Corn Response to Traditional Nitrogen Sources and Ammonium Sulfate Byproduct

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Background and Approach

Nitrogen (N) applications for corn (Zea mays L.) constitute a substantial cost of production and an important one, as corn is normally very responsive to N. Ammonium sulfate production as a byproduct of Archer Daniels Midland (ADM) operations could represent a viable alternative to more traditional N sources for corn production.

Objectives

The objective of this study was to evaluate corn grain response to:

1) Different sources of N (specifically compare traditional sources to a byproduct from ADM operations),

2) Timings of application (Fall vs. Spring), and

3) Application rate

Methods

- Field experiments were conducted at the Crop Science Research and Education Center, near Urbana, Illinois during 3 corn growing season: 2012, 2013, and 2014.
- Soils were Drummer silty clay loam, and Flanagan silt loam.
- Fall vs. Spring applications were only evaluated in 2013.

Treatments

- **N sources: anhydrous ammonia (AA+S, 82-0-0), dry ammonium sulfate (AMS, 21-0-0-24S), and ADM's ammonium sulfate (ADM-AMS, 5-0-0-3S)**
- **N rates: 0, 90, 135, 180, 225 kg N ha^{-1}.**
- **N timing: N was applied pre-plant for each growing season. In 2013, N was applied in the Fall and Spring (pre-plant).**

- At the rate of 180 kg N ha^{-1}, a comparison among N sources was performed including urea-ammonium nitrate (UAN) applied as pre-plant and as split application (UAN-Split, 35 kg N ha^{-1} preplant and 135 kg N ha^{-1} at sidedress (V6).
- Sulfur fertilizer levels were adjusted to prevent differential response due to S across treatments.
- Soil was sampled at V6 at depth of 0-15, 15-30 and 30-60 cm to determine soil ammonium and nitrate content.
- Canopy color (SPAD readings) was measured at two development stages: V6 and V10.
- Total above-ground tissue N content was measured at physiological maturity (R6).
- Grain yields and grain N content were determined at harvest.
- Experiment was arranged in a randomized complete block design with four replications.
- Data analysis was performed using PROC GLIMMIXED procedure (SAS, Institute).

Air Temperature and Precipitation

Similar average growing season air temperatures were observed in 2012-2013-2014 compared with the 30yr- normal. The only substantial difference was in July 2012 when the monthly average temperature was 3.7°C above normal.

The high temperature combined with drier than normal conditions for much of the 2012 growing season (especially in June and July) until August severely limited the crop. The 2013 growing season stared with adequate precipitation but it became drier than normal during July through September.

In general, the 2014 growing season was wetter than the 30-yr normal except in August, but the crop had adequate moisture from precipitation accumulated in previous months.

Summary of Results

Grain yield- Spring application

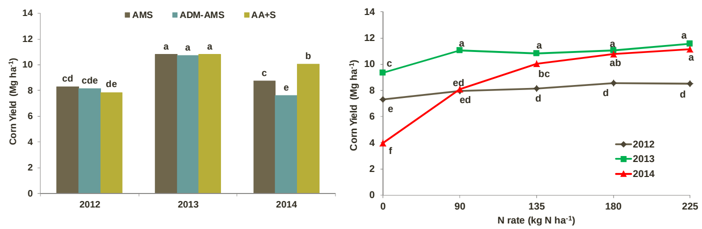

Figure 1. Corn grain yield (Mg ha^{-1}) for the 3 growing seasons: Effect of N sources (averaged across N rate) and N rate (averaged across N source). Different letters indicates significant differences at P<0.05.

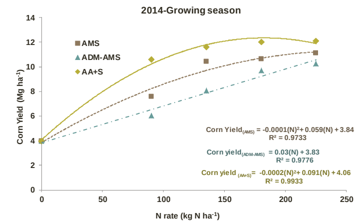

Figure 2. Corn grain yield (Mg ha^{-1}) in 2014 affected by N application rate.

The 2012 growing season was characterized by a severe drought for much of the summer that overshadowed any treatment effects and yields were severely limited. Also the crop was planted late. Statistical analysis indicates that there was no differences in corn yield and grain N uptake due to source of N, rate of application (above the check), or interaction of these variables (Fig. 1).

During the 2013 growing season, corn yields were greater than the 2012 and 2014 growing seasons, however there were not significant differences due to source of N, rate of application (above the check) or the interaction of these variables (Fig. 1). Grain N uptake was greater under AMS (132 kg N ha^{-1}) than AA+S (121 kg N ha^{-1}), but similar to ADM-AMS (128 kg N ha^{-1}),however no differences were found on grain N uptake among N rates.

