Nitrogen source comparison of ammonia volatility, soil N content and nitrate leaching in irrigated and dryland sites

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Introduction:

Ammonia is a vital component of the nitrogen (N) cycle of terrestrial ecosystems in terms of volatilization and deposition. All nitrogen fertilizers are prone to loss after application and transformation when applied to crops and produce ammonium in two forms: free or unionized (no charge) form (NH_3) and ionized (with a charge, here a positive charge) form (NH_4^+). Ionized ammonium is soluble in water while unionized ammonia is volatile and could be easily removed from soil. Our previous studies (2016-2017) have debrided this process and shown that NH_3 volatilization accounts for 15–60% of the applied N. Enhanced efficiency fertilizers (EEFs) have been developed to minimize losses through NH_3 volatilization and can be divided into two broad categories: a chemical additive and coating nitrogen granules (such urea) with a physical barrier.

AgroLiquid manufactures several different proprietary nitrogen products such as eNhance and PrimAgro-N. eNhance has a plant-derived flavonoid (or flavonol) organic substance which proprietarily derived flavonol constituent results in strong intermolecular forces with nitrogen-containing compounds resulting in metamorphosed behavior. While PrimAgro-N combines improved chemistries with BioActivites, i.e., with specific combinations of beneficial nutrients, microbes, and carbon compounds. The strength of these interactions can be controlled through Targeted Molecular Expression which performs reaction on the specific part of the flavonol polymer molecule and creates new structural features that help to stimulate plant roots and microbes activity and liberate nutrients affected by soil tie-up.

Hypothesis

Our hypothesis was based on that eNhance and PrimAgro-N should enable ammonium release into the soil from a protected form of nitrogen. A process influencing as well the amount of ammonia to volatility which decreases PrimAgro-N susceptibility to nitrogen volatility due to the activation of the nitrogen cycle in soil.

Objective:

The primary objective of this research was to determine the effectiveness of different enhanced efficiency liquid fertilizers of AgroLiquid compared to UAN in reducing fertilizer N volatilization losses

Materials and methods:

Two nitrogen volatility study was carried in two research fields: irrigated site in Farm 3 as a demonstration plots (4 rows x 25') for 2018 AgroExpo and dryland site in Farm 10 (6 rows x 120').

Ammonia volatility: A semi-quantitative simple method known as a "passive sampler" was used for measurement of NH_3 emissions in small-scale plots. This method is a closed-static system which restricts the exchange of ammonia with the atmosphere and thereby creates a closed ammonia sink or absorption that proved to be a valid method under a wide range of environmental and experimental conditions. Each of the passive samplers was filled with 20 ml of a diluted 0.05 M sulfuric acid (H_2SO_4) in a transparent jar of 2.5" diameter held by metal rod fixed at the top 5.6" x 24" PVC tube pushed in the soil to 1" and firmly covered with plastic lid to allow for maximum ammonia absorption. Three passive samplers were placed in each treatment and moved to another spot after sampling the sulfuric acid to start the next measurement. The sulfuric acid samples were taken and filled in 20 ml in vials, weighed, and reported as the concentration of actual solution volume (i.e., 20 ml) before evaporation for accurate assessment of ammonia loss. Subsequently, new sulfuric acids were added by the same procedure for continuous measurement and calculation the ammonia cumulative loss during the studies period.

Lysimeters: In both research fields, Lysimeters were installed at 8" depth in the irrigated site and at 24" depth in the dryland site depth for soil solution suction and assessment of the nitrate leaching in all treatments of the dryland site and in 4 treatments in the irrigated site as noted in the treatments description.

Soil sampling: In both fields, composite soil samples were taken prior to planting at 0-6" on May 16, 2018, in the irrigated site and on June 24, 2018, in the dryland site for soil testing information.

Soil sampling for soil ammonium and nitrate content: Soil samples were taken periodically at 0-6" in the lysimeters treatments for assessment of soil ammonium (NH_4-N) and soil nitrate content (NO_3-N). Soil samples were analyzed at Michigan State University Lab after extraction by 1 M KCl solution.

