IN-SEASON N FOR CORN REDUCED NITROUS OXIDE EMISSIONS AND DRAINAGE WATER NITRATE CONCENTRATION

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ABSTRACT

Farmers want to get the N fertilizer they apply into their crop, not lose it to air and water. This can be difficult to accomplish during wet years when N loss processes are going strong. Applying N in-season can be difficult to accomplish during wet years, but reduces the odds that N will be lost before the crop has a chance to take it up. We compared 2 N management strategies (140 lb N/acre applied pre-plant and variable-rate N applied sidedress based on canopy sensor measurements) and 3 drainage strategies (undrained, free drainage, controlled drainage) in continuous no-till corn. In the drought year of 2012, none of the treatments affected yield or N loss. Springs were wet in both 2013 and 2014, leading to N loss. Nitrogen applied pre-plant was more vulnerable to loss in both years, leading to higher nitrous oxide emissions, higher drainage water nitrate concentration, and lower yield than when N was applied to knee-high corn with rate based on canopy sensor measurements. Yield difference in these two years averaged 15 bu/acre in favor of in-season N.

INTRODUCTION

Increasingly there is a need to get nitrogen fertilizer into the crop and avoid losing it to air and water. And increasingly Midwestern corn growers are dealing with wet springs that spur N loss to air and water.

When excess water drains through soils, either naturally or with the help of artificial drainage systems, nitrate in the soil can be carried with the water and lost from the root zone. Nitrate from drainage systems is carried quickly to surface water. In the Midwest, most fields drain ultimately to the Gulf of Mexico, where excess N spurs large algal blooms that ultimately deplete bottom water oxygen to levels below those needed to sustain most animal life.

When excess water doesn't drain through soils and they remain at or near saturation for extended periods, nitrate can be lost through denitrification. This is especially true when soils are warm and wet. Most of the nitrate is converted to inert nitrogen gas, but a fair proportion is converted to nitrous oxide and lost to the air. Nitrous oxide is very effective at capturing infrared radiation, and therefore heat, before it escapes from the Earth; it also has a very long half-life in the atmosphere.

Both paths of N loss can lead to N deficiency in corn, creating a yield limitation.

Fertilizer applications closer to the time of rapid N uptake by the corn crop are less at risk for loss, but can also be difficult to accomplish in a wet year.

Applicator-based canopy sensors are an emerging technology to allow N fertilizer rate to be adjusted to complement N being provided by the soil.

METHODS

An experiment was initiated in 2012 near Columbia, MO. Cropping system is continuous no-till corn (though plots were tilled spring 2012 to even out soil from tile installation). There are five treatments related to drainage and nitrogen management:

1. Undrained, conventional N management
2. Drained, conventional N management
3. Controlled drainage, conventional N management
4. Drained, sensor-based sidedress N
5. Controlled drainage, sensor-based sidedress N

Experiment design is a randomized complete block with 4 replications. Plots are 40 feet wide and 200 feet long. Drainage laterals are installed at a spacing of 20 feet with two laterals per plot, each 10 feet from the edge of the plot. In the controlled drainage treatments, a drainage control structure controls the water table at which drainage begins. Drainage control structures are gated to soil surface level until about 2 weeks before planned field activities in spring, then gates are removed and left out until spring field operations are complete. If needed they are removed again in fall prior to planned field operations. Laterals are installed at a shallow depth, average about 17 inches, due to the low hydraulic conductivity of the clay subsoil below that depth.

Both N management treatments are applied as injected urea-ammonium nitrate solution (32% N). The conventional N management treatments are applied shortly before planting at a rate of 140 lb N/acre. This rate is the MRTN (Maximum Return to N) rate for corn after corn in Missouri.

The sensor-based sidedress treatments are applied at growth stage V7 (knee high corn) using three Holland Scientific ACS-210 active reflectance sensors to sense corn color. The algorithm used is reported in Scharf et al. (2011). Reflectance values are collected in a ruggedized tablet computer using custom software, averaged, used to calculate N rate according to the algorithm reported in Scharf et al. (2011), and calculated N rates are applied using a Capstan Ag pulse width modulation system. Nitrogen rate is calculated once per second and recorded along with position in the tablet computer.

Drainage tiles empty into polyethylene barrels that are pumped out when full. A flow meter records the volume pumped out of the barrels, and a splitter is used to sample a small proportion of the pumped water. Water samples are sent to a lab for determination of nitrate concentration.

