Factors contributing to nitrous oxide emissions from soil planted to corn in no-till dairy crop rotations

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

Objective

Determine environmental and management factors contributing to N_2O emissions from soil planted to no-till corn.

Methods

- Soil N_2O emissions were evaluated in 2015 and 2016 in the NESARE Dairy Cropping Systems experiment at the PSU Russell E Larson Agronomy Research Farm PA, USA.
- Gas samples were collected on a Murrill soil (Fine-loamy, mixed, semiactive, mesic Typic Hapludults) with vented chambers from soils planted to corn following (Fig 1.):
  1. alfalfa and orchardgrass
  2. crimsom clover
  3. soybean
- Sources and methods of N application were compared in the corn-soy rotation:
  1. Urea ammonium nitrate as N source.
  2. Dairy manure slurry broadcasted as the main N source.
  3. Dairy manure slurry injected as the main N source.

Fig. 1 Two chambers in each treatment-plot

- Soil samples were collected weekly at 5 cm depth and analyzed for NH_4^+ and NO_3^-.
- Soil moisture and soil temperature were measured at 8 cm depth.
- Biomass and C/N of crop residues were measured.
- Rainfall, maximum and minimum air temperature were collected year-round.

Statistical Analyses

- Soil N_2O analysis conducted using PROC MIXED of SAS with cropping system treatment and N inputs as fixed effects, block as a random effect, and with repeated measures with sampling date as a repeated fixed effect . The SLICE option of the LSMEANS subcommand was used to test differences among treatment means by day. Treatments were considered statistically different at P ≤ 0.05.
- Random forest analysis in R was used to identify and rank the predictor variables for N_2O emissions.

