N_2O-N emissions from corn with different management practices

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Introduction

Agriculture contributes ~13% of anthropogenic sources of greenhouse gases (GHG's), mainly carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). N_2O contributes approximately 6% of the total radiative forcing (IPPC, 2007). Of anthropogenic N_2O emissions, ~85% is due to N fertilized soils thus N management can be a significant mitigation option.

Hypothesis and Objectives

Under the hypothesis that long-term no-till systems and banded application of N fertilizer will have lower N_2O-N flux than recently adopted no-till systems and broadcast N application the objectives were to:

1. Quantify N_2O-N emissions under long-term (LT) no-till (NT) and till (T) systems with different N placements and sources,
2. Determine the effect of different N strategies (N placements and slow release N fertilizer –SRNF–) on N_2O-N emissions in a short-term (ST) (3-years) no-till system.

Methodology

Soil: Kennebec silt loam.
Treatments
- Long-term Experiment (Established in 1990)
  - Tillage: NT and T continuous corn systems. T included fall chisel and spring offset disk
  - N source: Manure (M), N fertilizer as urea (F) and no N (NF)
  - Placement: During 2009 N fertilizer was surfaced band (SB) and subsurface band (SUB).
- Short-term NT (ST)
  - N fertilizer placement: Broadcast (BC), surface band (SB), and subsurface band (SUB),
  - Slow release N fertilizer (SRNF)
  - Control (No Fertilizer (NF))

The fluxes in the banded treatment were corrected for area
- 2008: BS and SB are the sum of the banded treatments plus 2.75 times the flux in the control.
- 2009: Two sampling points in each plot were used , one on the band and the other between the plant row and the band.

N_2O-N flux measurements:
- Briefly, the flux measurements were performed placing vented chambers on polyvinyl rings (PVC) and collecting gas samples after 0, 15, and 30 min.
- Concentrations were determined by gas chromatography (Model GC 14A; Shimadzu, Kyoto, Japan) equipped with a ^{63}Ni electron capture detector and a stainless steel column (0.318-cm dia. by 74.5 cm long) with Poropak Q (80-100 mesh).

Ancillary measurements:
- NO_3-N and NH_4-N concentrations (0-5cm).
- Daily precipitation collected at a nearby meteorological station.
- Soil temperature (5 cm)
- Surface water content (0-5 cm)

Experimental Design

The experimental design for the LTE is a split-plot design with repeated measures and four replications. The main plot is the tillage system and the subplot is fertilizer type or fertilizer placement. The ST no-till experiment is a randomized block design with repeated measures and four replications. The results were statistically analyzed using Mixed procedure from SAS (SAS v 9.1, 2003).

Results

Long-term systems

During 2008, high N_2O-N emissions were associated with high rainfall events and high NO_3-N (Fig. 1). Overall, there were no significant differences between tillage systems and N source. The cumulative fluxes were NT=398 and T=328 g N_2O-N ha^{-1}. The N source, F and M, were (393 and 332 g N_2O-N ha^{-1}, respectively). Due to the longer period of evaluation during 2009 the cumulative N_2O-N fluxes were 2199 g N_2O-N ha^{-1} for T and 2059 g N_2O-N ha^{-1} for NT.