Nitrogen treatments, as designed per treatment, were broadcast by Backpack sprayer: on May 18, 2018, in the irrigated site and on June 29, 2018, in the dryland site.

In both research sites, PVC chambers of alkali trap respirometers (Passive samplers) were installed for accurate measurement of NH_3 emissions after broadcasting the nitrogen and long-term continuous measurements were carried out for assessment of the ammonia volatility.

Nitrogen treatments:

Research plots in the irrigated site (farm 3), were designed as following:

1. Control (No N)
2. 28% UAN (250 lb-N/A or 100% rate) + Lysimeters for nitrate leaching
3. 28% UAN (175 lb-N/A or 70% rate)
4. High NRG-N (250 lb-N/A or 100% rate) + Lysimeters for nitrate leaching
5. High NRG-N (175 lb-N/A or 70% rate)
6. PrimAgro N (250 lb-N/A or 100% rate) Note: should be 76.5 gal
7. PrimAgro N (175 lb-N/A or 70% rate)
8. 28%/ eNhance (250 lb-N/A or 100% rate) + Lysimeters for nitrate leaching
9. 28%/ Agrotain (250 lb-N/A or 100% rate)

Research plots in the dryland site (farm 10), were designed as following:

1. Control (No N)
2. 28%/ Agrotain (150 lb-N/A)
3. 28%/ eNhance (150 lb-N/A) + Lysimeters for nitrate leaching
4. 28% UAN (150 lb-N/A) + Lysimeters for nitrate leaching
5. PrimAgro N (150 lb-N/A).

Results and discussion:

The irrigated site (farm 3):

The cumulative loss of ammonia was compared between eight sources of nitrogen, as listed in the above treatment list. (Figure 1).

Lower amounts of ammonia volatility reported with 28% UAN+ Agrotain and 28%UAN + eNhance, followed by PrimAgro-N and High NRG-N, and highest value of ammonia volatility in the 28% UAN treatment. Cumulative loss was carried for these same products at the reduced N rates of 175 lb-N/A of PrimAgro-N, High NRG-N, and 28% UAN. Results showed a reduction in ammonia volatility when eNhance is added to the 28% UAN compared with Agrotain added to 28% UAN. In the same run, PrimAgro-N and High NRG-N showed lower loss compared with 28% UAN treatment.

Highest loss of ammonia came from the 250 lb-N/A rate under irrigation. Also, the ammonia loss continued to be less in PrimAgro-N and High NRG-N compared with 28% UAN treatment when nitrogen applied at an equivalency rate (175 lb-N/A).

Results of Nitrate (NO_3-N) extracted from soil by 1 M KCL presented in Figure 2. Positive and significant values of soil nitrate content were in the PrimAgro-N treatments and decreased with High NRG-N, 28% UAN + Agrotain, 28% UAN + eNhance, and 28% UAN treatments, subsequently (Figure 2).