The 2014 corn yield was affected by source of N and rate of application (P<0.05, Fig. 1).The AA+S treatment had significantly greater grain yield than AMS and ADM-AMS, and AMS was greater than ADM-AMS (Fig. 1). There was a significant response to N application rates reaching the maximum yields between the 180 and 225 kg N ha^{-1} rates (Fig 2). The response to N application in 2014 varies among N source: AMS and AA+S had a quadratic response, ADM-AMS had a lineal response (Fig.2).

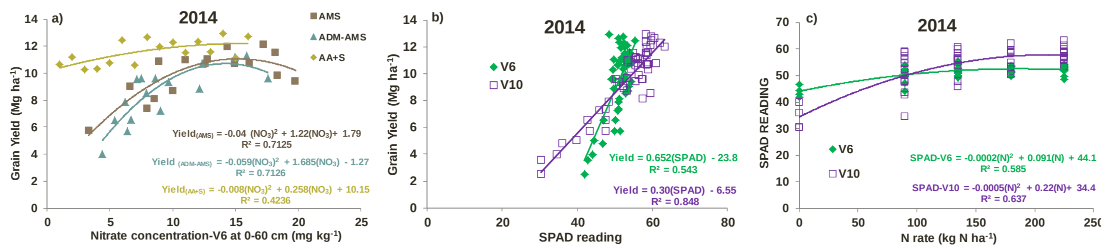

Figure 3. Relationship between grain yield and nitrate concentration in soil (a), and SPAD readings (b), and also SPAD readings and N rate (c) in the 2014 growing season.

There was a strong relationship between grain yield and nitrate concentration at V6 (Fig. 3a). Both ammonium sulfate sources follow the same pattern, however the AA+S showed a weaker relationship between these variables. Also grain yield linearly correlated with SPAD reading, with strong correlation at V10 (Fig. 3b). A significant response also was observed between SPAD readings and N application rate with the V10 stage being more strongly correlated (Fig. 3c).

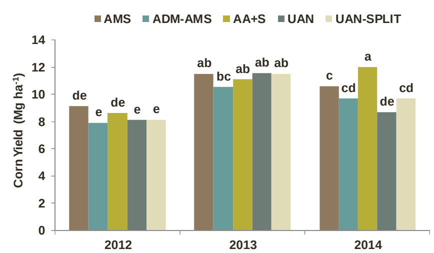

Figure 4. Grain yield response to different N sources at a fixed rate (180 kg N ha^{-1}) in 3 growing season. Different letters indicates significant differences at P<0.05.

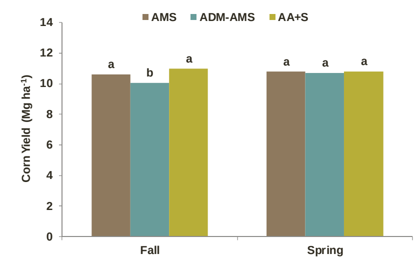

Figure 5. Grain yield response to Fall vs Spring N application in 2013 corn growing season. Different letters indicates significant differences at P<0.10.

Corn yield among different N sources at a fixed rate (180 kg N ha^{-1}) was only significantly different in 2014. AA+S had greater corn yields than the other sources (Fig. 4). AMS had similar yield than ADM-AMS, but greater than UAN. Splitting the UAN application by adding a portion of N at sidedress did not increase yields (Fig. 4).

In 2013, N was applied during the Fall 2012 and in Spring to evaluate the effect of time application and N sources on grain yield. The interaction Time x N source was significant (P<0.10) (Fig. 5), where similar grain yields were obtained with AA+S and AMS , but significantly greater than ADM-AMS during the Fall application. Although the differences were significant, the actual yield difference relative to ADM-AMS was 0.5 and 1 Mg ha^{-1} with AMS and AA+S, respectively (Fig. 5). Similar yields were obtained among N sources during Spring application (Fig 5).

Summary

- **Only in the 2014 growing season we detected significant differences in grain yield and grain N uptake due to N rate application and N source.**
- **AA+S had significant greater corn yield than AMS and ADM-AMS products, and AMS in turn produced greater yield than ADM-AMS product.**
- **The effect of N sources at fixed N rate showed greater yield with AA+S, with similar yields between AMS and ADM-AMS, but AMS significantly greater than UAN.**
- **No differences were detected among N sources for Spring applications, but greater yields were observed with AA+S and AMS than ADM-AMS for Fall applications.**
- **Overall, ADM-AMS appears to be an acceptable N source, agronomically similar to AMS under most conditions. However, further evaluation is required to more clearly understand the potential of ADM-AMS as an N source.**

Acknowledgements

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