# Nitrous oxide emissions from diverse no-till dairy crop rotations

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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 reduce $N_2O$ 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 (Fig. 2) from soils planted to corn in 3 blocks of the experiment with:

A. Four different previous crops:
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. rye cover crop with fall injected manure
4. soybeans with spring broadcast manure

B. Three different N inputs in a soy-corn rotation:
1. injected manure (Fig 3.),
2. unincorporated, broadcast manure (Fig 4.)
3. inorganic nitrogen fertilization

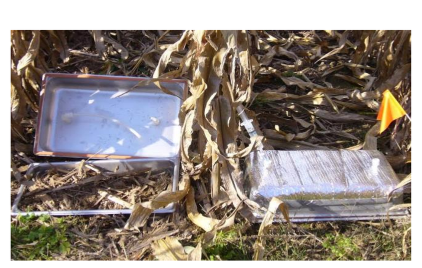

**Fig. 2** Two chambers in each treatment-plot

**Fig. 3** Shallow disk injector

**Fig .4** Manure broadcasted

- $N_2O$ fluxes were measured biweekly from May to July, in 2014 and 2015. Soil moisture and temperature were also measured in the same location.
- 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 samples (3 cores/plot) were taken once a week and analyzed for $NH_4$ and $NO_3$.
- Data analysis conducted using Proc MIXED with repeated measures; crop residues and N inputs as fixed effects, block as random in SAS.