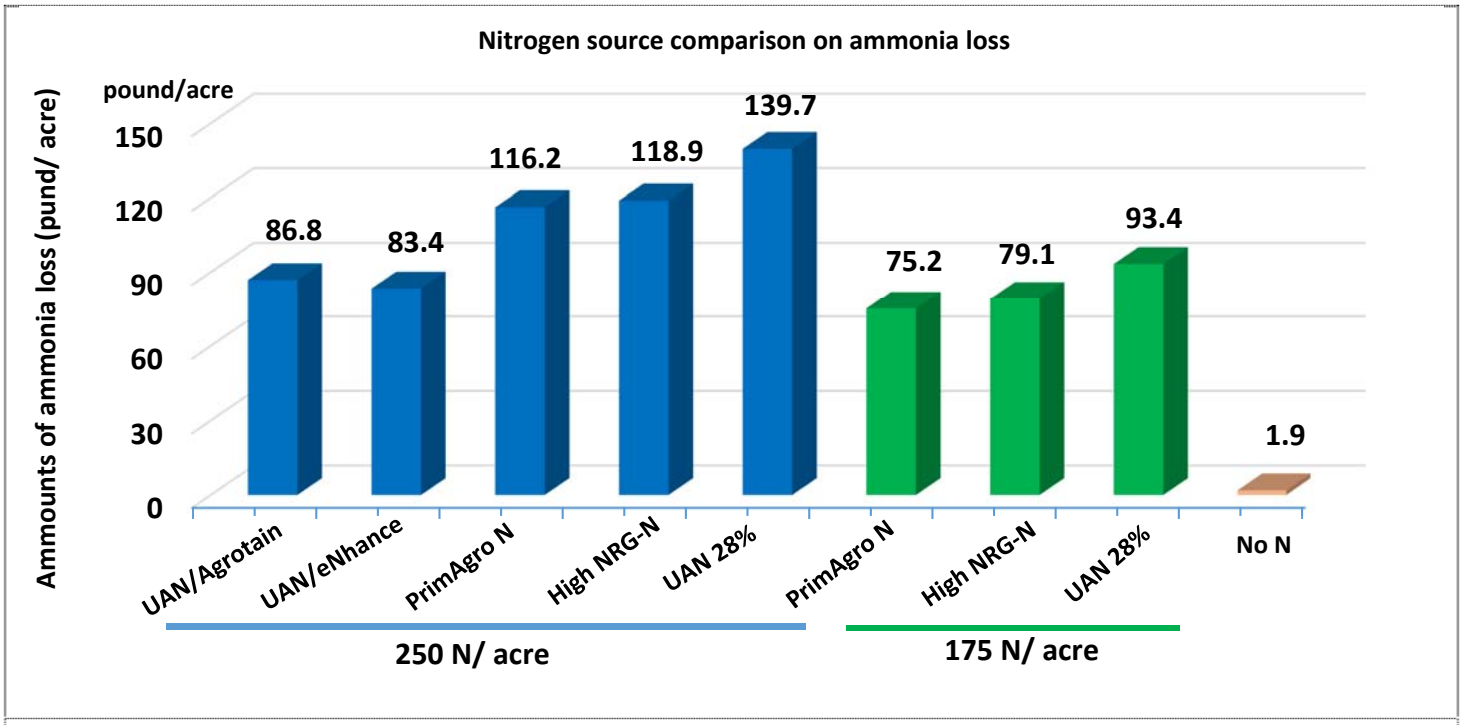

Figure 1. Cumulative Loss of Ammonia N (lb-N/A) measured during May 19- June 25, 2018, from different N sources applied on corn in Learning Center Plots (2018, Farm 3).

