Temporal analysis of nitrous oxide emissions from a Pennsylvania no-till dairy cropping system

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Nitrous oxide (N_2O) is a potent greenhouse gas released from soils as a by-product of the microbial processes of nitrification and denitrification.

Objective

Evaluate and compare different management strategies that potentially impact N_2O emissions from soil planted to no-till corn.

Study site

NESARE Dairy Cropping System project, PSU Russell E Larson Agronomy Research Farm PA, USA. (Fig. 1).

Fig. 1 NESARE Dairy Cropping System.

Methods

- Gas samples were collected with vented chambers from soils planted to corn following three different crops (Fig. 2):

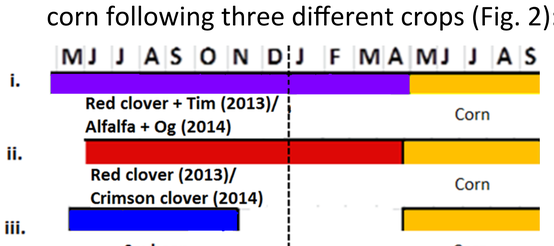

Fig. 2 Corn planted after: i. Alfalfa + Og, ii. red clover iii. soybean

1. alfalfa and orchardgrass with spring broadcasted manure (red clover & timothy grass in 2014)
2. crimsom clover with spring broadcasted manure (red clover in 2014)
3. soybeans with spring broadcast manure

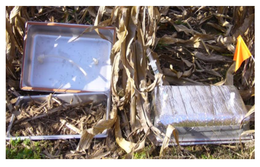

Fig. 3 Two chambers in each treatment-plot

Fig .4 Manure broadcasted

- N_2O fluxes were measured in 2014 and 2015.
- Gas samples were collected at 0, 10, 20 and 30 minutes and analyzed with a gas chromatography.
- The rate of N_2O emissions (g N_2O ha^{-1} day^{-1}) was calculated from the four data points using linear regression.
- Soil moisture and temperature were measured in the same location.
- Soil samples (3 cores/plot) were collected once a week and analyzed for NH_4^+ and NO_3^-.
- Data were analyzed in SAS with PROC Mixed with repeated measures.

