Abstract

Global warming is mainly caused by the emission of greenhouse gases (GHGs) due to human activities. The major GHGs, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are emitted from agroecosystems, and quantification of these GHGs emission has been separately carried out. In paddy fields, CH_4 is produced by methanogens under the flooded anaerobic conditions. The CH_4 emission from paddy fields is reported to account for 4-9% of the annual global emission. Thus, it is effective for mitigating global warming to decrease CH_4 emission from paddy fields by some field management, but these also affect CO_2 and N_2O emission. The CH_4 and CO_2 emission shares soil carbon as a substrate. For sustainable rice cultivation, it is necessary to consider the carbon cycle in a paddy field. However, there are few reports on the carbon budget including both CH_4 and CO_2 emission. The objectives of this study were to quantify the effects of field management on CH_4 and CO_2 emission from a paddy field, and to propose integrated management for mitigating the CO_2-equivalent emission with considering the Global Warming Potential.

A series of field and pot experiments were carried out at the Agricultural and Forestry Research Center, University of Tsukuba, Japan in 2001 to 2004. Experimental factors were type and rate of nitrogen application, method of water management, and rate of rice straw incorporation. Type (ammonium sulfate [AS] and urea) and rate of nitrogen fertilizer have been reported to affect CH_4 emission. Drainage of the flooded water decreases CH_4 emission with causing the oxidative conditions to the soil. I suggested the water management based on soil redox potential named Eh control. Straw incorporation generally increases CH_4 and CO_2 emission, but has a potential for increasing soil carbon storage. The CH_4 and CO_2 emission were estimated from the results of flux measurements by a closed chamber method. Carbon fixation by rice plants was also measured. The CO_2-equivalent emission (g CO_2 m^{-2} y^{-1}) and the carbon gas budget in the soil (g C m^{-2} y^{-1}) were calculated.

The CH_4 emission was decreased with increases in AS and urea application rate. The CH_4 emission at AS application was lower than that at urea application, but increases in AS application rate caused decreases in soil carbon content (%). With increases in urea application rate (under the conditions of

no straw application), the CO_2-equivalent emission was decreased mainly as a result of decreases in CH_4 emission. However, the carbon gas budget in the soil showed loss at all rates. This result indicates a necessity of applying organic matter for the conservation of soil carbon storage. The CH_4 emission was decreased with increases in the frequency of drainage. The Eh control decreased CH_4 emission to lower than half of continuous flooding, i.e. to the minimum level without regard to the annual variation. However, CO_2 emission from the oxidative soil during Eh control was not negligible amount. Straw incorporation increased the CO_2-equivalent emission, but decreased the carbon gas loss from the soil. Moreover, it was evident that straw incorporation has a possibility to increase soil carbon storage from the results of decreases in soil particle density and increases in plant residue in the soil.

In conclusion, the combination of Eh control and straw incorporation decreased the CO_2-equivalent emission and the carbon gas loss from the soil to 43 and 50% of the combination of continuous flooding and straw removal, respectively. This study demonstrated that the combination of Eh control and straw incorporation is effective to establish the ideal state that decreases GHGs emission and increases soil carbon storage for mitigating global warming. It is necessary for increasing soil carbon storage to control the decomposition of soil organic matter and to increase humus content.