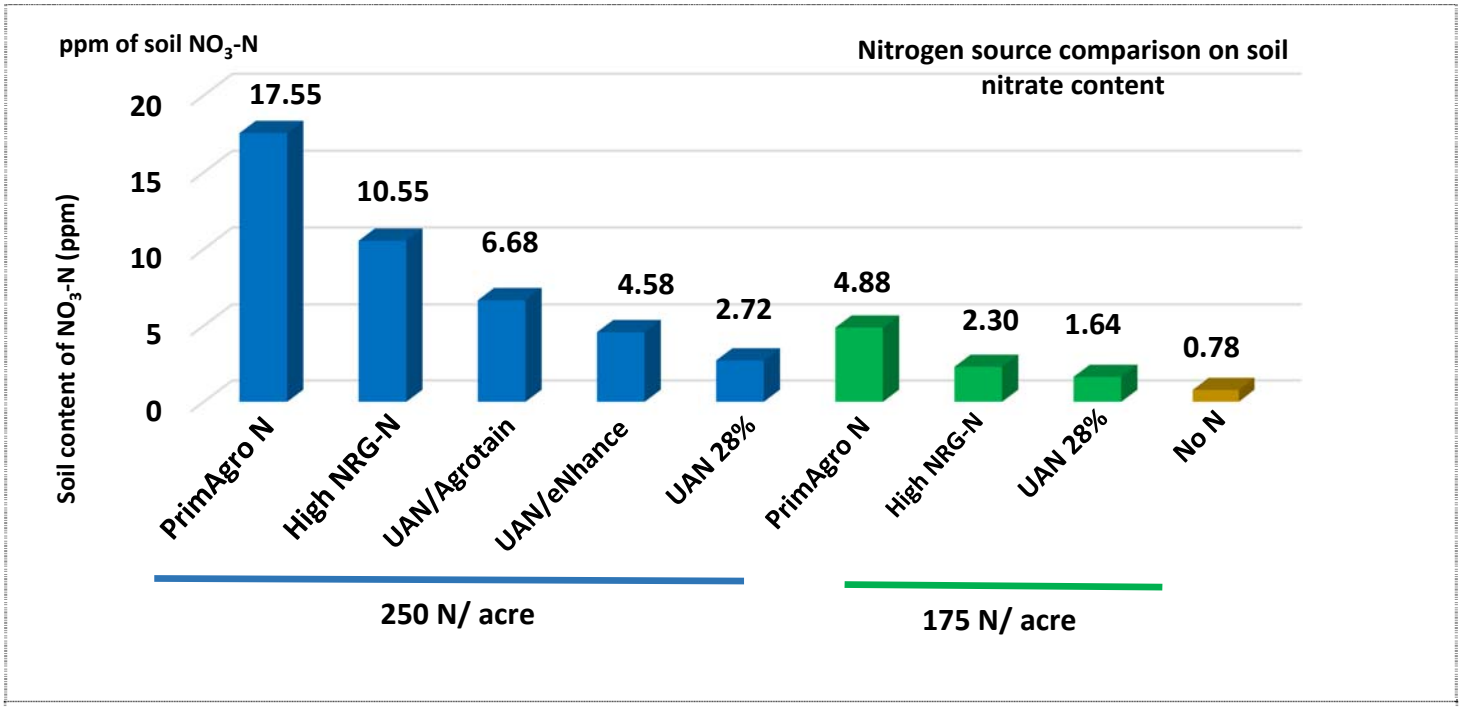

Figure 2. Nitrate (NO3-N) extracted from soil by 1 M KCL potential for plant uptake sampled on June 04, 2018 From Nine N Sources applied on corn in Learning Center Plots (2018, Farm 3).

Values of soil nitrate content of the reduced rate comparison with application of 175 lb-N/A continued to be higher in PrimAgro-N, High NRG-N, and 28% UAN subsequently. Results show the active contribution of PrimAgro-N in sequestering more NO_3-N that is soil available for plant roots uptake. (Figure 2).

Installation of lysimeters in the irrigated site at 8" depth helped to explore a higher nitrate leaching (193 ppm) in the in the 28% UAN compared with 28% UAN + eNhance and High NRG-N (144.1 ppm and 80.1 ppm) subsequently (Figure 3). Thus, the formulations of AgroLiquid nitrogen fertilizers substantially reduced nitrogen loss through volatility and leaching.