Results

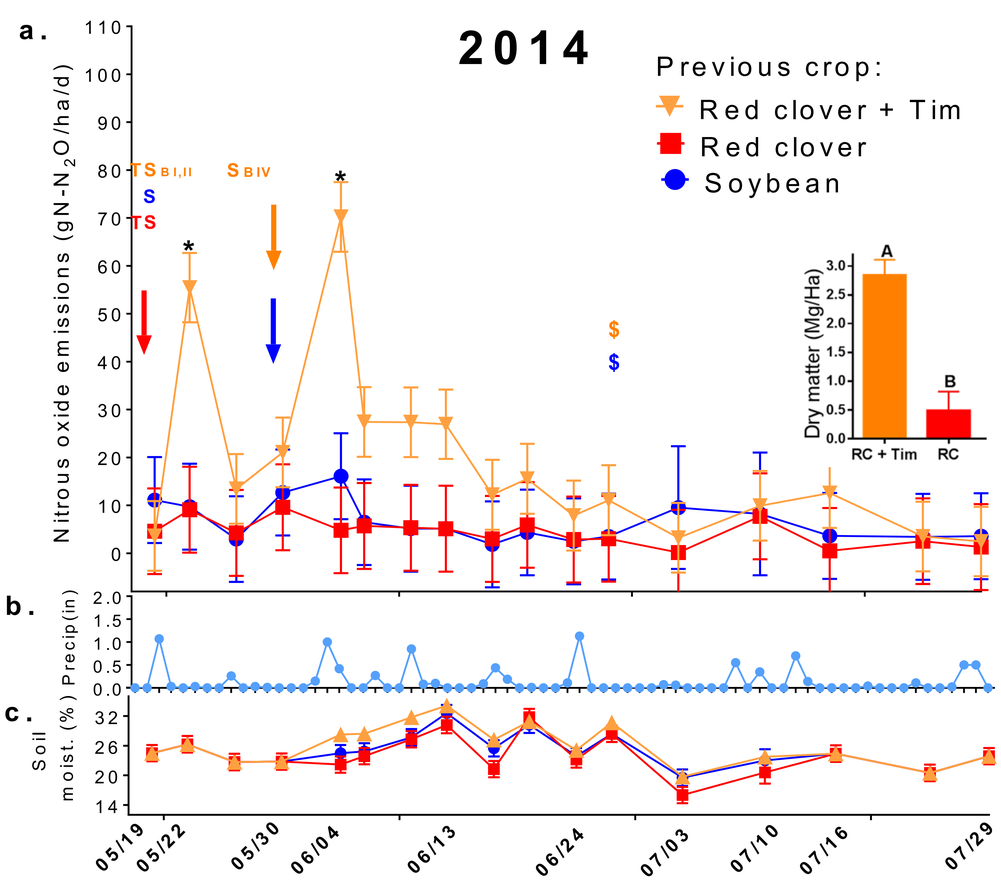

Fig. 5 a. 2014 N_2O emissions from soil planted to corn after three different crops b. Precipitation c. Soil moisture

T indicates when the crop prior to corn was terminated; ↓ indicates when corn was planted. **S** indicates application of manure 19T/A (Avg of total manure N applied :150 kgN/Ha). **B** blocks where manure was applied **$** indicates fertilizer application * significant difference among treatments at p value <0.05

