

Chapter 2. Testing DNDC for its applicability to Japanese tea fields

The comparison of the simulated N_2O emission flux with the observations in a field in Aichi prefecture indicated that DNDC is applicable to the simulation of N_2O emissions from Japanese tea fields. However, the results indicated the needs for modifications to accurately estimate of the N loading from Japanese tea fields. Modifications are also required to the harvest routine of tea cultivation system and biogeochemical processes in acid soils, which is prevalent in Japanese tea fields due to the very heavy doses of N fertilizers.

Chapter 3. Nitrous oxide emissions from Japanese tea fields as simulated with modified DNDC model

DNDC was modified according to the observations in the tea fields having very acidic soils in Shizuoka prefecture. The modifications included: (1) new parameterizations for tea plant physiology and phenology, (2) partitioning of plant biomass in regard to the harvest routine of tea cultivation system, (3) new parameterization for microbial activities: nitrification and denitrification under low pH, and (4) addition of chemodenitrification occurring in acidic soil conditions. The modified DNDC was better able to capture the magnitudes and temporal patterns of N_2O emissions under different fertilizer treatments. Sensitivity tests showed that the alternative fertilization practices could enhance or mitigate N_2O emissions at the experimental site.

Chapter 4. Nitrate leaching from Japanese tea fields as simulated with modified DNDC model

DNDC was tested in simulating the observations in a tile-drainage experiment in Kagoshima prefecture. This result indicated that DNDC could simulate discharge flow and N leaching from Japanese tea field. Sensitivity tests showed that NO_3-N leaching could be reduced by soil properties and alternative managements at the experimental site.

Chapter 5. Estimating N loading from the tea fields and assessing alternatives for mitigation of N loading across Japan

In this chapter, I estimated the N_2O emissions and NO_3-N leaching from tea fields across Japan for 10 years from 2001 to 2010 using the modified DNDC (DNDC-Tea). The simulation with DNDC-Tea estimated N_2O emissions and NO_3-N leaching from Japanese tea fields as 0.64 Gg N_2O and 13.01 Gg N, respectively, on average across the 10 years. The process-based model allowed the effects of soil properties, climates and farming practices on the estimates of N_2O emission and NO_3-N leaching. While DNDC estimates (0.64 Gg N_2O) of N_2O emission from Japanese tea fields was less than half the estimate (1.3 Gg N_2O) based on a constant fraction of N_2O emission in total N supply, the former is arguably, more realistic than the latter. The alternative management scenario across Japan was tested with DNDC-Tea, and the results suggested that the efficacy of the alternative management in mitigating the N loading from tea agro-ecosystems depends on the fertilization pattern, local soil properties and climate conditions.

Chapter 6. General discussion

The findings in the preceding chapters are synthesized and discussed against the wider context of climate change mitigation and sustainable agriculture. The findings showed that DNDC-Tea facilitates reliable prediction of N_2O emissions and NO_3-N leaching at regional and national levels and that the model shall be useful for comprehensive assessment of climatic impacts and sustainability in Japanese tea agro-ecosystems. DNDC, with the new capability of simulating the tea agro-ecosystems shall be a powerful tool for farmers and crop and environmental managers to accurately predict crop production and environmental impacts for a wide range of farming operations and climate conditions in tea agro-ecosystems. This study is an initial step towards this direction.