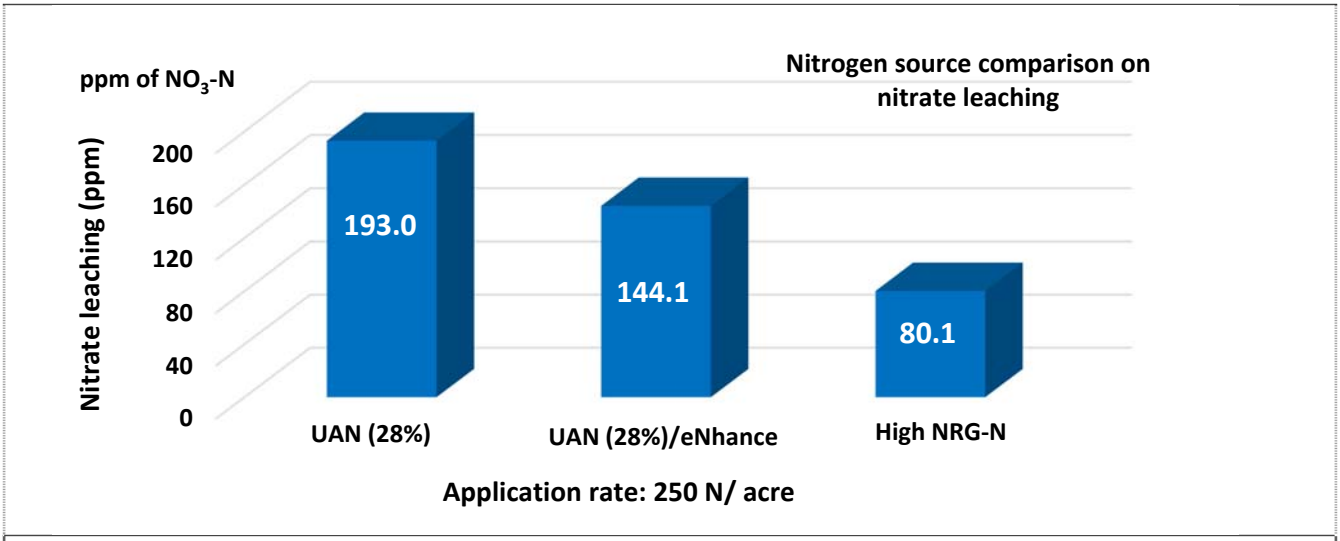

Figure 3. Nitrate (NO_3-N) leaching suctioned at 8" soil depth in three treatments measured on June 13, 2018, From Three N sources, applied on Corn in Learning Center Plots (2018, Farm 3).

Dryland site (farm 10):

A long period of minimal rainfall and high temperature where dominant conditions followed the late corn planting on June 26 June 2018 and initiation the research activities on June 29, after broadcasting the nitrogen. Unfortunately, such drought impacted the performance of lysimeters resulted in negligible quantities of solution suction.

However, such conditions of drought and warm stimulated the ammonia volatility process and enabled us to research AgroLiquid's product under harsh and optimal conditions that other nitrogen stabilizers ingredients such Agrotain likely, will not work efficiently, or at all. Figure 4, presents the cumulative loss of ammonia expressed in pounds of ammonium collected after 48 days after spraying a rate of 150 lb-N/A in dryland site. Lowest values of ammonia volatility reported with the application of PrimAgro-N, followed by 28% UAN+ eNhance, 28% UAN, and 28% UAN + Agrotain (49.6, 65.0, 75.7, and 93.4, in lb-N/A respectively).

