Addressing nitrogen controversies

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Objective:
The objective of this project is to collect data that will help to address several controversies about nitrogen management, including:

1) How do various nitrogen rate recommendation systems perform?
2) Is foliar N more efficient than soil-applied N, and is Coron more efficient than UAN?
3) Among the range of new N products and N-enhancement products, which are profitable to use and how do they rank?

Accomplishments for 2008:

- Three separate small-plot experiments (addressing objectives 1, 2, and 3 listed above) were conducted as planned at Bradford Farm near Columbia. All experiments used corn as the test crop.

Nitrogen rate recommendation systems experiment

- This experiment was planted on May 6. Due to the later-than-desired planting date, we decided to plant on May 6 despite borderline soil conditions for planting.
    - This resulted in stand problems, with average emergence of 50-60%.
    - There was rain during 9 of the 10 days after planting.
    - Weather was cool and wet and full emergence took nearly three weeks, so by the time we knew the severity of the problem it was too late for a replant (and soil conditions were still poor for planting anyway).
    - Of the three experiments, this was the only one with severe stand problems.

- By early August, all of the treatments with preplant nitrogen appeared severely nitrogen-deficient over the entire plant, and had the classic V-shaped nitrogen deficiency burn up the midrib on the leaf below the ear leaf.

- All sidedress nitrogen treatments had much better leaf color but also had V-shaped burn up the midrib on leaves below knee height indicating that they were deficient as well.

- Yields were low in this experiment, especially considering that lack of water was never a source of stress. Average yield for treatments receiving N was 94 bu/acre. Stand problems, N stress in all treatments, and late-germinating waterhemp that provided significant competition only in the sidedress treatments all contributed to the low yields.

- Nitrogen timing had a large effect on yield in this experiment.
  - Plots receiving preplant N had an average yield of 75 bu/acre (see table next page).
  - Plots receiving sidedress N had an average yield of 119 bu/acre. Although this yield is not very good, it's 44 bushels above the yield for preplant nitrogen. This is in agreement with the appearance of the plants as shown in the photos on the previous page.
  - If not for stand problems, the yield effect of N timing probably would have been larger. This is explained in more detail in the next bullet.

- Population at harvest ranged from 11,000 to 18,000 plants/acre and affected yield of some but not all treatments.
  - Average population was 13,900/acre, about half of the 27,700 seeds we planted.
  - This did not appear to be a yield-limiting factor in the treatments that received 140 lb N/acre or less preplant. In these treatments, yield level was the same from 11,000 to 17,000. Nitrogen availability apparently limited yield so strongly that extra plants did not increase yield.
  - In the treatment that received 180 lb N preplant, yield went up by about 3 bu/acre for every 1,000 plants/acre.
    - Yield increased by 22 bu/acre from 11,000 to 18,000 plants/acre.
    - This is a small increase for populations this low. It is probably related to the N limitation that clearly existed despite receiving 180 lb N/acre preplant.
  - Population effect on yield was larger for the sidedress N treatments, over 7 bu/acre for every 1,000 plants/acre. This is probably because these treatments were less N-limited and is probably a more typical population response at this population level.
    - Harvest population range was narrower for the sidedress treatments, from 12,700 to 17,100. Yield increased by 32 bu/acre from 12,700 to 17,100 plants/acre.
    - It appears that if populations had been better, yields with sidedress N would have been higher and the yield difference between preplant and sidedress N would have been larger.

- After two years, the most profitable systems are the two systems in which N rate is based on corn color (Crop Circle sensor and Minolta chlorophyll meter).
  - These systems gave profits nearly $100/acre/year above the profits given by preplant N management.
    - This is mostly due to the poor yields with preplant N in 2008.
  - They also out-performed sidedress N management based on soil nitrate testing (Iowa State University interpretations) by about $35/acre/year.
    - Yield was higher with color-based management in both years.
    - This cannot be explained by N rates applied in 2008, which were similar for the soil test and the Crop Circle sensors (and both higher than the chlorophyll meter).
    - The soil nitrate test recommended a very low N rate in 2007 which resulted in a yield penalty of about 20 bushels. Residual effects of this low N rate may explain the lower yield seen with this treatment in 2008, which was 9 bu/acre less than the color-based systems (statistically significant with $\alpha = 0.05$).

Table 1. Nitrogen rates recommended and corn yields produced by eight different recommendation systems in 2007-2008.