After planting, an aluminum anchor (30 inches by 10 inches) is installed in each plot. The lip of the anchor protrudes 1 inch above the soil surface. This lip is filled with water and a lid is set into it when taking nitrous oxide measurements, creating a water seal between the anchor and the lid. A photoacoustic spectrometry unit is hooked to small ports in this lid with plastic tubing and circulates gas from the chamber through the unit for 15 minutes. Nitrous oxide flux is calculated from the change in nitrous oxide concentration inside the chamber during these 15 minutes, during which time nitrous oxide concentration is measured 8 times.

Plots are harvested with a combine, grain is weighed in a weigh wagon, and grain moisture level is determined. Yields are calculated at standard moisture.

RESULTS AND DISCUSSION

<u>2012</u>

Severe and early drought in 2012 resulted in zero drainage water being collected, very low nitrous oxide emissions, and yields below 35 bushels/acre. No yield difference was observed between treatments. Average N rate applied in the sensor-based sidedress treatments was 102 lb N/acre.

2013

In 2013, rainfall was abundant and soil conditions were wet until approximately the date on which sidedress N was applied. After sidedress, little rain occurred for several weeks and soils dried. As a result, most nitrous oxide flux for the year occurred before sidedress N was applied. Treatments receiving all N pre-plant had high flux during the period between planting and sidedress, while the sidedress treatments had very low flux during this time (Figure 1). Both types of N management had low flux after sidedress due to dry soil conditions.

Yields were not affected by drainage treatments, but average yield for conventional N management was 125 bu/acre and for sensor-based sidedress N was 142 bu/acre. The average N rate for sensor-based sidedress N treatments was 155 lb N/acre and appeared to compensate for early loss of soil-derived N. Nitrogen deficiency symptoms were seen in August in the plots that received conventional pre-plant N management.

Drainage water nitrate concentrations were also higher in the conventional N management plots: flow-weighted nitrate-N concentration was 18 ppm, compared to 12.5 ppm for sidedress plots. Most drainage occurred before sidedress N fertilizer was applied.

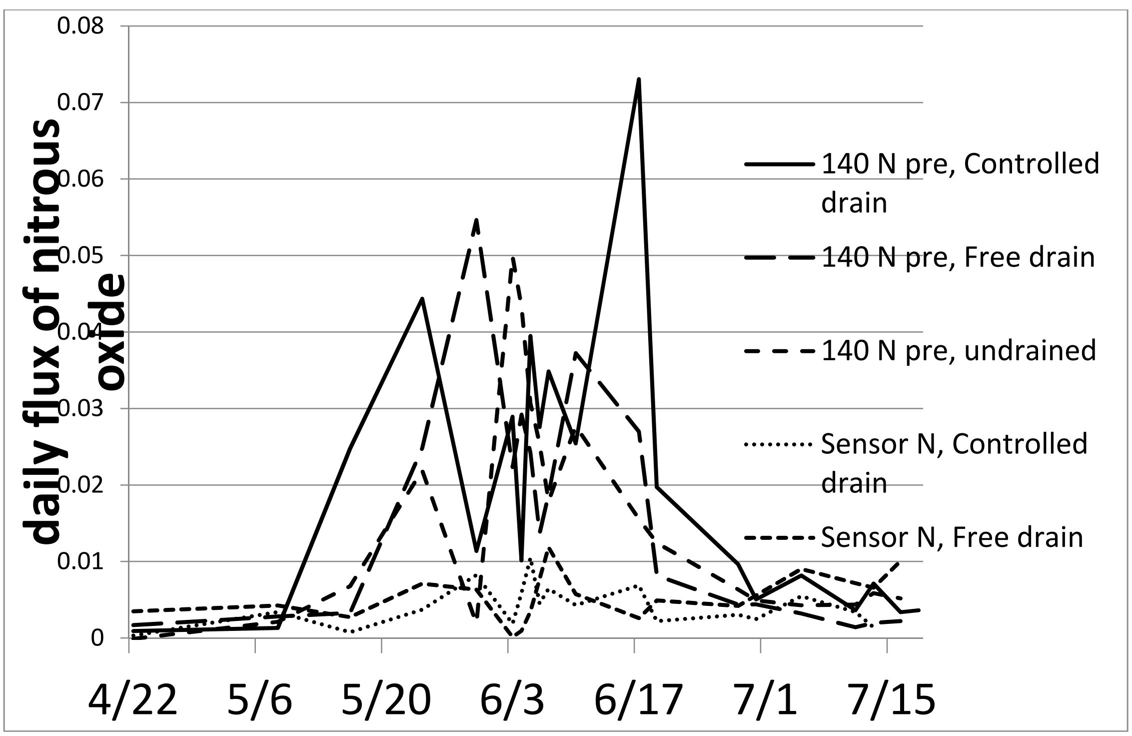

Figure 1. Nitrous oxide flux was much greater from preplant N treatments in 2013 than from sensor-based sidedress N treatments. Sidedress N was applied in mid-June, at which time soil was drying and nitrous oxide flux was greatly reduced.

