Nitrous Oxide Emissions in Soybean Fields with Differential Drainage in Poorly Drained Soils in Minnesota

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Background

Soybean [*Glycine max* L. (Merr.)] is grown extensively in rotation with corn (*Zea mays* L.), yet because it is typically not fertilized with nitrogen, less emphasis has been given to quantifying nitrous oxide (N_2O) emissions from soybean. Similarly, studies evaluating the effect of soil drainage on N_2O emissions for this crop are lacking.

Objective

To quantify in-season N_2O emissions over three soybean growing seasons in a corn-soybean rotation under tile-drainage and natural (no tile) conditions with different N fertilization management in the corn phase.

Materials and Methods

- Field study was established near Wells, Minnesota in a Marna silty clay loam and Nicollet silty clay loam soil.
- Tile drainage was installed in 2011 in all plots, but since installation some have been open and others closed to create drainage treatments (Drained and Undrained).
- N application was managed in the corn phase as follows: Zero-N control, a single pre-plant application of 135 kg N ha^{-1} (Single Preplant), and a split application (45 kg ha^{-1} pre-plant, and 90 kg ha^{-1} [with urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT)] at V4 development stage) (Split).
- Data were collected during the 2014, 2015 and 2016 soybean growing seasons.
- Season-long volumetric water content and soil temperature were measured at 0-5, 5-10, and 10-15 cm depth increments.
- N_2O flux was measured using the non-steady state chamber method, twice a week through July and weekly thereafter until harvest.
- Soybean yield was measured and adjusted to 130 g kg^{-1} moisture content.
- Statistical analysis was conducted using the PROC GLIMMIX procedure of SAS with year, drainage systems, and N management variables as fixed effects and block and block by drainage as random effects.

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Results and Discussion

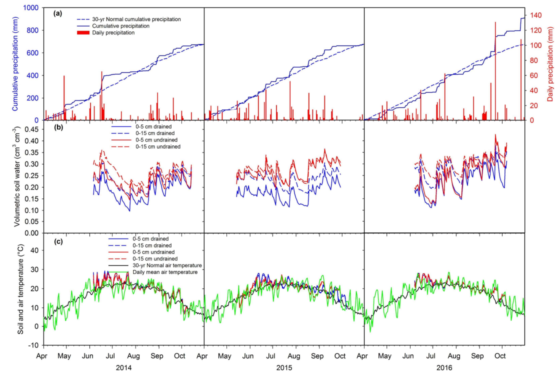

Figure 1. Daily and cumulative precipitation and 30-yr normal cumulative precipitation (a), volumetric soil water content at 0-5 and 0-15 cm soil depth for Drained and Undrained treatments (b), and air and soil temperature at 0-5 and 0-15 cm soil depth (c) in 2014, 2015 and 2016.

- Precipitation (Fig. 1a) influenced soil volumetric water content (VWC) (Fig. 1b). The Undrained soils had greater VWC than Drained soils, especially in 2015 (year with more uniform precipitation) than 2014 and 2016 (Fig. 1b).
- Air temperature was close to the 30-yr mean except in July where it was 2.1°C cooler in 2014 (Fig. 1c) and in 2015 where air temperature was lower than the 30-yr normal from the start of the growing season to mid-July, and greater thereafter.
- Soil temperature was similar between drainage systems and followed air temperature closely in 2014 and 2016. In 2015, soil temperature was greater at the beginning of growing season in the Drained than Undrained soils, but this differences disappeared in early July (Fig. 1c).

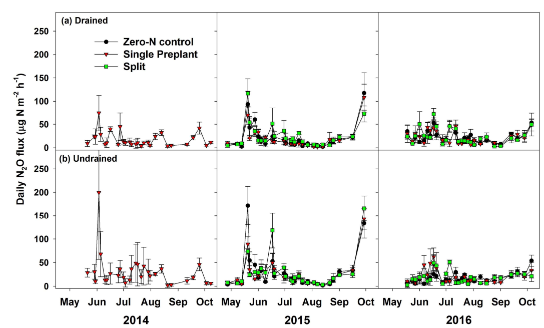

Figure 2. Daily N_2O-N emissions in Drained (a) and Undrained (b) soils for the Zero-N control, and 135 kg N ha^{-1} applied as Single-Preplant or Split during the corn phase of the rotation in 2014, 2015 and 2016 soybean growing seasons.

- Episodic increases in N_2O flux (Fig. 2) often occurred in relation to large precipitation events or wet soil conditions resulting from frequent precipitation through June (Fig. 1a), especially in Undrained soils in 2014 and 2015.
- Despite significant precipitation later in the seasons, daily N_2O fluxes were low (Fig. 2) likely due to rapid uptake of water and N by the crop.
- In late Sept-Oct., N_2O fluxes increased (Fig. 2) likely as soil N increased from mineralization and crop senescence while soils were still warm and moist.

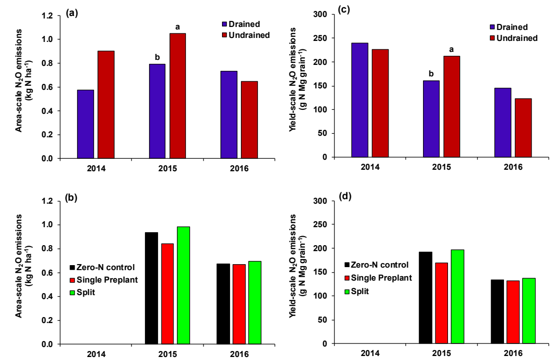

Figure 3. Season-long cumulative area-scale N_2O emissions (aN_2O), and yield-scale N_2O (yN_2O), in Drained and Undrained soils (a,c), and for the Zero-N control, and 135 kg N ha^{-1} applied as Single-Preplant or Split (b,d) during the corn phase of the rotation.

- Area-scale N_2O emissions were significantly greater in the Undrained than Drained soil in 2015 (Fig. 3a). A similar non-significant trend (P=0.345) was observed in 2014, and no differences were detected in 2016.
- There were no differences in area-scale N_2O emissions due to N treatment (residual N applied to the corn phase) (Fig. 3b) or interaction with drainage.
- Neither drainage nor N treatment (residual N applied to the corn phase) impacted soybean yield.
- Average soybean yields were 4.0, 5.0 and 4.9 Mg ha^{-1} for 2014, 2015 and 2016, respectively.
- Because of lack of treatment differences in soybean yield, results for yield-scale N_2O emissions (Fig. 3c,d) were similar to area-scale N_2O emissions (Fig. 3a,b).

Summary

- Tile-drainage reduced N_2O emissions in 1 of 3 growing season in poorly to somewhat-poorly drained soils.
- N treatment (residual N applied to the corn phase) did not impact soybean yield or N_2O emissions.
- Overall, 0.78 kg N_2O-N ha^{-1} was emitted during the soybean growing season.