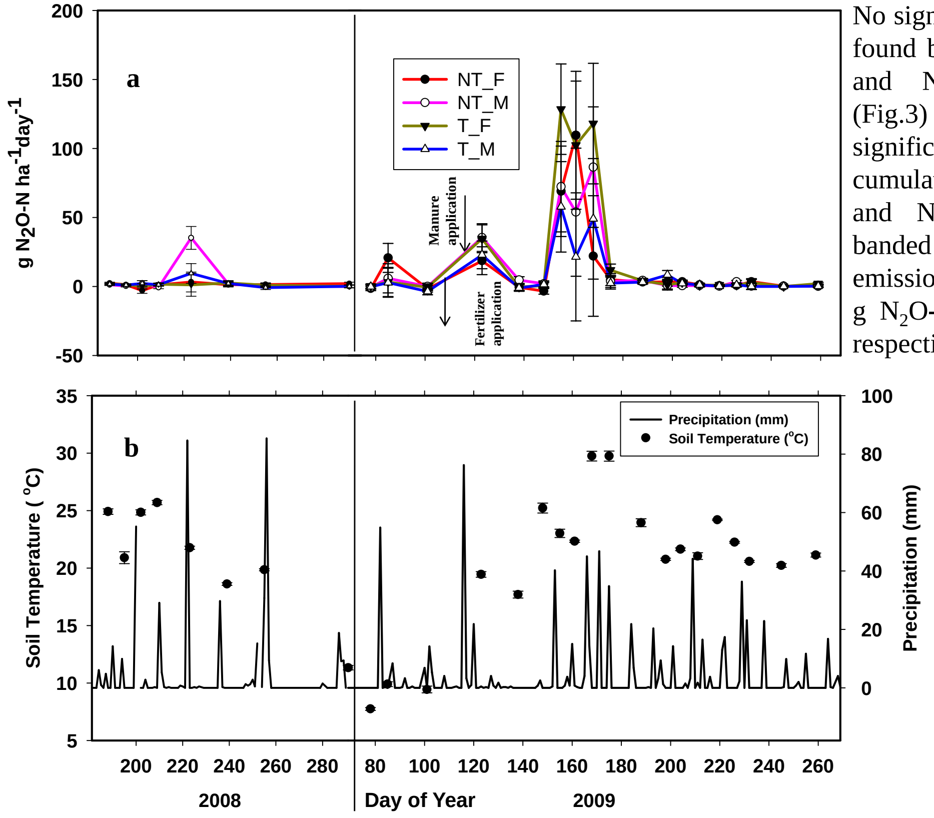

Figure 1.a) Effect of tillage , F and M on N_2O-N flux. **b)** Soil temperature and precipitation at sampling times throughout the study period

No significant interaction were found between tillage systems and N source. Placement (Fig.3) did not show significant differences but the cumulative emissions under T and NT were affected by banded applications whose emissions were 6630 and 3773 g N_2O-N ha^{-1} for T and NT, respectively.

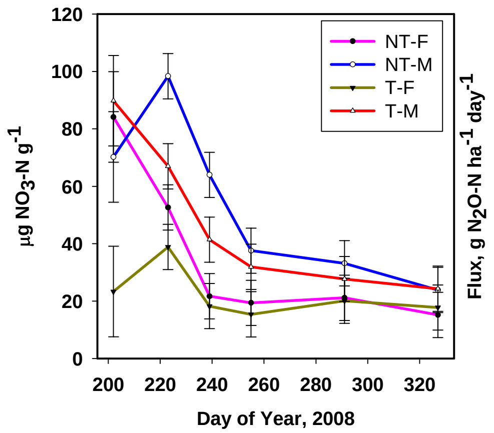

Figure 2. NO_3-N concentration presented in the LTE

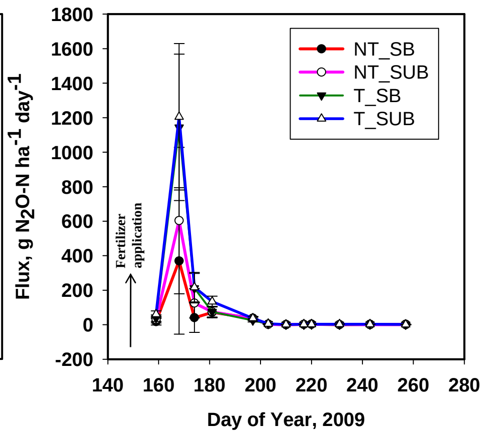

Figure 3. N_2O-N flux at LTE during 2009

Short-Term Experiment

There were significant differences among the treatments, although at the end of the year significant differences were not found among the treatments (Fig. 4). During 2008 and 2009 SB and SUB had the highest N_2O-N emissions which were statistically significant from the BC and NF. The high concentration of NO_3-N at that time explains those differences (Fig. 5 and Fig. 6). The highest emission during the experiment (769 g N_2O-N ha^{-1}day^{-1}) occurred under the SB treatment. Overall, the cumulative emissions during 2008 were significantly different among treatments of which SB and SUB presented higher values (9401 and 6164 g N_2O-N ha^{-1}, respectively). Although the fluxes were lower during 2009 the trend remained similar where the banded treatments SB and SUB had higher cumulative emission values (5365 and 6291 g N_2O-N ha^{-1}, respectively). The cumulative emission in SRNF , BC and NF were 3298, 2980 and 122 g N_2O-N ha^{-1}, respectively.

