Title: The influence of nitrogen stabilizers and application dates in no-tillage corn production on nitrogen use efficiency and N losses to the atmosphere and groundwater.

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Research Goal: The purpose of this project is to answer questions that have yet to be addressed in commercial agriculture systems of South Dakota. This includes determining the effect of hydrolysis inhibitor treated urea, and polymer-coated urea (ESN) on gaseous N emissions (NH_3 and N_2O), NO_3-N leaching, and the amount of N needed to attain corns economic optimum N rate. Based on the research we will conduct a cost-benefit analysis.

Summary: This is the 3rd year of a project that was initiated in the spring of 2021. During the 2021 and 2022 growing seasons soil and plant tissue samples were collected yields were measured and GHG were quantified. In 2023, treatments have been applied, spring soil samples collected, and GHG are being measured. Our plans are to analyze soil nutrient samples taken from inside the ring for carbon and nitrogen content. Soil samples taken will be ground and extracted for nitrogen using KCl.

Justification: One of the outcomes of this project is to identify management practices that optimizes productivity while minimizing the effects of agriculture. This outcome will be achieved by exploring the effects of management on N losses and utilization by corn. Fertilizer derived N can be lost to the environment through many different mechanisms that include leaching, denitrification, or nitrification (Figure 1). The amount lost through each mechanism is affected by interactions among the fertilizer material, the soil processes, the climate, and management. For example, research that we conducted in 2018 and 2019 showed that the urea-N losses to the atmosphere were much lower when applied after the soil had cooled to < 50 F. In a second example, research conducted in the 1980's showed that the treatment of urea with nitrification and hydrolysis inhibitors reduced ammonia volatilization from over 20% of the applied N to less than 1%. In summary, these studies had multiple combined findings. First, a one-size fits all product is not available. Second, the use of nitrogen stabilizers works in some environments but not others and that minimizing losses through one mechanism can increase losses through another. Third, reducing losses leads to improved efficiency and lower N rates and carbon footprints. This project will provide guidance on how to select fertilizer products that fit different problems.

Work Plan: This replicated field and laboratory study will test different fertilizer products for their ability to improve nitrogen use efficiency and reduce N losses to the atmosphere and groundwater. The research site, Aurora was selected because our previous work showed that it is uniquely suited to conduct detailed experiments with a minimal variation and that we can detect relatively small changes in economic optimum N rates. The treatments were 5 N rates (0, 60, 100, 140, and 180 lbs N/a), 3 application dates (Fall temperature < 50F, preplant, and between V4 and V6), 3 urea products (untreated, poly coated, and hydrolysis inhibitor treated) and 2 yield potentials. Each treatment was replicated 4 times. Hyperspectral remote sensing data was collected from the site to identify N and water sensitive bands and create remote sensing algorithms for characterizing water and N stress in corn on May 30 (following emergence), June 15 (V4), July 15 (V8), and August 24 24 (prior to tasseling). No-tillage was used at the site and DKC 97-97 was seeded at 32000 plants/a.

The low yield potential treatments were not irrigated and the high yield potential treatments were irrigated. Each plot was approximately 30 ft long and 15 ft wide with 6 rows of corn. Each plot has one of four different treatments: 100% untreated urea, 100% treated urea with NPBT (also known as factor), 75% ESN combined with 25% urea, and 100% ESN. The experiment has 3 application dates: fall, spring, and split application in spring/summer. Each treatment will be replicated 4 times in experiments conducted in 2021, 2022, and 2023. This project will use no-tillage and the findings will be used to create Nitrogen fertilizer fact sheets.

