学位論文内容の要旨

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学位論文題名

Management practices and climate change influencing on rice yield and soil organic carbon in Northeast Thailand

（東北タイにおける管理作業と気候変動のイネ収量と土壌有機炭素への影響）

Introduction

Increasing concern of climate change requires the development of agricultural practices for maintaining agricultural productivity with reducing greenhouse gas (GHG) emissions to the atmosphere. The Environmental Policy Integrated Climate (EPIC) model is a notable integrated model of management of the soil–water–atmosphere system. The model is able to simulate the impacts of climate change and management practices on crop yields and soil organic carbon (SOC) dynamics. In this study, following three specific objectives were performed: Firstly, investigation rice yield and SOC content under different land management practices (manure, fertilizer application and burning rice residues). Secondly, estimation the effect of land management practices on net global warming potential (GWP) and greenhouse gas intensity (GHGI). Finally, evaluation of possible impact of climate change on rice yield and SOC sequestration using the EPIC model.

Materials and Methods

Study was conducted in a rice paddy area of sandy soil of Thung Kula Sub-district, Suwannaphum District, Roi-Et Province, Thailand. In 2014, SOC and soil properties in 0 to 40 cm depths were measured at 64 sites covering 59.45 ha (24 sites covering 22.29 ha from irrigated area and 40 sites covering 37.16 ha from rain-fed area). At 13 sites of the 64 sites, SOC was estimated by the Land Development Department in 2004, and soil organic carbon sequestration rate (SOCSR) from 2004 to 2014 was calculated. At each sampling site, questionnaires to farmers were conducted to gather the information on rice yield and their practices during 2010–2014. The CO_2, methane (CH_4), and nitrous oxide (N_2O) emissions associated with the management practices were calculated using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The net GWP was calculated as total CO_2 emissions equivalents minus the SOCSR in the rice field, and the GHGI was calculated as a ratio of net GWP and rice yield. The EPIC model was calibrated using measured rice yields, SOC, and management practices of 13 sites in 2004, and was validated using the measured values of all 64 sites. Coefficient of determination (R^2) and Nash–Sutcliffe model efficiency coefficient (*Ens*) were used to evaluate model performance. Using the properly calibrated parameter values, simulation was conducted for two long-term periods (2015–2045 and 2045–2075) under the IPCC A2 (medium high emissions) and B2 (medium low emissions) scenarios, which were proposed by the Southeast Asia

START Regional Center. Data for the baseline period (1986–2014) were from the Thai Meteorological Department.

Results and Discussion

1) Practices sustaining soil organic matter and rice yield

Mean rice yield and SOC were significantly higher in irrigated area than rain-fed area (2.93 Mg ha^{-1} yr^{-1}, and 47.09 Mg C ha^{-1}, respectively in the irrigated areas, and 2.38 Mg ha^{-1} yr^{-1}, and 32.08 Mg C ha^{-1} in the rain-fed areas). There was a significant positive correlation between rice yield and SOC in both irrigated and rain-fed areas. Furthermore, rice yield was significantly correlated with manure, crop residue, and fertilizer applications. Balancing the nutrients increases rice yield and SOC.

2) Practices for reducing greenhouse gas emissions from rice production

Net GWP ranged from -433 to 5554 kg CO_2eq ha^{-1} yr^{-1}, with an average value of 2464 kg CO_2eq ha^{-1} yr^{-1}. GHGI ranged from -0.16 to 2.41 kg CO_2eq kg^{-1} yield, with an average value of 1.02 kg CO_2eq kg^{-1} yield. The management practices leading to low net GWP and GHGI were no burning rice residues and combined application of manure and chemical fertilizer or application of chemical fertilizer only.

3) Using EPIC model to predict local scale impact of climate change on rice yield and soil organic carbon sequestration

EPIC model was well calibrated for rice yield (R^2 = 0.64 and *Ens* = 0.61) and for SOC (R^2 = 0.75 and *Ens* = 0.72). The model was very well validated for rice yield (R^2 = 0.77 and *Ens* = 0.75) and for SOC (R^2 = 0.86 and *Ens* = 0.82). Higher average temperatures and precipitations under the A2 scenario in the study area increase rice yields more than those under the B2 scenario, especially in rain-fed areas. Conversely, climate change decreases SOC sequestration in the model because of rises in temperature and precipitation that accelerate SOC decomposition.

Conclusion

This study clearly showed strong correlation between rice yield and SOC, and the management practices of manure, residue and fertilizer applications increased rice yield and SOC. Burning residue was the main cause to increase GWP in rice paddy area. Increase of temperature and precipitation with climate change may increase rice yield, but may decrease SOC. Increase of temperature and precipitation stimulates microbial activities increasing the rate of SOC decomposition, and high amount of precipitation increases soil erosion reducing SOC. Furthermore, sandy soil, which dominates in this study area, is easy to decrease SOC due to low clay content to protect the SOC from microbial decomposition. Therefore, management practices of manure and residue applications, avoiding burning crop residues and balancing nutrients by chemical fertilizer application will be more important for sustainable rice production in Northeast Thailand.