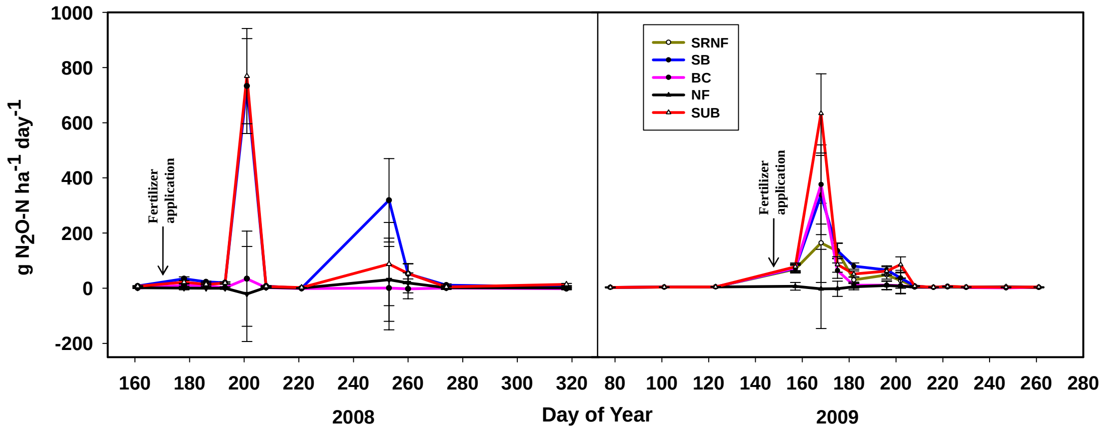

Figure 4. N_2O-N flux at the short-term no-till system throughout the study period

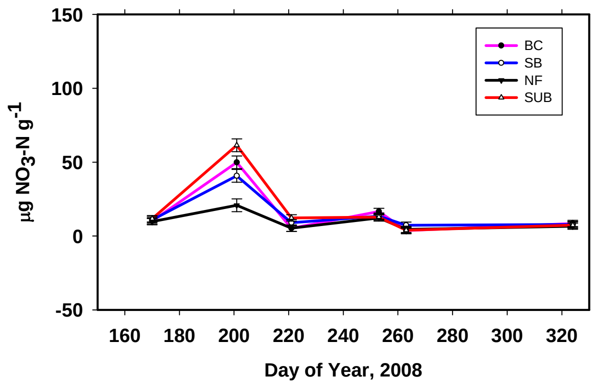

Figure 5. NO_3-N concentration in ST, 2008

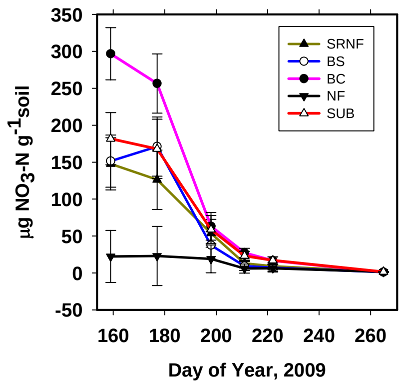

Figure 6. NO_3-N concentration in ST, 2009

Summary

N_2O-N fluxes in T and NT were not significantly different when the fertilizer was broadcast.
Banded N fertilizer had higher N_2O-N fluxes under the till than the no-till system.
Banded application of N increased the N_2O-N flux under long-term and short term no-till systems. This effect is higher in the short-term than the long-term no-till system.
The N_2O-N fluxes were clearly related to precipitation events at the sampling time as well as NO_3 concentrations and soil temperature.

Acknowledgements

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