Nitrogen rate recommendation system	Nitrogen timing	Nitrogen rate(s) 2008	Yield 2008*	Nitrogen rate(s) 2007	Yield 2007	Gross minus N cost (2-year ave)**
		lb N/ac	bu/ac	lb N/ac	bu/ac	$/ac
Crop Circle sensor	V7†	147, 146, 168, 125, 158, 143‡	122	96, 110, 73, 116, 57, 40	156	481
Chlorophyll meter	V7	110	122	155	159	476
Sidedress soil test	V7	141	113	50	140	443
Yield goal / MRTN	preplant	140	79	140	162	390
Low	preplant	100	67	100	158	385
High	preplant	180	84	180	164	380
Preplant soil test	preplant	140	70	140	163	374
Check	-------	0	49	0	104	306

*2008 yields are different than each other (95% confidence) if they are 7 or more bushels apart.

**Used $4/bushel corn price, $0.65/lb N price as estimates of average corn and N prices over these 2 years.

†Growth stage V7 is about knee high corn.

‡A different N rate was applied in each of 6 replications for this treatment. It is feasible to use this sensor to change N rate automaticallly while fertilizing a field, and we felt that this ability would be most accurately reflected by diagnosing N rate for each plot separately.

- No statistical difference in profitability was found between the preplant N rates (100, 140, 180) after two years.
  - There is only a $5/acre/year difference between the low (100) and high (180) N rates. The yield difference between these two treatments has been almost exactly balanced by the difference in N fertilizer expense. However, the yield difference in 2008 (17 bu/ac) was larger than the difference in 2007 (6 bu/ac) and may reflect a trend for yield differences between the low and high rates to get larger over time.
  - Over these two years, the preplant soil nitrate test system has been exactly the same as the yield goal system, because not enough soil nitrate was found either year to justify reducing the N fertilizer rate. A credit is given only when soil nitrate-N is above 50 lb N/acre. The average profitability of these two treatments ($382/ac gross minus N cost) falls between the profitability for the low and high rates.

Foliar N efficiency experiment

- This experiment was designed to compare the ability of different foliar N sources to deliver N to corn, and to compare foliar applications with soil applications at the same rate and timing.
- A total N rate of 80 lb N/acre was used. This rate was chosen with the expectation that corn would be N-stressed and the ability of treatments to deliver N would be directly reflected in yield. The 80 lb was divided into three applications, 30 lb N preplant and two in-season applications of 25 lb N/acre.
- We wanted to test the ability of foliar treatments to deliver an amount of N that could make a substantial difference in yield. We chose 25 lb N/acre as the most that we thought we could apply without producing major leaf burn problems (based on previous MU experiments with foliar K on soybean by Motavalli and Nelson).
- All treatments received a broadcast application of ammonium nitrate preplant at a rate of 30 lb N/acre.
- All treatments received two in-season applications of N at a rate of 25 lb N/acre each time. Applications were made on July 2 (stage V10, waist high) and again on July 11 (V13, shoulder high). Treatments were forms of N used in these applications:
    - foliar CoRoN
    - foliar UAN
    - foliar urea
    - dribbled UAN (between rows)
    - broadcast ammonium nitrate
    - broadcast urea with Agrotain
    - check (no in-season N)

Table 2. Corn yields with foliar or dry N sources.

in-season N source	yield*	average burn rating**
dry urea with Agrotain	133	1
foliar urea	130	7.5
dry ammonium nitrate	126	4.5
UAN dribbled	122	0
foliar CoRoN	116	4
foliar UAN	112	8.5
no in-season N	69	0

*Yields are different than each other (95% confidence) if they are 9 or more bushels apart.
**0 = no burn, 10 = severe burn

- Foliar treatments did not show superior ability to deliver in-season N to a corn crop relative to soil-applied treatments.
    - Average yield with foliar N was 119 bu/acre, with soil-applied N was 127 bu/acre.
    - High soil moisture and frequent rainfall throughout the summer contributed to efficient use of soil-applied N. Water to deliver soil-applied N to roots was plentiful.

- Some yield differences were observed within foliar and soil-applied N sources.
  - Broadcast dry urea with Agrotain gave significantly higher yield than dribbled UAN.
  - Foliar urea gave significantly higher yield than foliar CoRoN or foliar UAN.

- Within N source, placement mattered for UAN but not for urea.
  - Dribbled UAN yielded 10 bushels more than foliar UAN. This was likely due to leaf burn, as UAN produced the highest leaf burn rating among all treatments.
  - Dry urea and foliar urea gave similar yields despite a fairly high leaf burn rating with foliar urea. The leaf burn associated with foliar urea was more gray 'tissue damage' compared with foliar UAN which produced a more yellow progressing to brown burn that was clearly death of the affected leaf tissue.

- Average yield response was 54 bu/acre to 50 lb N/acre applied in-season. This is an excellent yield response and shows that any of these methods of applying N would be highly profitable if corn was for some reason N-stressed and needed additional N.

