学位論文内容の要旨

博士の専攻分野名称：博士（農学）　　　　　氏　名：Ikabongo Mukumbuta

学位論文題名

Carbon, nitrogen and greenhouse gas flux dynamics in cornfield and managed grassland: Effects of land-use change, manure management and liming

（飼料畑および草地における炭素、窒素、温室効果ガス動態：土地利用、堆肥施与、酸性矯正の影響）

Agricultural activities are a major source of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). To combat the effect of greenhouse gases **(**GHG) on the climate, management practices that mitigate their emissions while enhancing crop productivity are required.

Land-use change can greatly affect soil organic carbon (SOC) and nitrogen (SON) dynamics influencing the GHG emissions due to differences in vegetation types and management practices among land-uses.

The objectives of this study were to; (i) investigate the effect of land-use change between grassland and cornfield on C, N and GHG dynamics; (ii) investigate the effect of manure management (timing and rate) on global warming potentials (GWP) and greenhouse gas intensities (GHGI) in a cornfield; and (iii) evaluate the possibility of reducing N_2O emissions from denitrification through liming.

1. Effect of land-use change on C, N and GHG dynamics.

A study was conducted from 2005 to 2015 at a field used as an old permanent grassland (OG), which was ploughed and converted to a cornfield (2010–2012) and then converted to a new grassland (NG) (2013–2015) at Shizunai livestock farm. SOC, SON and GHG were measured in three treatments; chemical fertilizer and manure (MF), chemical fertilizer only (F) and control (CT). Manure was broadcasted in all land-uses and additionally incorporated by tillage in cornfield. Chemical fertilizer was broadcasted in grassland and banded in cornfield at a recommended rate of ~150 kg N ha^{-1}. Contrary to what is widely reported, SOC and SON contents and stocks increased after conversion of grassland to cornfield. This increase was significant mainly in manure amended plot ($p<0.01$) at both 0–15 and 15–30 cm depths. A further increase in SOC and SON contents in the manure plot was observed after land-use change from cornfield to new grassland. Ploughing is therefore essential to turn plant residue and manure into SOC. Overall N_2O emissions and heterotrophic CO_2 were highest in cornfield followed by NG and lowest in OG ($p<0.01$). GHG fluxes had reduced to same level as OG by 3rd year of NG. Higher N_2O in cornfield was mostly due to high soil NO_3^- and NH_4^+ relative to available C compared to grassland, while higher heterotrophic CO_2 fluxes were due to increased organic matter decomposition caused by tillage.

2. Mitigating GWP and GHGI in cornfield through manure management

The three plots from part 1 (CT, F and MF) and two additional plots; manure plus inorganic fertilizer (MF2) and manure only (M) were used in experiment 1 conducted for three years. In experiment 2, conducted for one year, 3 treatments namely autumn manure only (M1), autumn manure plus spring inorganic fertilizer (MF) and autumn plus spring manure (MM) were investigated. GHGI and GWP were investigated in both experiments. Application of inorganic fertilizer together with manure significantly reduced GHGI and GWP, while increasing net primary production (NPP) and net ecosystem carbon balance (NECB) ($p<0.01$). Additional spring manure or inorganic fertilizer application increased NPP by a similar amount, but additional manure application also increased NECB, and decreased GWP and GHGI.

3. Effect of liming on denitrification N_2O fluxes.

Under field conditions (part 2 above) a significant negative correlation between N_2O emissions and soil pH was found in cornfield ($r = -0.72$, $p < 0.01$) suggesting that increasing pH through liming could reduce N_2O emissions. To investigate whether liming could indeed reduce N_2O emissions three liming treatments; unlimed (LO), 4 mg $CaCO_3$ kg^{-1} soil (L1) and 20 mg $CaCO_3$ kg^{-1} (L2) were investigated under aerobic conditions using ^{15}N-labelled KNO_3 and isotopic N_2O analyser, and under completely anaerobic conditions using acetylene inhibition method on N_2O fluxes. Liming significantly reduced N_2O emissions under anaerobic conditions. Under aerobic conditions, the high lime treatment (L2) emitted at least 30% less N_2O than the unlimed treatment (L0). However, low lime rate (L1) showed highest N_2O emissions under aerobic conditions. Occurrence of both nitrification and denitrification processes under aerobic conditions, and the lower pH of L1 treatment (6.0) than the reported optimum pH of N_2O reductase (pH 6.5) could be the reason for higher N_2O in L1 treatment than unlimed soil.