## Results

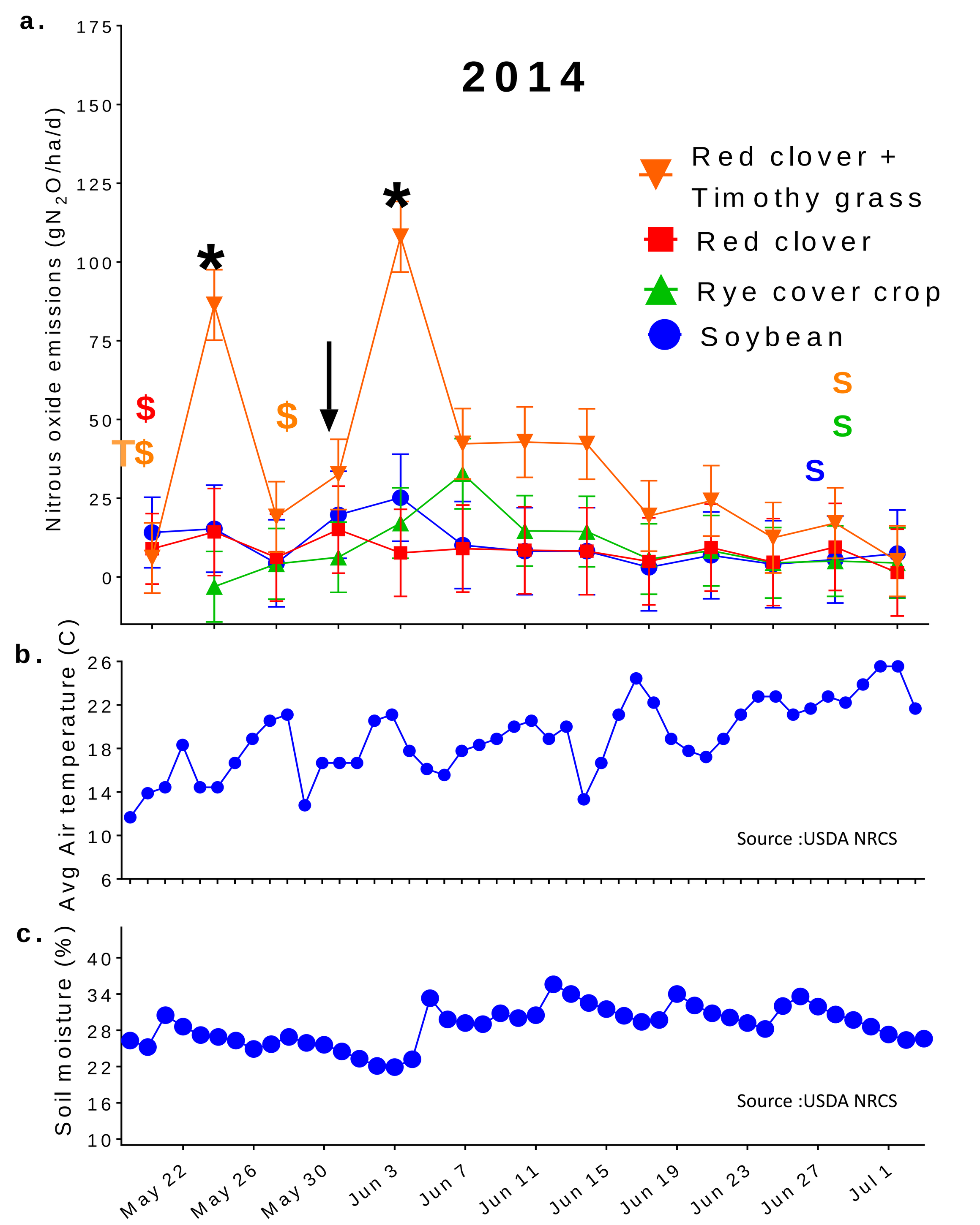



**Fig. 3 a.** 2014 $N_2O$ emissions from soil planted to corn after four different crops b. Average air temperature c. Soil moisture.