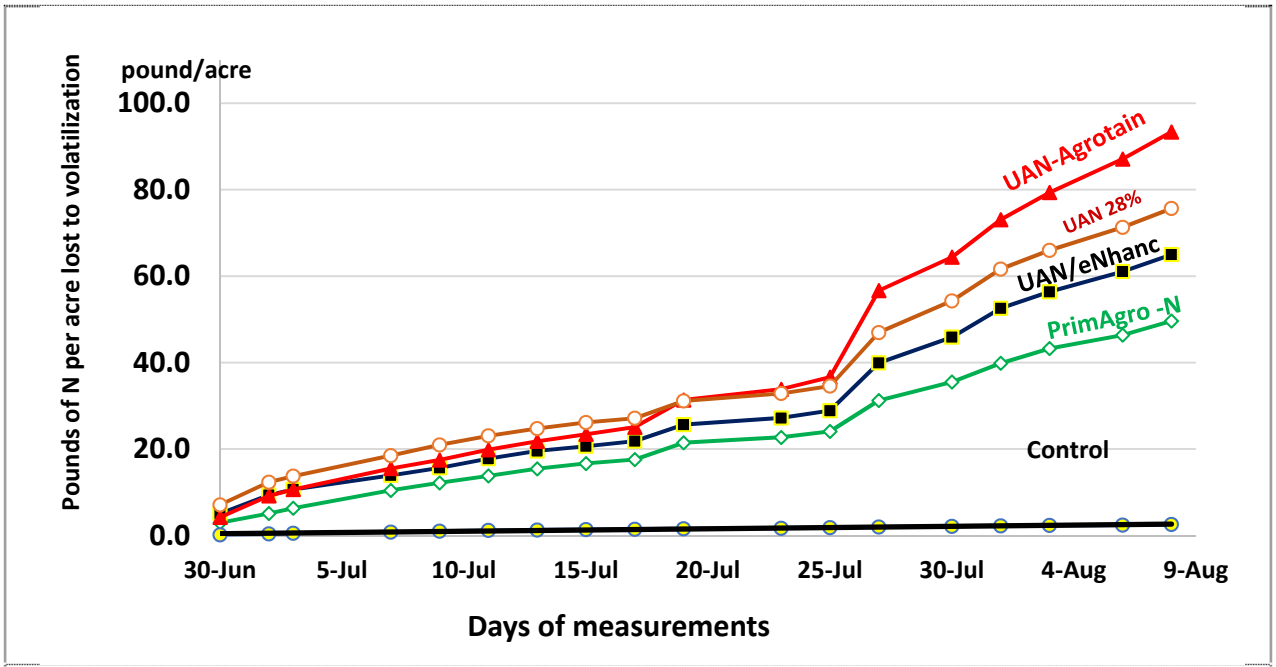

Figure 4. Cumulative loss of ammonia expressed in pounds of ammonium collected after 48 days after spraying a rate of 150 lb-N/A in dryland site (2018. Farm 10).

Amounts of soil ammonium (NH_4^+-N) and nitrate (NO_3-N) content in the dryland (Farm 10) during the corn growth period are shown in Table 1. Values of soil ammonium content where significantly high after application (measured on July 3rd, 2018) and decreased along the corn growth in all the treatments due to increasing magnitude of precipitation reduction and an increase of temperature which is a common phenomenon in dryland agriculture. Such dry soil conditions reduce soil microbial biomass and enzymes activity and stimulate ammonia volatility and conversion of ammonium to nitrate. Therefore, the difference between treatments for soil ammonium and nitrate content were statistically insignificant.

Table 1. Amounts of soil ammonium and nitrate contents analyzed at Michigan State University Lab after extraction by 1 M KCl solution in dryland site. Soil samples were taken at 0-6" in the dryland.

Soil ammonium-N content (ppm) at 0-6", (NH_4-N measured in ppm N as)						
	3-Jul	**11-Jul**	**17-Jul**	**24-Jul**	**1-Aug**	**Sum**
PrimAgro_N	37	16	10	4	9	76
UAN 28%	22	15	6	6	11	60
UAN 28% + eNhance	29	17	15	6	17	84
UAN 28% + Agrotain	41	6	7	2	5	61
Control	2	2	2	1	2	9
Soil nitrate content (ppm) at 0-6", NO_3-N measured in ppm N as						
PrimAgro_N	74	49	42	51	47	263
UAN 28%	76	47	42	50	54	269
UAN 28% + eNhance	78	53	45	52	68	296
UAN 28% + Agrotain	81	46	42	40	44	253
Control	21	22	21	19	21	104

Conclusion:

- Ecosystem rainfall manipulations provided a powerful approach for understanding how drought affects N dynamics under in situ field conditions. Thus enabled us a better understanding of the fate of nitrogen under irrigated and dryland agriculture.

- Highest loss of ammonia came from the 250 lb-N/A rate under irrigation compared with the reduced rate (175 lb-N/A).

- In the irrigated site (farm 3) lower amounts of ammonia volatility reported with 28% UAN+ Agrotain and 28%UAN + eNhance, followed by PrimAgro-N and High NRG-N, and compared with highest values of ammonia volatility in the 28% UAN treatment.

- In the dry land site, lowest values of ammonia volatility reported with the application of PrimAgro-N, followed by 28% UAN+ eNhance, 28% UAN, and 28% UAN + Agrotain (49.6, 65.0, 75,7, and 93.4, in lb-N/A respectively).

- In the irrigated site, positive and significant values of soil nitrate retention were in the PrimAgro-N treatments and decreased with High NRG-N, 28% UAN + Agrotain, 28% UAN + eNhance, and 28% UAN treatments, subsequently.

- Soil solution suction by lysimeters in the irrigated site reported higher nitrate leaching (193 ppm) in the in the 28% UAN compared with 28% UAN + eNhance and High NRG-N (144.1 ppm and 80.1 ppm) subsequently.

- Drought and warm conditions reduce soil microbial biomass and enzymes activity and stimulate ammonia volatility and conversion of ammonium to nitrate. Therefore, the difference between treatments for soil ammonium and nitrate content were statistically insignificant.