学位論文内容の要旨

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学位論文題名

Effect of manure application on carbon budget in managed grassland and corn field in southern Hokkaido, Japan

（北海道南部の草地と飼料畑における炭素収支への堆肥施与効果）

Carbon dioxide (CO_2) exchange between terrestrial ecosystem and the atmosphere results from photosynthesis and autotrophic and heterotrophic respirations. Photosynthesis assimilates atmospheric CO_2 to plant body, which is main natural carbon (C) import into the ecosystem, called as gross primary production (GPP). Autotrophic and heterotrophic respirations emit CO_2 from plant body and dead organic matter including soil organic matter to the atmosphere, respectively, which are main natural C export from the ecosystem, called as ecosystem respiration (RE). The difference between GPP and RE is net ecosystem production (NEP), and is directly measured by eddy covariance method. The NEP represents the amount of C used to produce new biomass in the ecosystem. Therefore, NEP is also described as the difference between net primary production (NPP) and heterotrophic respiration (RH), which are measured by biometric method and chamber method, respectively. The RH is often measured in the root exclusion plot. Root respiration (RR) is estimated as the difference between soil respiration (RS) measured in root intact plot and RH. In agricultural ecosystem, management practices influence the ecosystem C budget. Manure application is main anthropogenic import of organic C into the ecosystem, and harvest is main anthropogenic export of organic C from the ecosystem. Therefore, C budget in agricultural ecosystem is estimated as NEP + manure application - harvest, which is called as net biome production (NBP). In this study, the combination of eddy covariance, biometric and chamber methods was used to evaluate and compare the effect of manure application on the C budget in managed grassland and corn field.

1. Effect of manure application on the C budget of managed grassland

The C budget of a managed grassland in Shin-Hidaka, Hokkaido, Japan was estimated for five years (2008-2012). Chemical fertilizer was applied to fertilizer (F) plot at a rate of 79 ± 20 kg N $ha^{-1}·yr^{-1}$. In the manure (M) plot, dairy cattle manure was applied at a rate of 10 Mg fresh matter ha^{-1} yr^{-1} (1923 ± 407 kg C $ha^{-1}·yr^{-1}$, 159 ± 68 kg N $ha^{-1}·yr^{-1}$). There was no significant difference in seasonal GPP and harvest between the treatment plots, indicating that both fertilizer and manure can increase the biomass production. Annual NEP and RE was significantly different between the treatment plots. The difference in RE, and between M and F plots approximates heterotrophic respiration of manure (RHm), which ranged from 1.2 to 1.3 Mg C $ha^{-1}·yr^{-1}$. Average annual RHm was 1.3 ± 0.1 Mg C $ha^{-1}·yr^{-1}$, and accounted for 40 % of the total amount of applied manure C. The annual NBP in the M plot (from 0.5 to 1.5 Mg C $ha^{-1}·yr^{-1}$) was significantly higher than in the F plot (-1.1 to 0.7 Mg C $ha^{-1}·yr^{-1}$). The long-term effect of manure application combined with chemical fertilizer did not reduce grass production compared with chemical fertilizer only; however, manure application decreased the NEP throughout manure decomposition, and long-term manure application enhanced the NBP.

2. Land use change effect on C budget

The knowledge of the effect of land use change on C budget is limited. This study compared the effect of manure application in managed grassland and corn field. The manure applied managed grassland was converted into corn field in 2013 and C budget was measured for two years. Fifty Mg fresh matter $ha^{-1}·yr^{-1}$ (4864 ± 823 kg C $ha^{-1}·yr^{-1}$, 268 ± 108 kg N $ha^{-1}·yr^{-1}$) of manure was applied to the corn field. Annual GPP and RE slightly decreased after the conversion from managed grassland to corn field, while NEP slightly increased. Annual harvest in corn field was three times greater than that in managed grassland. The conversion to corn field significantly decreased RS due to the reduction of RR. Annual RH after the conversion to corn field significantly increased due to increase of RHm, which may be ascribed to tillage in corn field. Annual RHm in corn field was 2.5 ± 0.0 Mg C $ha^{-1}·yr^{-1}$ which accounted for 52% of manure C application rate. Consequently, annual NBP in corn field decreased to -2.0 ± 0.4 Mg C $ha^{-1}·yr^{-1}$. Although the amount of manure C applied in corn field was 2.5 times greater than that in managed grassland, the conversion from managed grassland to corn field led the ecosystem to be C source.