SENSON-BASED NITROGEN MANAGEMENT AFFECTS CORN PRODUCTION AND ENVIRONMENTAL N FOOTPRINTS

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ABSTRACT

To improve air and water quality, nitrogen (N) management in corn production systems should shift from the current N decision support system [maximum return to N (MRTN)], which suggests a single rate N addition, to sensor-based (GreenSeeker) active N management (variable N rate approach). Single rate N recommendations often result in under- and over-N addition and either increase environmental N losses or cause corn yield penalty. Our objectives were to evaluate corn economic optimum N rate (EORN) and determine if sensor-based N management improves N fertilizer use, end of season N, nitrous oxide emissions, and nitrate-N leaching during a corn growing season. Our results indicated that sidedressing N improved N use by corn. A pretty simple empirical relationship (215 lb/a for 215 bu/a) can be derived across all the data. Nitrogen balances are generally positive at around 90 lbs/acre (100 kg/ha) at EONR. End of season N is generally spatially variable but always increases exponentially at rates above the EONR. Compared to flat-rate N management, sensor-based decreased N fertilizer requirement, corn yield, nitrate-N leaching, and nitrous oxide emissions. Future research should explore the effect of sensor-based N management on farm economics and environmental footprints at multi-site-years.

INTRODUCTION

The Illinois Nutrient Reduction Strategy aims to reduce nitrate-N losses to surface waters by 15% by 2025 (IEPA, IDOA, and University of Illinois Extension, 2015). Among the recommended approaches, 4R nitrogen (N) management strategies are designed to minimize nutrient losses to Illinois waterways and the Gulf of Mexico while also reducing nitrous oxide (N_2O) emissions. Applying the right N rate is one of the most effective practices for mitigating environmental N losses (Morris et al., 2018). However, determining the optimal N rate is challenging because corn N requirements depend on N responsiveness, soil N availability, and yield potential—factors that vary spatially and temporally. Precision N management has the potential to address this variability, improve N use efficiency, and reduce N losses. To address uncertainties related to variable-rate N applications, this study aimed to compare the performance of the Maximum Return to Nitrogen (MRTN) approach with a GreenSeeker-based N rate on corn grain yield and N losses including nitrate-N leaching and nitrous oxide emissions.

MATERIALS AND METHODS

Experimental Site, Design, and Treatments

This study was conducted at the Agronomy Research Center of Southern Illinois University, Carbondale, IL. Treatments were arranged in a randomized complete block design (RCBD) with five replications during the 2022–2025 growing seasons; only 2022 data are reported here. Treatments included: (i) a zero-N control, (ii) N fertilizer applied at planting using the Maximum Return to Nitrogen (MRTN) rate, (iii) N fertilizer applied at the MRTN rate at sidedress, and (iv) N fertilizer applied at sidedress based on the GreenSeeker sensor algorithm. Experimental plots measured 60 ft in length by 10 ft in width. Corn (Dekalb DKC64-35RIB) was planted using a no-till drill at a population of 32,000 seeds ac^{-1} on 18 May 2022. Sidedress N applications were made at the V8 growth stage using 32% urea-ammonium nitrate (UAN). All fertilized plots received 55 lbs N ac^{-1} as a starter application at planting, except for the zero-N control. The MRTN rate used in this study was 203 lbs N ac^{-1}.

Measurements

Soil samples (0–6 in) were collected throughout the 2022 corn growing season using a soil probe and analyzed for nitrate-N and ammonium-N. Nitrous oxide emissions were measured using custom closed, vented aluminum chambers installed between corn rows on permanently anchored bases. Gas samples were collected on 21 sampling dates using syringes at 0, 15, 30, and 45 minutes after chamber closure, and N_2O concentrations were quantified by gas chromatography (GC). Nitrous oxide fluxes were calculated from the linear change in N_2O concentration over time, and cumulative emissions were derived by linear interpolation between sampling events. Soil volumetric water content (VWC) and temperature were recorded at each gas sampling event. Corn grain yield was measured at harvest using a plot combine. Subsamples of grain and aboveground biomass were collected prior to harvest to determine N concentration and calculate plant N uptake. Yield-scaled N_2O emissions were computed by dividing cumulative N_2O emissions by grain yield. Nitrate-N leaching was assessed using resin bag lysimeters installed at 12–16 in depth, depending on the claypan layer. After retrieval, resin bags were extracted and analyzed for nitrate-N using an OI Analytical Flow Solution IV system.

RESULTS AND DISCUSSION

Corn Grain Yield

Corn grain yield was 175 bu ac^{-1} for the MRTN treatment which was 10 bu ac^{-1} higher than that of the GS treatment. However, about 80 lbs N ac^{-1} less was applied to corn based on GreenSeeker recommendation which compensated for the lower yield in 2022 (data not shown).

Soil nitrate-N trends

Soil nitrate-N was consistently higher in the MRTN-upfront treatment as compared to the no-N control and GS treatment. Soil nitrate-N reached its peak before VT stage of corn and then at R1 and any dates after that, all treatments had similar nitrate-N concentrations (Fig. 1).

