学 位 論 文 要 旨

Spatial and Temporal Variations in Soil Parameters, Plant Growth and Environmental Impact of Paddy Rice Production in South East Asia

東南アジアの水稲生産における土壌因子、植物生長および環境負荷の空間的および時間的変動

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It is essential to know the spatial variability of soil factors and their influence on the variability of crop growth and yield, and greenhouse gas emission from lowland rice ecosystem for developing the site-specific management strategies of crop for sustainable rice production in Southeast Asia. For this purpose, two field experiments were conducted in Northwest Vietnam and lowland Myanmar. The research objectives were i) to assess the spatial variations in soil properties, crop yield and CH_4 emission related to field positions, ii) to assess the influence of mineral fertilizer on plant growth related CH_4 emission from paddy soils and iii) to conduct a quantitative analysis of the relation of grain yield and greenhouse gas emission to the economic benefit of the different positions in these study areas of Southeast Asia.

In 2011, field experiment was conducted in spring and summer rice seasons with two cascades of double-cropping paddy rice fields in Yen Chau district, Northwest Vietnam. The cascades were divided into fertilized and non-fertilized parts and all measurements were conducted at top, middle and bottom field of each part. Silt and clay content showed increasing trend towards the bottom field positions while higher sand content was observed in top field positions in both cascades. Total nitrogen and carbon contents showed higher in lower lying fields than that in the top field positions. Plant growth and yield component parameters showed higher in middle positions than that of other positions. Grain yields in the middle fields were higher than other field positions in both fertilized and unfertilized parts.

Variations in CH_4 emissions were also observed and the results showed that the rate and cumulative amount of CH_4 emissions in non-fertilized part were higher than that of fertilized one in both crop seasons. The spatial variation in CH_4 emissions among the positions was high in both cropping seasons with the highest in the bottom fields and the lowest in the top fields. The differences among field positions were influenced by clay content, TN and TC content which showed toposequence differences. Cumulative CH_4 emissions for spring rice

ranged from 3.1 to 13.7 g CH_4 m^{-2} and that for summer rice from 4.3 to 23.5 g CH_4 m^{-2}. 61.7% were emitted during summer rice season and 38.1% from spring rice season.

In 2012, field experiment was conducted with two successive rice fields (1st field and 2nd field) in Kanyutkwin district, Pago Division, Myanmar. The fields were divided into fertilized and non-fertilized parts and all measurements were conducted at inlet, middle and outlet positions for both fields. Decreasing trend of sand content, soil total nitrogen and total carbon content were observed, while silt content tended to increase from 1st inlet to 2nd outlet position. Plant growth parameters showed better performance in all positions in the 1st field than in the 2nd field. High grain yield and yield components were observed in 1st inlet, 1st middle and 1st outlet positions in the 1st field. Farmer practice of fertilization increased grain yield over non-fertilized part, but it was not significant in all positions in the 1st field. In the 2nd field, although grain yield significantly increased in all positions due to fertilization, yield was still lower than that in the 1st field.

Considerable variations in CH_4 emissions were recorded among the positions, which were influenced by soil temperature, surface water pH, Eh, surface water depth, as well as the clay and TC content of soil. The CH_4 flux of the 1st outlet and 2nd inlet were 53.2 and 66.5 g CH_4 m^{-2}, respectively, and were 2 to 2.5 times higher than that of other positions. Seasonal cumulative CH_4 emissions for the 1st and 2nd fields were 33.6 and 39.3 g CH_4 m^{-2}, respectively. Fertilization reduced CH_4 emission in the 1st inlet (18.1%), 1st outlet (50.4%), 2nd inlet (15.9%) and 2nd outlet (13.4%). However, an increase in CH_4 emission due to fertilization occurred in the 1st middle (43.8%) and 2nd middle (7.7%) which might be related to different micro-elevation in the field.

Relationships among the grain yield, net income and greenhouse gas emission among the field positions were conducted using eco-balance analysis method. Rice production cost in Vietnam was comparably higher due to high cost of seeds, fertilizers and pesticides than that in Myanmar. Land preparation and labor costs were comparable in both study sites. High ranges of net incomes were observed among the positions of toposequence rice in Northwest Vietnam than that in Myanmar. Methane emission flux was higher in lowland, Myanmar than that in toposequence rice fields due to much more negative of soil redox status with high total C content of rice soil. High grain yields with low emission fluxes were achieved in fertilized and non-fertilized parts of middle positions in toposequence rice fields in Northwest Vietnam and mostly non-fertilized parts of all positions in the 1st field of lowland rice in Myanmar.