Results

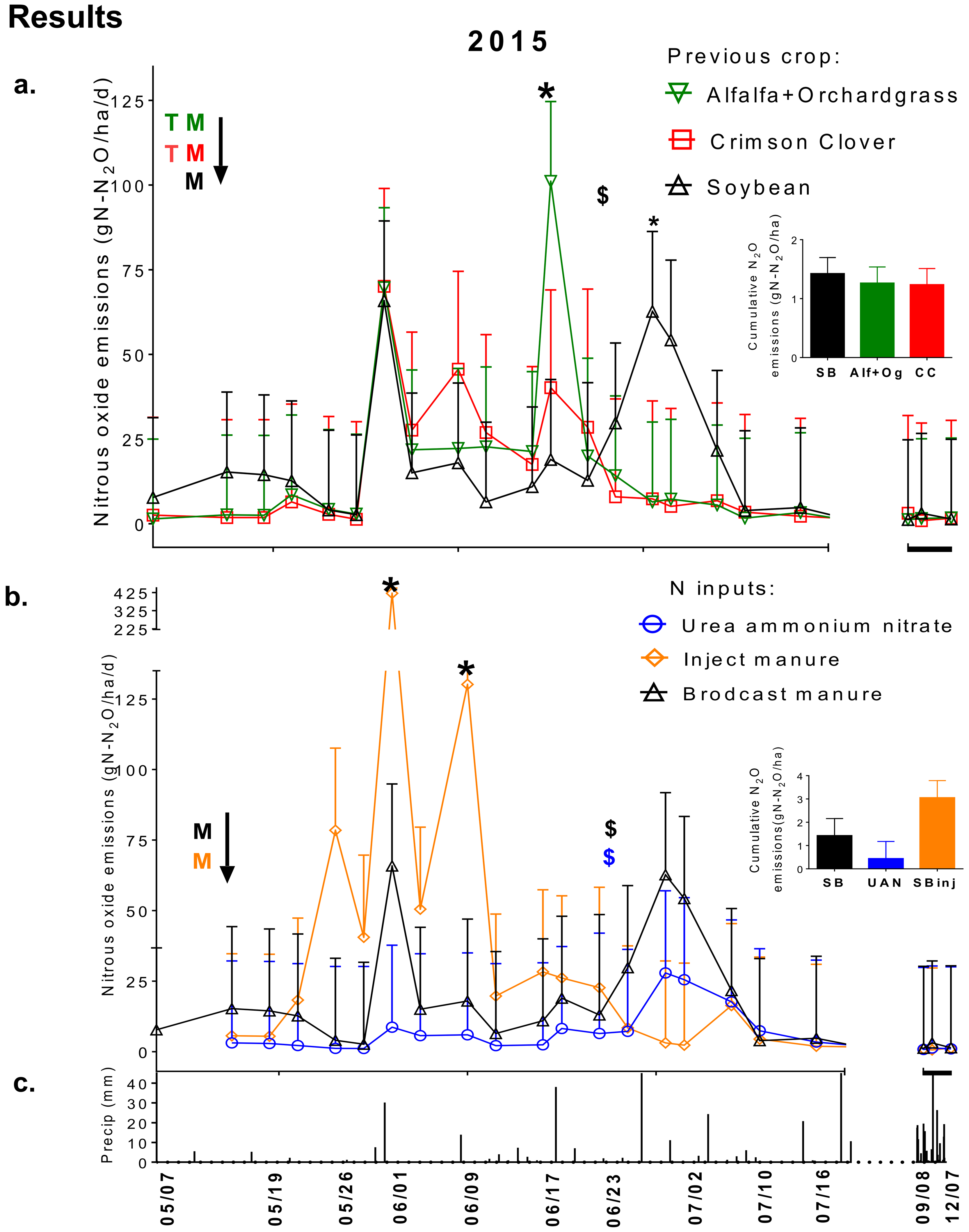

Fig. 2 a. 2015 N₂O emissions from soil planted after three different crops. b. 2015 N_2O emissions from soil planted to corn after soybean and three different N inputs. c. Precipitation.