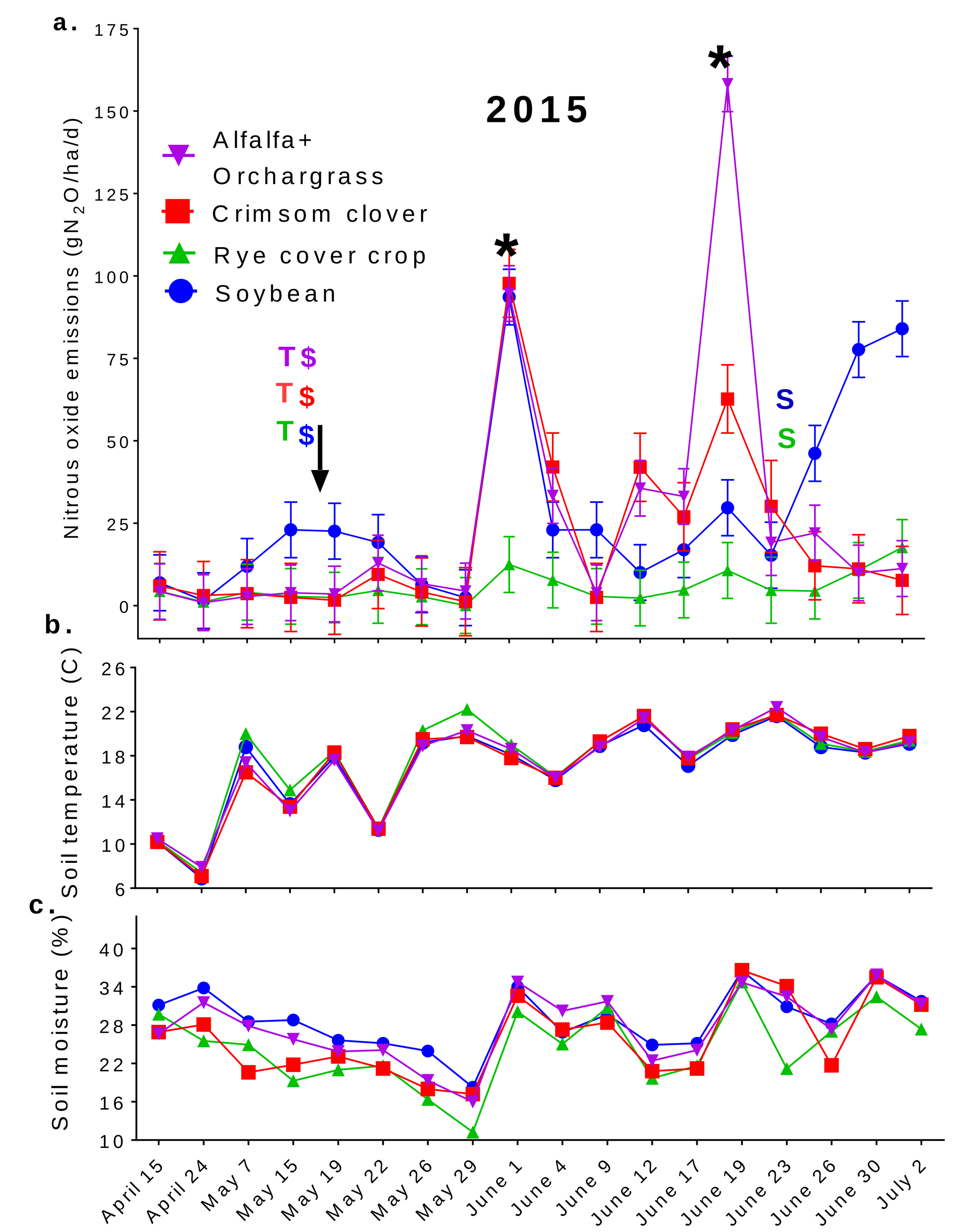



**Fig. 4 a.** 2015 $N_2O$ emissions from soil planted after four different crops. b. Soil temperature c. Soil moisture.

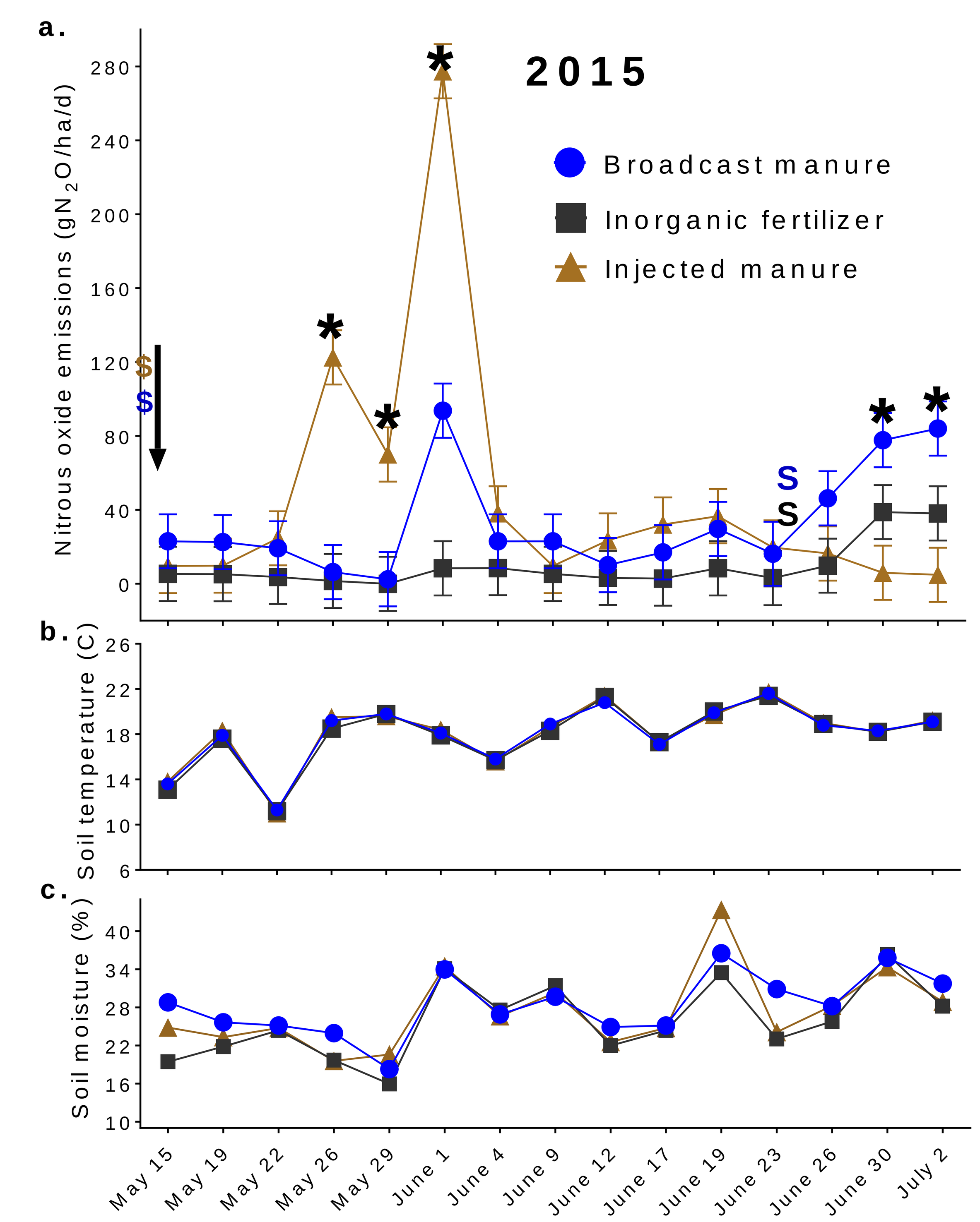



**Fig. 5** 2015 $N_2O$ emissions from soil planted to corn after three different N inputs. b. Soil temperature c. Soil moisture.

T indicates when the crop prior to corn was terminated; S indicates application of manure 19T/A; $ indicates fertilizer application based on the Pre-sidedress Nitrate Test (PSNT) in corn planted after red clover+timothy grass, rye, soybean- broadcast manure and soybean fertilizer; ↓ indicates when corn was planted * significant difference among treatments at p value <0.05.

## Discussion

- In 2014, $N_2O$ peaks were observed 5-10 days after red clover + timothy were terminated and manure was applied. This was likely due to an increase of soil N from the legume biomass that stimulated denitrification in the presence of inorganic N (Fig. 6). Later in the season, when side-dress fertilizer N was applied to corn, $N_2O$ emissions were lower than when manure was applied earlier. This is likely because fertilizer N was more rapidly taken up by the actively growing corn, reducing N available for denitrification (Fig. 3).
- In 2015, $NO_3^-$ and $NH_4^+$ soil levels increased slowly early in spring after manure was applied and cover crops were terminated (Fig. 7), likely because organic N inputs were being slowly decomposed. Later in the season when soil was fertilized, $NO_3^-$ and $NH_4^+$ increased. About 15 days after the previous crops were terminated and spring manure was applied, $N_2O$ peaked in the legume treatments. Peaks likely occurred due to the high legume biomass and manure N inputs (Fig 6.) and weather conditions that favor denitrification.
- In 2015, in the corn after soybean, emissions from the injected manure treatment were higher compared to when manure was broadcast (Fig 5.). This is likely because manure injection created a 10 cm deep band of concentrated N, high moisture, and organic matter. Later in the growing season, when broadcast and fertilizer treatments were side-dressed with N, $N_2O$ emissions were higher than the injected manure treatment that was not sidedressed.