2014

In 2014, rainfall was again abundant early in the season, but if anything was more abundant during the period following sidedress N application. As a result, peak nitrous oxide flux for the year occurred during the two weeks following sidedress N application. During this period, flux was equal for the two N application strategies and was not influenced by drainage treatment.

The conventional pre-plant N treatment again had higher flux during the period before sidedress N was applied, giving it higher total flux for the year (Figure 2).

Yields were again not affected by drainage treatments. Average yield for conventional N management was 135 bu/acre and for sensor-based sidedress N was 148.5 bu/acre. The average N rate for sensor-based sidedress N treatments was 158 lb N/acre and appeared to compensate for early loss of soil-derived N. Nitrogen deficiency symptoms were seen in August in the plots that received conventional pre-plant N management.

Drainage water nitrate concentrations were also higher in the conventional N management plots: flow-weighted nitrate-N concentration was 13 ppm, compared to 11 ppm for sidedress plots.

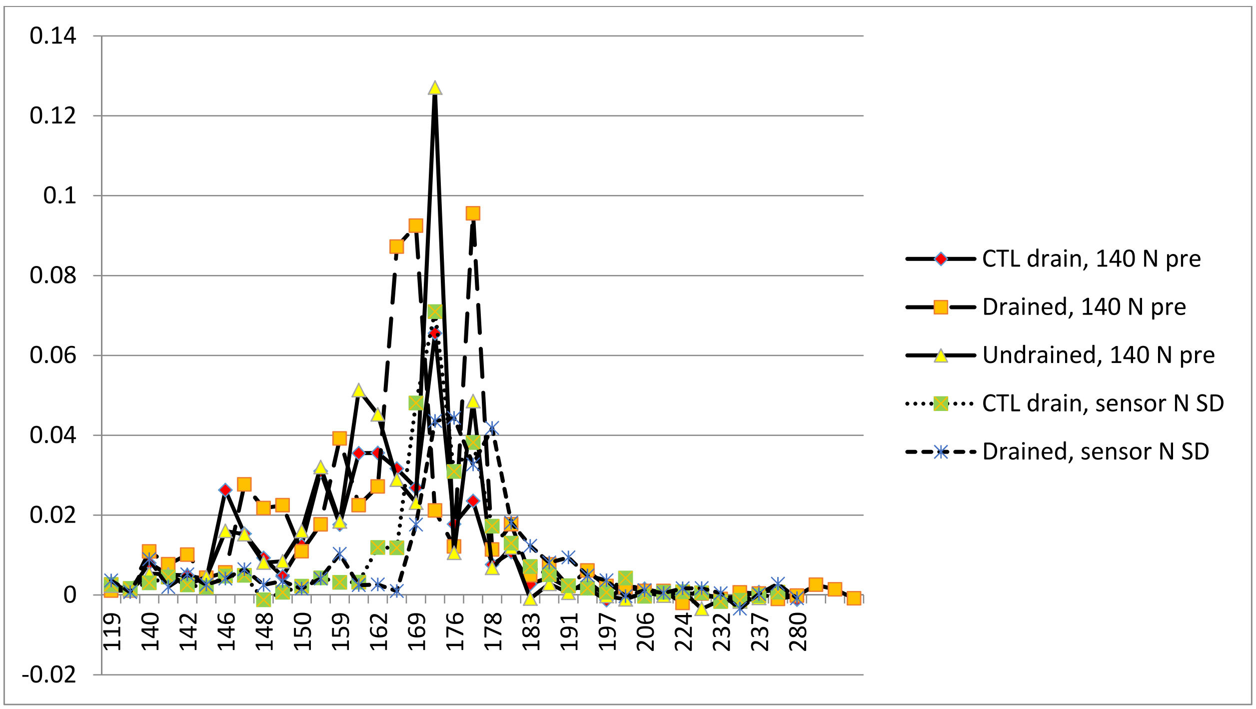

Figure 2. Nitrous oxide flux in 2014 peaked after sidedress application on day 163 (June 12). From this date onward, nitrous oxide flux was equal for the two N timings. However, substantial nitrous oxide was lost before this date from the preplant N treatments and not from the sidedress N treatments.

SUMMARY

In the drought year of 2012, treatments did not affect any measured variables.

In both 2013 and 2014, sensor-based sidedress N gave higher yield, lower nitrous oxide flux, and lower drainage water nitrate than conventional N management (140 lb N/acre pre-plant). Both years had wet early spring conditions, but soil began drying in mid June 2013 while remaining wet throughout June in 2014.

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