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Effect of Renovation on Greenhouse Gas Emissions in a Managed Grassland

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1. Introduction

Renovation practices effect on greenhouse gas (GHG) emissions need to be evaluated for sustainable land management and protecting the environmental quality. Soil disturbance during renovation and tillage incorporation with residue may increase GHG emissions (Prior et al., 2000; Reicosky and Lindstrom, 1993). Since the state of tillage method and residue management can be considered to be different depending on the different renovation method, therefore this study were to investigate the effects of renovation practices on soil GHG emissions in a managed grassland, to evaluate the effects of renovation practices related to environment factors to soil GHG emissions, and to assess the greenhouse gas intensity (GHGI) expressed as Global Warming Potential (GWP) per unit crop yield in order to provide data that could contribute to decision-making for sustainable agricultural practices.

2. Materials and Methods

The study was conducted in a managed grassland with Timothy grass (*Phleum pretense* L.) as main species at Shizunai Experimental Livestock Farm of the Field Science center for the Northern Biosphere, Hokkaido University, Japan. Six different tillage treatments under split-plot design with three replications were established on 1 September 2015: No tillage plot (NT), strip-tillage (ST), shallow tillage-15 cm depth with residue (T15+) and without residue (T15-), deep tillage-30 cm depth with residue (T30+) and without residue (T30-). All plots were sprayed by herbicide on 25 August 2015 and seeded on 3 September 2015. The amount of residue input was 1.14 Mg C ha^{-1}. CO_2, CH_4 and N_2O fluxes were measured by closed chamber method. CO_2 emissions from bare plot and planting plot in each treatment were defined as microbial respiration (Rh) and soil respiration (Rs), respectively.

3. Results and discussion

Rs from all treatment plots were relatively high in early period immediately after tillage operations. The Rs rate ranged from -0.88 to 424.36 mg C m^{-2} h^{-1}. Both the lowest and highest Rs rates were observed at NT. The lowest flux was recorded in February, coinciding with the lowest soil temperatures, while the highest Rs occurred on 15 August 2016. A significant correlation ($P<0.01$) was observed between Rs and soil temperature. Rs and Rh showed similar seasonal patterns. Rh rate ranged from -0.88 to 405.78 mg C m^{-2} h^{-1}. Annual cumulative carbon among the tillage methods did not differ from Rs but significantly different from Rh. Annual Rh was T15+> T30+> NR > ST= NT ($p <0.01$). CH_4 fluxes ranged from -421.22 to 370.89 µg C m^{-2} h^{-1}. Tillage method significantly enhanced annual CH_4 uptake ($p<0.05$). The amount of annual CH_4 uptake was T30+ = T15+ = NR = ST > NT. N_2O fluxes ranged from -166.46 to 2416.62 µg N m^{-2} h^{-1}. The peak of N_2O fluxes were observed in all renovation plots immediately after renovation operations, and in all treatments within 9 days after fertilization. Annual N_2O emissions were not significantly different among the treatments, but there was a tendency of NR> T15+> T15–> NT> ST> T30–> T30+. The GWP tended to be higher at T15–, T30–, T15+ and T30+ than NR and lower at ST and NT. The difference in total gas emissions was due to the difference in CO_2 emissions. Total yield biomass was highest in NR (8.20 Mg ha^{-1} yr^{-1}) followed by T15+ (5.78 Mg ha^{-1} yr^{-1}) and lowest in NT (4.77 Mg ha^{-1} yr^{-1}).

4. Conclusions

Even though T15+ tended to have high GWP, T15+ was also produce significantly high total yield, so that resulted in low value of GHGI. This results suggest that adopted T15+ for grassland renovation could be expected to produce high yield and reduce GHG emissions.