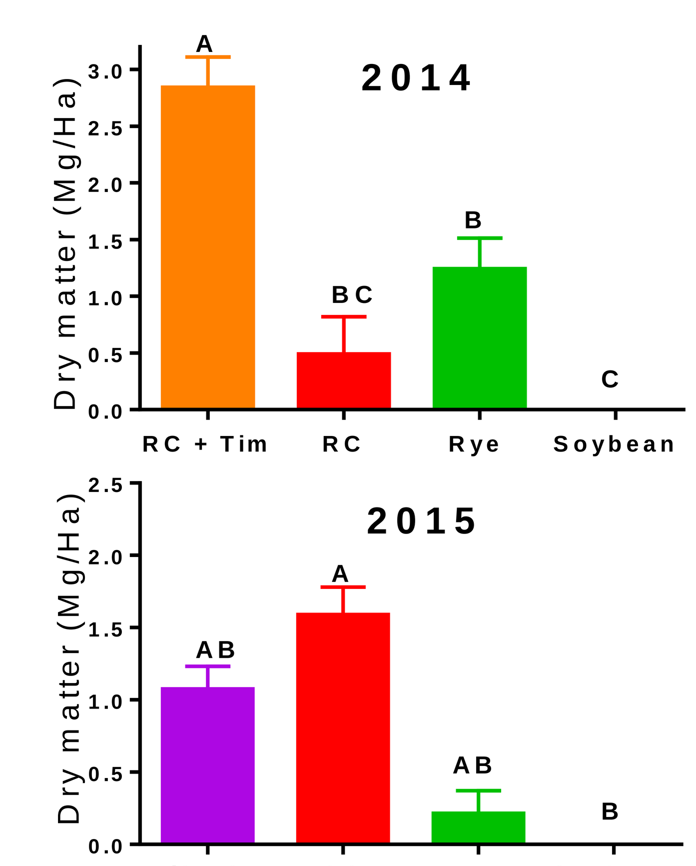



**Fig. 6** 2015 Dry matter production
A, B, C indicate treatments that differ at p < 0.05

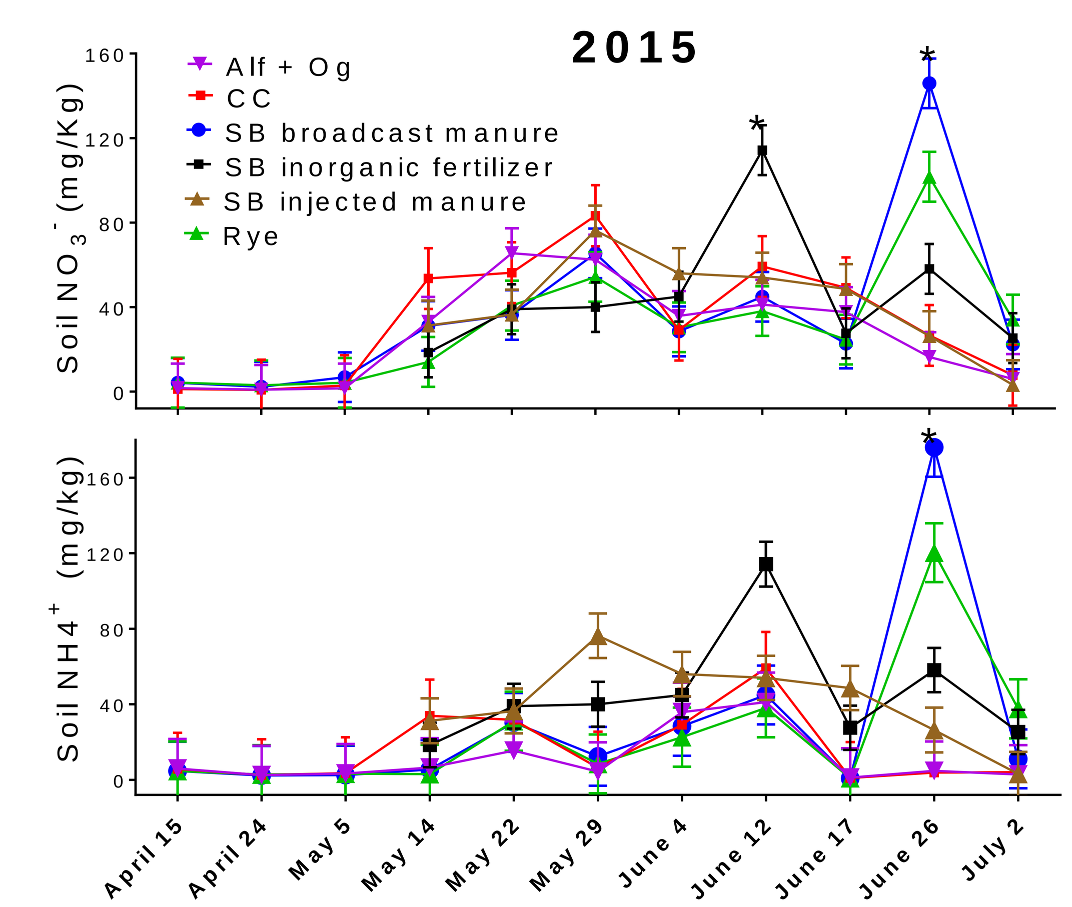



**Fig. 7** 2015 Soil nitrate and ammonium concentrations
* Indicate significant difference among treatments at p value <0.05

## Conclusions

- Application of side-dress N had lower potential for $N_2O$ emissions than pre-plant manure applications, probably due to largely to active N uptake by the growing crop.
- Shallow-disk injection of manures has greater potential for $N_2O$ emissions than surface application with manure or inorganic fertilizer, offsetting previously identified benefits of injection (including reduced ammonia volatilization and P runoff).

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