<u>New N products and N-enhancement products experiment</u>

- This experiment was designed to test the new N products Calcium Ammonium Nitrate and Nurea, the new N-enhancement products ESN and Nutrisphere, along with the established N-enhancement product Agrotain. All treatments are dry broadcast N products.
- No-till corn is the test crop. Soybean was the previous crop.
- A nitrogen rate of 140 lb N/acre was used for all treatments, broadcast on May 1, followed by planting on May 6 at 27,700 seeds/acre.
- Average harvest population was 21,700 plants/acre.

Table 3. Yields with new dry N sources or N additives compared to standard dry N products.

Nitrogen source	Yield*
ESN	124
Urea + Agrotain	107
Calcium ammonium nitrate	106
Urea + Nutrisphere	104
Ammonium nitrate	102
Urea	93
Nurea	84

*Yields are different than each other (95% confidence) if they are 18 or more bushels apart.

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- Yields were not very good in this experiment considering the lack of drought stress.
  - Population was one reason. Average harvest population was 21,700 plants/acre and within the range of populations in this experiment, higher populations gave higher yields. Cold, wet planting conditions led to slow emergence and significant stand loss despite the late planting date (May 6).
  - Nitrogen timing (leading to N deficiency) was probably another reason.
    - This experiment was located immediately adjacent to the foliar N experiment reported above. Average yield of fertilized plots in that experiment were 20 bushels higher than in this experiment despite receiving 60 lb less N (80 lb N/acre in the foliar experiment vs. 140 lb N/acre in this experiment).
    - In the nitrogen rate systems experiment reported above, sidedress treatments yielded 44 bu/acre more than preplant treatments.
    - Both of these observations suggest that there was probably extensive loss of nitrogen from the preplant applications used in this experiment.

- ESN gave the highest yield, significantly higher (95% confidence) than all other treatments except urea + Agrotain. This is consistent with other experiments in Missouri where ESN increased yield under wet conditions. ESN appears to provide some protection from N loss during wet weather due to its slow-release properties.

- Calcium ammonium nitrate gave equivalent yield to ammonium nitrate. We expected and confirmed similar behavior for these two N sources. The chemical form of N is identical for the two, but with added calcium minerals in calcium ammonium nitrate to negate the explosive properties.

- Because of the high level of yield variability within treatments in this experiment, it took a large yield difference (18 bu) to be statistically different with 95% confidence.

- Untreated broadcast urea would be expected to often give lower yields than other sources due to volatilization loss of N.
  - This may have been the case in this experiment as yield with urea was 11 to 14 bu/acre less than with ammonium nitrate, calcium ammonium nitrate, urea plus Agrotain, or urea plus Nutrisphere. Statistically there is a 70 to 85% probability that these yield differences were true.
  - The 0.92 inches of rain that fell in the four days (mostly the first two days) after treatment application should have prevented any volatile N loss from urea. This suggests that the lower yields seen with urea are more likely to be accidental than due to N loss from this treatment.

- Although there is weak evidence that the urea additives (Agrotain and Nutrisphere) produced yield increases, this is counter to the expectation that there would be little N loss from untreated urea with 0.92 inches of rain in the four days after application.

- Nurea gave the lowest yield, significantly lower than all other treatments except urea.

Table 4. Details of experimental procedures for the three experiments in this project.

Operation	Experimental details for:		
	N rate rec. systems	Foliar / in-season N	New sources of dry N
Starting condition	Previous corn, no-till, 70-75% residue cover	Previous soybean, no-till, 20-30% residue cover	Previous soybean, no-till, 20-30% residue cover
Pre-plant soil sampling	April 15	none	none
Weed control: broadcast herbicide application	Gramoxone 2.0 pts/ac, Lexar 3.0 qts/ac, nonionic surfactant - 2 pt /100gal 4/16/2008	Gramoxone 2.0 pts/ac, Lexar 3.0 qts/ac, nonionic surfactant - 2 pt /100gal 4/16/2008	Gramoxone 2.0 pts/ac, Lexar 3.0 qts/ac, nonionic surfactant - 2 pt /100gal 4/16/2008
Pre-plant broadcast fertilizer treatments	3 fixed rate treatments & MO pre-plant soil test treatment 4/30/2008	All plots 30 lbs/ac N Source - Ammonium Nitrate 4/30/2008	7 treatments All pre-plant 5/1/2008
Planting	Planter: John Deere 7000 w/finger pickup Variety: Pioneer 34A20 RR2 Herculex xtra Seed drop: 27,700 Depth: 1.25" - 1.50" Conditions: Very Moist / