Nitrogen Losses in Response to Nitrogen Management Practices

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Research Questions

Adequate nitrogen (N) fertilization is critical for optimizing wheat yield and grain protein content. Nitrogen losses associated with fertilizer application have negative economic and environmental consequences. Therefore, N losses through denitrification (N_2O), volatilization (NH_3) and leaching (NO_3-) from wheat production system has local environmental implications with regard to gas emissions and water quality.

The overarching research question of the project is 'what are the ranges of nitrogen losses, soil nitrogen availability, and grain yield and protein content under spring wheat production system across the Red River Valley of Minnesota?'

Materials and Methods

During spring of 2018, nine spring wheat field located across the Red River Valley of MN were selected for this study (Table 1). Soon after planting, four collar for headspace air sampling to determine nitrous oxide flux, four suction cup lysimeter to collect soil solution at 2 ft depth for below-root-zone-nitrate concentration, and four open static chamber with ammonia trap to determine volatilization loss, were installed at 10 ft interval at each field (Figure 1). On a weekly basis, four soil samples from 0-6" soil depth were collected from each field and analyzed for inorganic nitrogen (ammonium and nitrate) concentration using 2M KCl extraction and TL2800 Timberline Ammonia Analyzer. Soil N_2O-N efflux will be measured every week interval using static chamber installed at each plot after planting. Headspace air samples of chamber was collected using a syringe at 0, 15, 30 min interval at each observation and air samples was analyzed using a Shimadzu gas chromatograph equipped with an electron capture detector. For volatilization, foam strips and the acid solution was collected. The sampled traps was transferred to the laboratory, where they was immediately extracted with 250 mL of 2 M KCl solution. The extracts were analyzed for NH_3 concentration using the ammonia analyzer. Soil water samples below the rooting zone was collected at a depth of 2' using a suction cup lysimeter consisting a sealed plastic tube that was equipped with a 100-kPa high flow porous ceramic cup. A slight vacuum in the tube draws soil water through porous ceramic tip and water sample was collected by a syringe to the suction line extending past the top seal and a clamp to seal it off. Sample water from lysimeters was be analyzed for NO_3-N using an automated Timberline TL2800 Ammonia Analyzer. For harvesting, five-feet long four-rows were harvested to determine grain yield and protein content.

Results

Grain yield and protein content of nine sites are presented in Fig. 2. The highest average yield was observed in Grygla (80.7 Bu/ac) and the lowest yield was recorded in Crookston (39.2 Bu/ac); and the opposite trend was observed in the case of protein content. Grygla site had 'Linkert' and Crookston site had 'Climax' (high protein cultivar). After harvesting, Crookston residual soil had the highest available nitrogen because of low yield and crop nitrogen uptake (Fig. 3). The highest cumulative nitrous oxide nitrogen loss was observed at the Argyle site, followed by Grygla, Crookston, and Ada; rest of the sites had similar denitrification losses (Fig. 4). Argyle and Crookston sites have high soil organic matter and clay content, these factors had positive influence on denitrification loss. Cumulative volatilization loss was relatively similar across sites as most growers apply through deep injection of nitrogen in the form of anhydrous ammonia. Subsurface application and incorporation of urea reduce the chance of volatilization (Fig. 5). Collection of soil solution using suction cup lysimeter was extremely erratic due to dry condition. Nitrate concentration above 50 ppm was observed at Argyle and Gentilly sites.

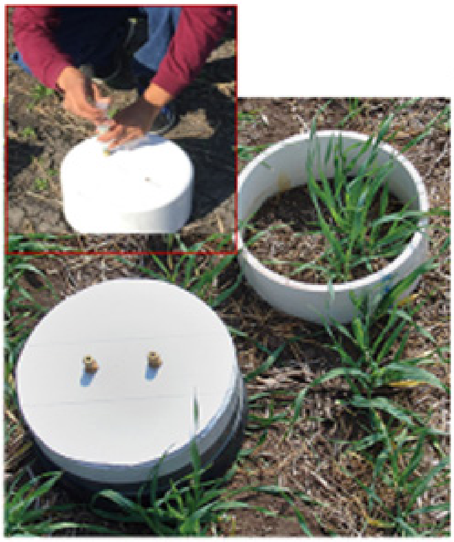
Argyle site was applied with urea on June 14 by mistake and might increase high nitrate concentration. On the other hand, Gentilly has a loamy fine sand soil, and light textured soil encourages fast water movement through profile. Red Lake Falls, Ada, Crookston and Glyndon had nitrate concentration higher than 10 ppm. Rest of the sites had negligible leaching loss of nitrate. This project will be continued for the next growing season also.

Publications

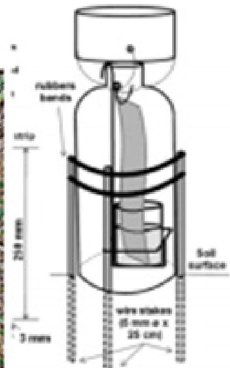
Chatterjee, A. 2018. Nitrogen dynamics in spring wheat production system. Oral presentation at ASA-CSSA-CSA Annual Meeting at Baltimore, Nov 4-7.

Figure 1. Different methods and procedure used to determine soil inorganic nitrogen concentration, and nitrogen losses in the form of nitrous oxide (denitrification loss N_2O-N), ammonia (volatilization loss of NH_3) and nitrate leaching (NO_3) from spring wheat fields located across the Red River Valley of Minnesota.

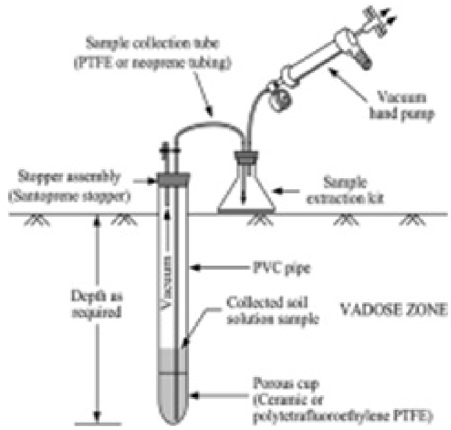
Soil ammonia and nitrate concentration at 0-6” depth



<u>Denitrification</u> loss of nitrous oxide Headspace air sampling and analyzing N_20 concentration by gas chromatograph



<u>Volatilization</u> loss of ammonia using open static chamber system



Below root zone nitrate concentration (leaching) using suction cup lysimeter 2 ft deep

Table 1. Information regarding nine growers’ fields used to determine nitrogen losses during the growing season in 2018.

	Argyle	**Crookston**	**Roseau**	**Red Lake Falls**	**Grygla**	**Gentilly**	**St. Hilaire**	**Ada**	**Glyndon**
Previous crop	Soybean	Soybean	Soybean	Soybean	Canola	Soybean	Soybean	Soybean	Soybean
Cultivar	Linkert	Climax	Linkert	Linkert	Linkert	Linkert	Prevail	Shelly	Linkert
Texture	Clay	Loam	Sandy Clay loam	Loam	Sandy loam	Loamy fine sand	Sandy loam	Clay loam	Loam
Soil OM%	4.5	5.2	3.9	4.2	3.1	2.0	3.4	5.3	3.9
Soil N (0-6”) lb/ac	40	60	31	75	106	70	73	117	70
Fertilizer application	Fall-anhy. NH_3 @160 lb N/ac with N-serve, 13-32-6-6@120 lb/ac-air seeder at soil depth 1.5 inch, 65 lb N/ac urea applied on June 14 broadcast	Fall-anhy. NH_3 @111 lb N/ac and 11-52-0@52 lb/ac. Spring-anhy. NH_3@75 lb N/ac and 11-52-0@ 85 lb/ac	Spring 100 lb N, 40 lb P_2O_5, 40 lb K_2O in dry fert. And topdress 30-0-0-15S on 9th June	Fall Anhydrous NH_3 80 lb N/ac and 58 lb of MAP	Fall 145 lb Anhydrous NH_3-N, Spring 110 lb/ac of 12-40-0	Fall: 150 lb N/ac and Spring: 100lb/ac of 12-40-0	Fall: Anhydrous NH_3 130 lb N/ac and Spring: 100lb/ac of 12:40:38	Spring 50 lb N/ac of 8-0-10	Spring 133 lb N, 30 lb P_2O_5 and 20 lb K_2O and 11-52-0@50 lb/ac applied in furrow
Planting date	29th April	29th April	12th May	4th May	13th May	3rd May	5th May	4th May	2nd May
Harvesting date	11th Aug	7th Aug	15th Aug	7th Aug	14th Aug	7th Aug	11th Aug	8th Aug	6th Aug

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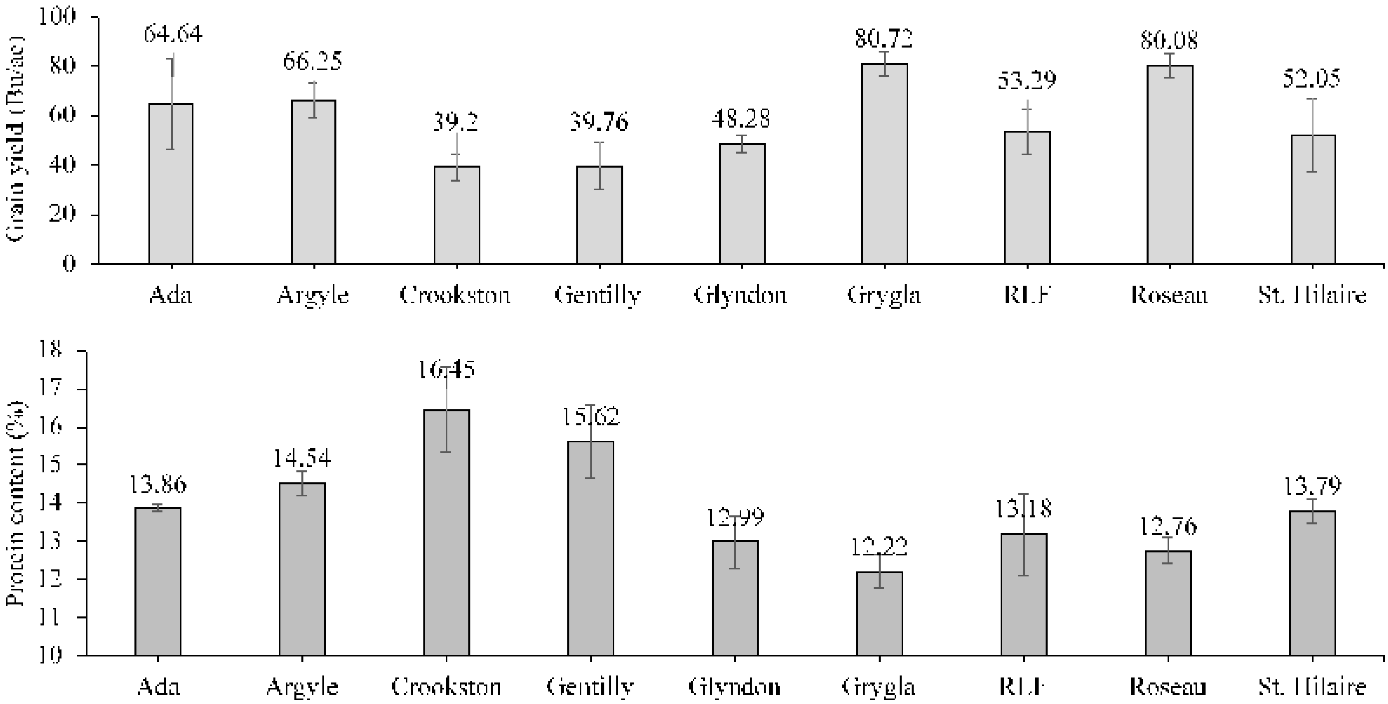
» **Figure 2.** Spring wheat grain yield (Bu/ac) and protein content (%) of nine growers' fields across the Red River Valley of MN



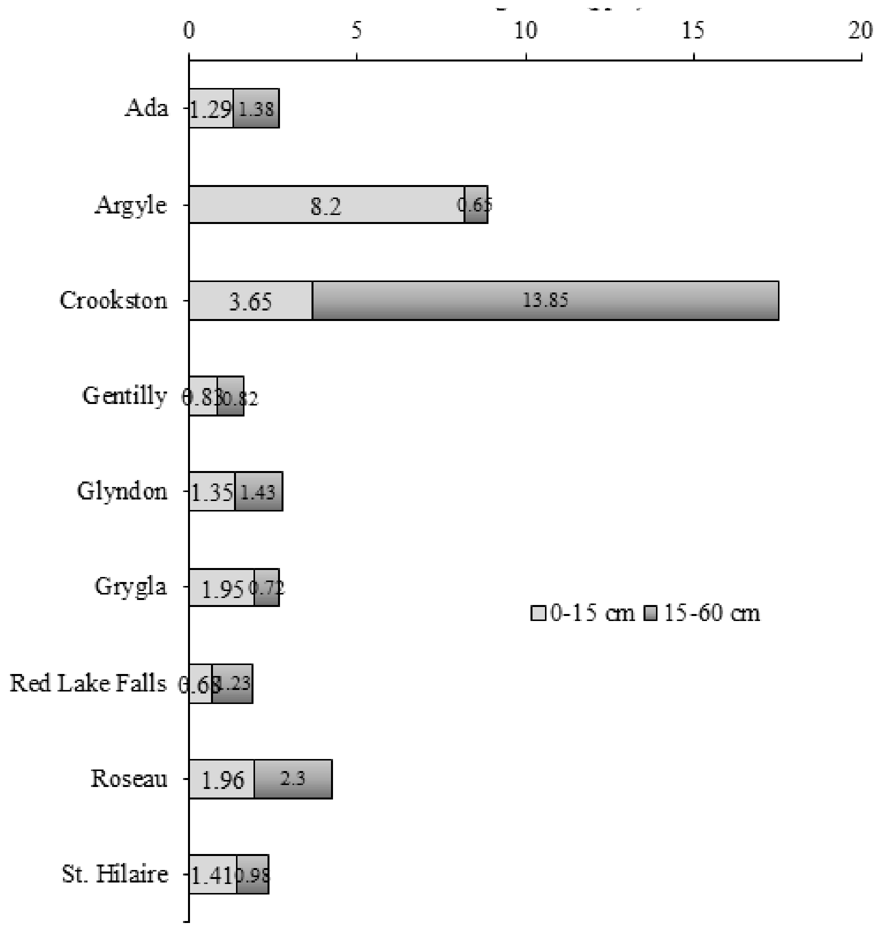


Figure 3. Soil available nitrogen (ppm) after harvest

Figure 4. Cumulative denitrification loss of nitrogen (kg N_2O-N ha^{-1}) from nine fields