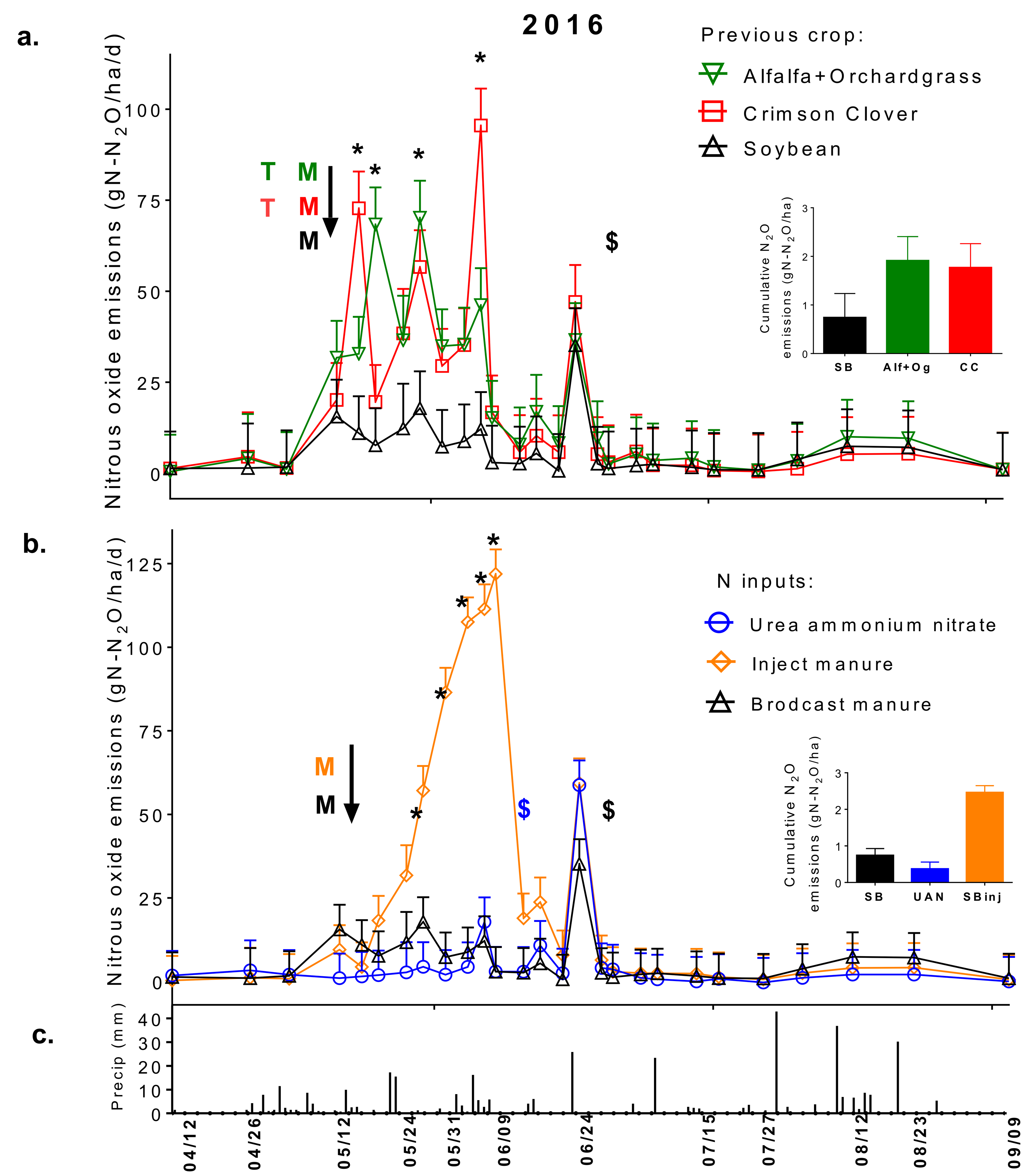

Fig. 3 a. 2016 N₂O emissions from soil planted after four different crops. b. 2016 N_2O emissions from soil planted to corn after soybean and three different N inputs. c. Precipitation.

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

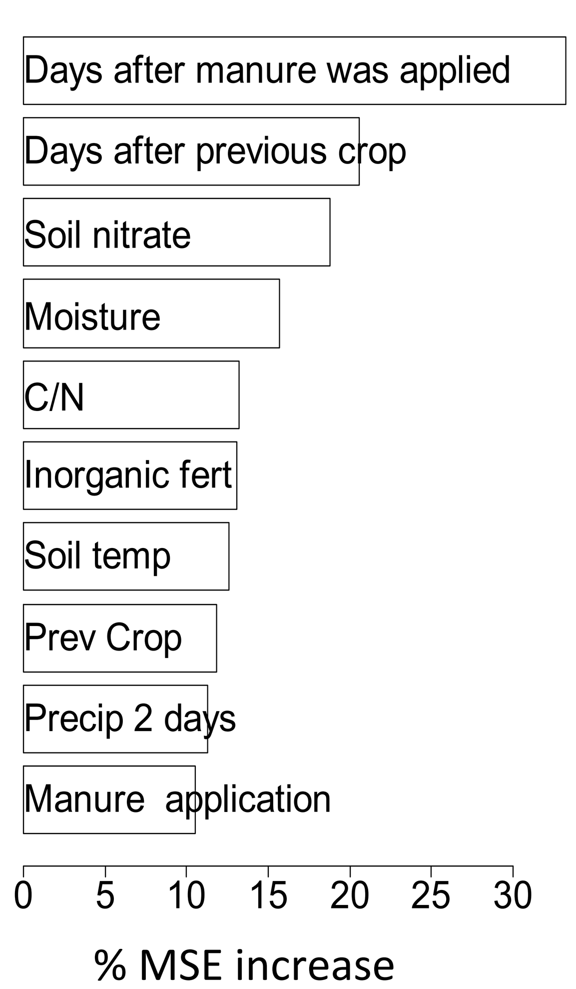

Fig 4. Ten most important predictor variables from random forests.

Discussion

- Elevated N_2O emissions were observed from legume treatments 15-42 days after the previous crops were terminated and spring manure was applied in 2015 and 2016 (Fig.2a). High legume biomass, manure N inputs prior to corn planting, and weather conditions favored denitrification early in the growing season.
- In 2015, large N_2O emissions after mid-season side-dress inorganic fertilizer application likely resulted from precipitation events that favored denitrification (Fig. 2b). In 2016, a dry period after inorganic fertilizer application limited the denitrification potential and overall N_2O emissions (Fig. 3b).
- In 2015 and 2016, N_2O emissions early in the season from the injected manure treatment after soybean were elevated compared to the broadcast manure treatment (Fig. 2b and 3b). The injected manure treatment had the highest emissions early in the season, likely because manure injection created a 10 cm deep band of concentrated N, moisture, and organic matter, that favored denitrification.
- Random forest (RF) explained 48% of the variation in N_2O emissions. Days after manure application was identified as the most important variable, followed by days after previous crop termination, soil nitrate levels and soil moisture (Fig 4).

Conclusion

- Shallow-disk injection of manures has greater potential for N_2O emissions than surface application with manure or inorganic fertilizer, partially offsetting previously identified benefits of injection (including reduced ammonia volatilization and P runoff).
- Time after manure application, time after previous crop residue termination, soil nitrate levels, and soil moisture were the measured factors that best predicted N_2O emissions rate. These results suggest that timing N inputs close to crop uptake and avoiding N applications when there is a high chance of precipitation can reduce nitrate accumulation in the soil and potential N losses from denitrification.

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