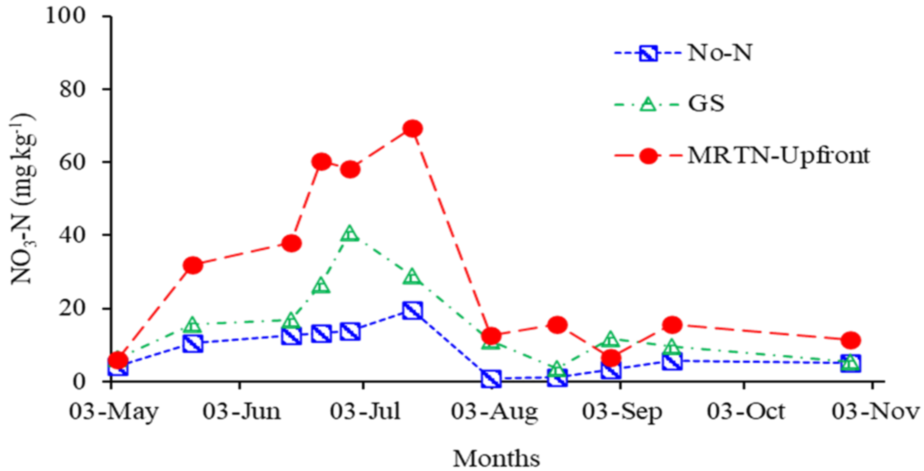

Fig. 1. Soil NO_3-N as influenced by N management in 2022. No-N is no fertilizer control, GS indicates GreenSeeker-based N rate and MRTN-Upfront is 203 lbs N ac^{-1} at planting.

Cumulative N_2O-N emissions

Cumulative N_2O-N emissions were higher in the MRTN-upfront treatment than the GS and the no-N control (Fig. 2) in line with higher N availability during the corn growing season in that treatment. Cumulative N_2O-N emissions were comparable to other reports in IL (Preza-Fontes et al., 2022; Wiedhuner et al., 2022).

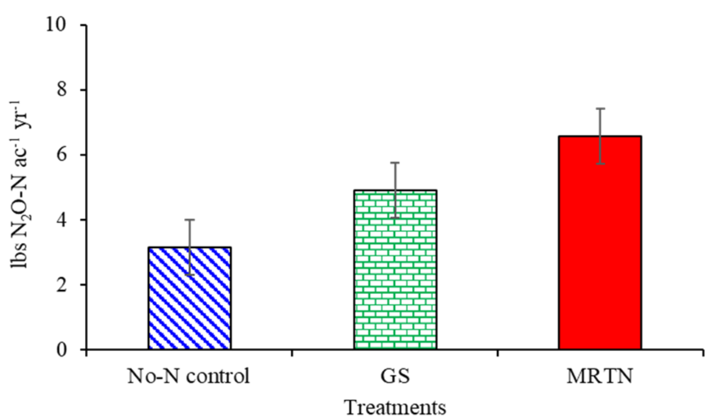

Fig. 2. Cumulative N_2O-N emissions during the corn growing season as influenced by N management in 2022. No-N is no fertilizer control, GS indicates GreenSeeker-based N rate and MRTN-Upfront is 203 lbs N ac^{-1} at planting.

Nitrate-N leaching

Nitrate-N leaching was higher in the MRTN treatment (upfront and sidedress) as compared to the GS and the no-N control. Implementing GS resulted in much lower N application that the MRTN which in turn, decreased both corn grain yield (10 bu ac^{-1}) and nitrate-N leaching. In 2022, nitrate-N leaching from the GS treatment was similar to that of the no-N control which is encouraging (Fig. 3).

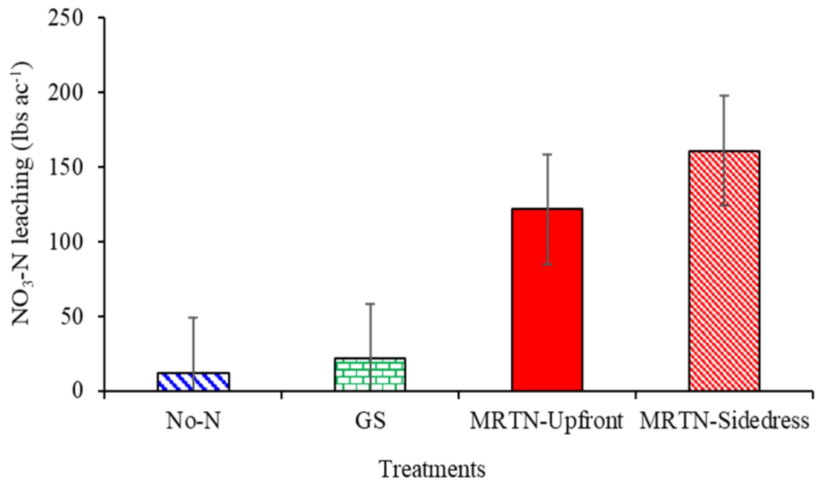

Fig. 3. Nitrate-N leaching during the corn growing season as influenced by N management in 2022. No-N is no fertilizer control, GS indicates GreenSeeker-based N rate and MRTN-Upfront is 203 lbs N ac^{-1} at planting and MRTN-sidedress is 203 lbs N ac^{-1} that was applied as 55 lbs N ac^{-1} at planting and the rest at sidedress timing.

PRELIMINARY CONCLUSION

In this preliminary trial, we observed that GS algorithm suggested 80 lbs ac^{-1} less N application to corn resulting in 10 bu ac^{-1} less yield. However, both N_2O-N and nitrate-N losses were reduced by the GS treatment compared to the MRTN. We require more site-years to confirm these results and fine tune the GS algorithm.

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