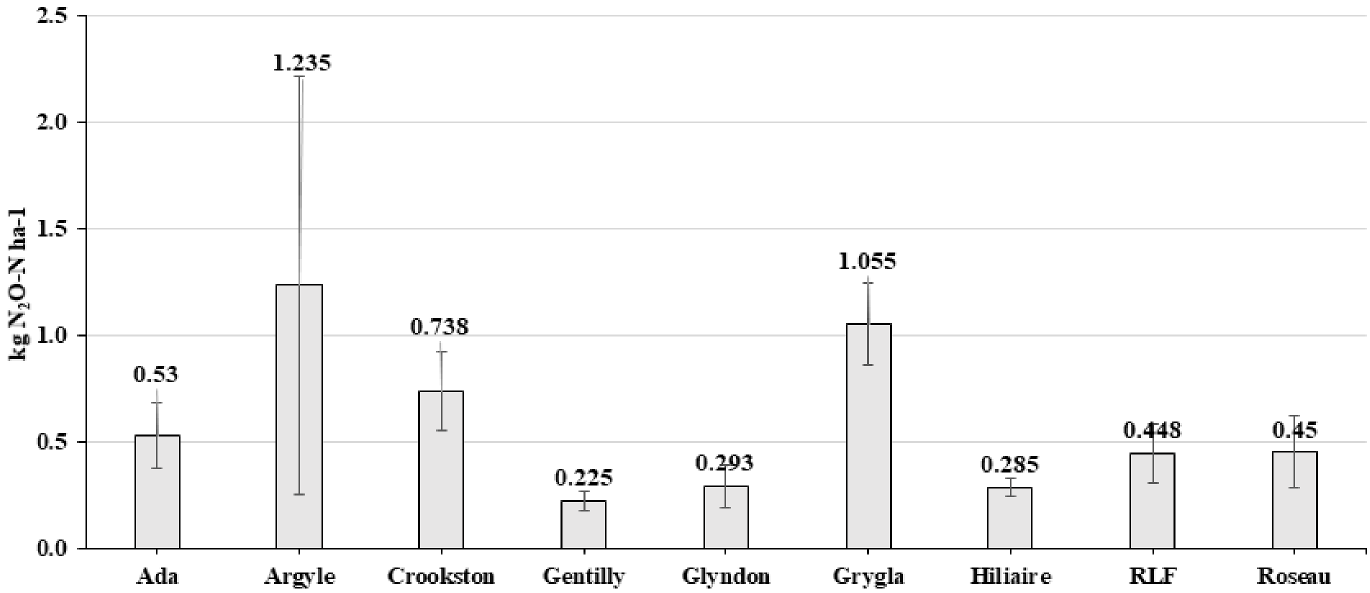


Figure 5. Cumulative volatilization loss (NH_3 kg ha^{-1}) from nine fields during 2018 growing seasons

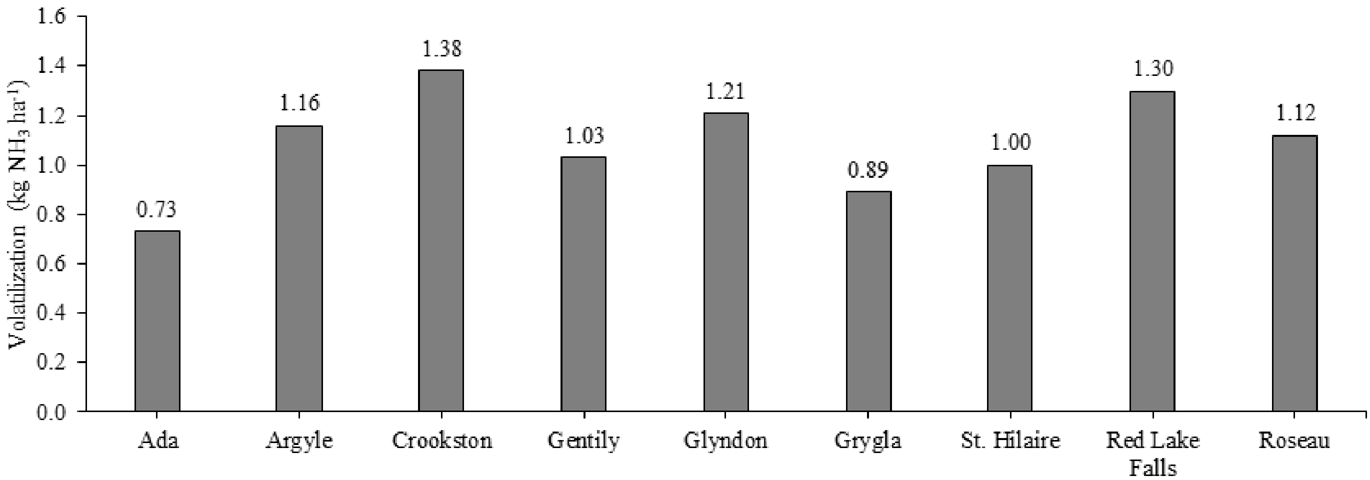


Figure 6. Peak nitrate concentration (ppm) observed at each field during 2018 growing season