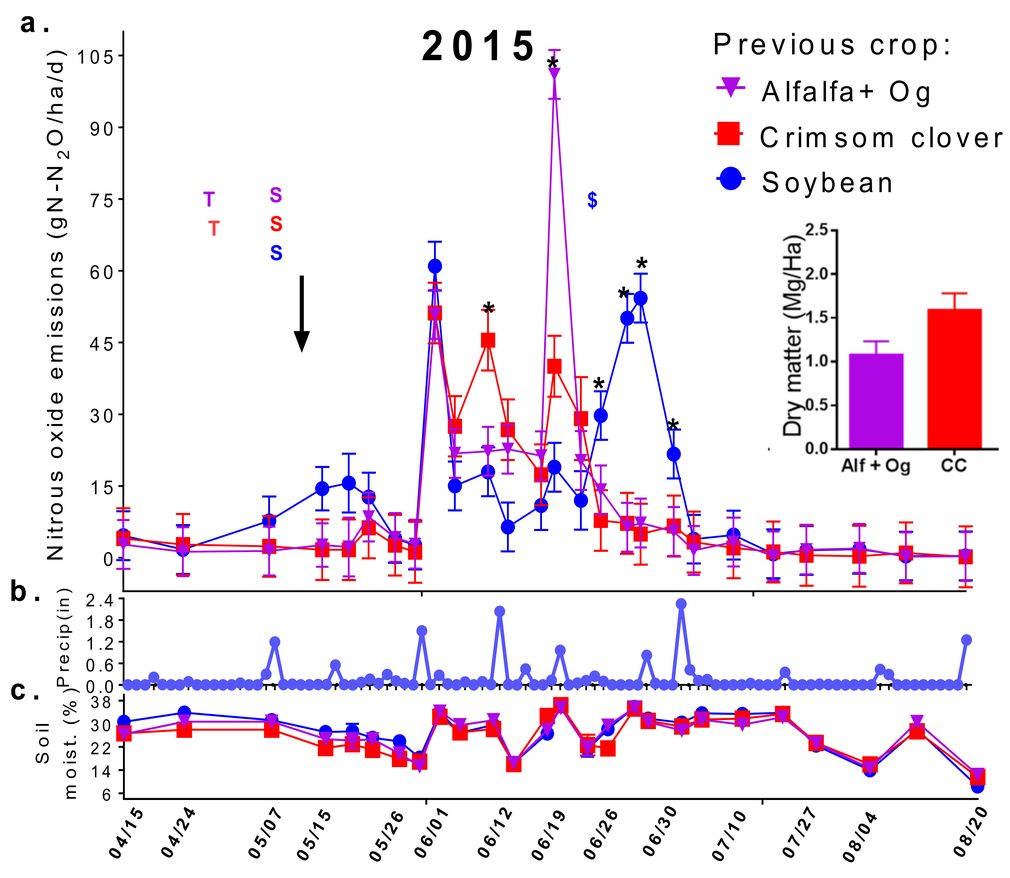

Fig. 6 a. 2015 N_2O emissions from soil planted after three different crops. b. Precipitation c. Soil moisture.

T indicates when the crop prior to corn was terminated; ↓ indicates when corn was planted. **S** indicates application of manure 19T/A (Avg of total manure N applied :150 kgN/Ha) **$** indicates fertilizer application * significant difference among treatments at p value <0.05

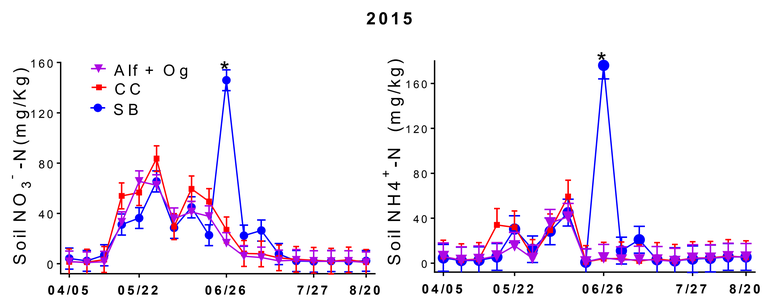

Fig. 7 2015 Soil nitrate and ammonium concentrations
* Indicate significant difference among treatments at p value <0.05

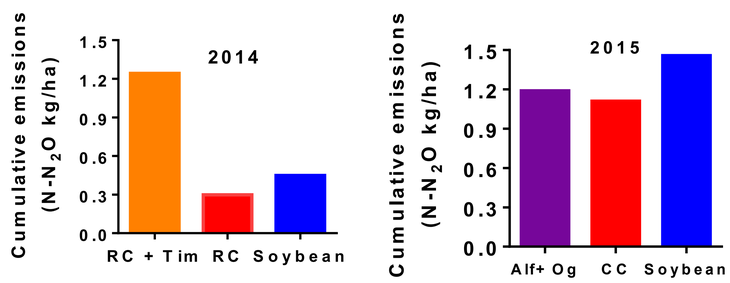

Fig. 8 2014 and 2015 Cumulative N_2O emissions

Discussion

- In 2014, N_2O emissions were elevated 5-10 days after RC+Tim were terminated and manure was applied. This was likely due to increased soil N from the legume biomass and weather conditions that stimulated denitrification of the inorganic N. Later in the season when side-dress fertilizer N was applied to corn, N_2O emissions were lower than when manure was applied earlier, likely because soil moisture was lower and fertilizer N was taken up more rapidly by the actively growing corn reducing N available for denitrification (Fig.5).
- In 2015, elevated N_2O emissions were observed from legume treatments about 15 days after the previous crops were terminated and spring manure was applied. High legume biomass, manure N inputs (Fig 6.) and weather conditions favored denitrification. NO_3^- and NH_4^+ soil levels increased slowly in early spring after manure was applied and cover crops were terminated (Fig. 7), likely due to slow N mineralization.
- RC+Tim treatment in 2014 was the only treatment with higher cumulative N_2O emission than the soybean treatment (Fig 8.). RC+Tim biomass was high in 2014; and precipitation events soon after manure was applied likely contributed to denitrification.

Conclusions

- Pre-plant manure application had high potential for N_2O emissions, likely because corn was not yet actively taking up the N.
- Cover crop residue input did not increase N_2O emissions relative to the soybean treatment, except for the case when there was high biomass production.