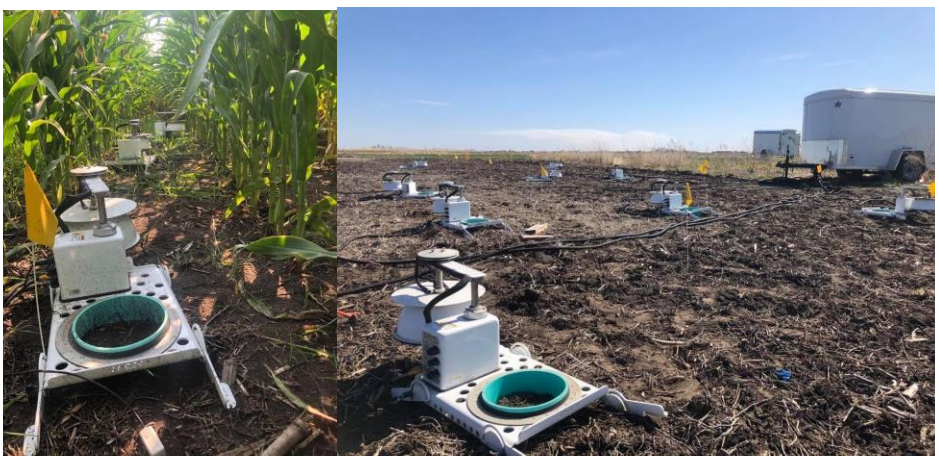
Progress

Field study: The field was planted May 9th, 2023. Currently, corn ears and stover from 2022 have been dried, shelled and ground to determine C and N concentrations through mass spectroscopy. Preseason and postseason soil samples have been collected from the 0- to 6-, 6- to 12- and 12-to 24 inch soil depths from each plot. Postseason samples from the same depths were taken from inside the rings of the greenhouse gas chambers. Preseason samples were sent to Ward labs in Nebraska to obtain background information on the 2022 plots, this information was received and utilized. All samples from 2021 and 2022 have been analyzed for inorganic N, soil moisture, pH, and EC. Soil samples collected on May 9, 2023 from the 0- to 6- inch depth for microbial analysis (PLFA) are currently being processed. Following collection, the samples were immediately placed into a cooler with dry ice and once sampling was complete, they were placed into a -80°C freezer. Plant tissue samples were collected June 16, 2023 to assess gene expression. Following collection, the samples were immediately placed into a cooler with dry ice and once sampling was complete, they were placed into a -80°C freezer. Check samples have been sent to Trace Genomics in Ames Iowa. The Licor and Picarro GHG measurement and analysis systems were placed into the field on April 26, 2023 and they measured N_2O-N, NH_3-N, CH_4-C, and CO_2–C emissions from fertilized and unfertilized plots until harvest. The spring fertilization application was applied on May 10, 2023.

Greenhouse gas emissions: The GHG collection and analysis system consists of LI-COR LI-8100-104 long-term opaque chambers (8100-104 LI-COR, Lincoln, NE) and Picarro® Cavity Ringdown Spectrometer (model G2508; Picarro Inc., Santa Clara, CA). Each chamber covered an area of 317 cm^2. Prior to sampling, the cover pivots over the PVC pipe, creating an enclosed volume. Gas samples were collected for 15-minutes six times daily (between 0000 to 0230 h, 0400 to 0630 h, 0800 to 1030 h, 1200 to 1430 h, 1600 to 1830 h, and 2000 to 2230 h).

At each gas sampling event, the chambers were sampled in a designated sequence, and corrections were applied to each individual chamber to account for air volume differences. During the individual sampling event, the gas within the chamber was mixed with a pump, a vent was used to equalize the chamber and atmospheric pressures, and the thermistor measured the air temperature. To assess accuracy, standard gasses are used prior to and at the completion of all experiments. Adjacent to the chambers in an identically treated area, soil moisture and temperatures for the surface 5 cm were measured using LI-COR LI-8150-205 Soil Moisture Probes (LI-COR, Lincoln, NE) and LI-COR LI-8150-203 Soil Temperature Probes (LI-COR, Lincoln, NE), respectively. Images of the system are provided in figure 1.

Figure 1. The chamber collects and measures GHG emissions in a growing corn crop (left) and prior to emergence (right).



Project delays: Procuring supplies to process RNA tissue has been difficult in the past year due to supply chains. PLFA analysis has also been slowed due to the computer attached to the gas chromatograph used for PLFA analysis needing repairs. These repairs were performed recently and there is still a significant issue with the computer, it is likely the computer and software will need to be replaced.

Activities for 2023

1. Complete the soil and plant sample analysis for 2023,
2. Prepare a thesis and complete the MS degree,
3. Start a PhD program,
4. Analysis of the hyperspectral data
5. Analyze the GHG measurements that were collected during the 2023 Spring and Fall
6. Prepare a spreadsheet containing all data
7. Harvest grain and stover biomass for 2023

Publications, presentations, and awards

1. Brugler, S., and Clay. D.E. 2022. The influence of nitrogen stabilizers in no-till corn production on nitrogen losses to the atmosphere. NUE meeting, Lincoln NE, August 1-3, 2022
2. Best Poster Presentation Award Graduate Research Day May 2023

Training

Graduate Student Skye Brugler Attended ASA Workshop: Crop Genomics, Bioinformatics, and Variant Calling, *Sponsored by ASA Section: Biometry and Statistical Computing and Statistical Education/Training for Researchers Community*

Additional funding base on project activities

1. Clay, D.E., Clay. S.A., Joshi, D., Westhoff, S., Reese, C.L., Reicks, G., Wang, T., and Nleya, T., Overcoming climate smart adoption barriers by demonstrating the value of linking no-tillage, cover crops, and enhanced N management into a single system, Classic USDA-NRCS-CIG program. Funding, 1,288,032. 2023-2026.
2. Bloom, P., (2022) GEVO from corn to jet fuel, 30 million dollars. SDSU 1.9 million, SDSU lead D.E. Clay. 2023-2027,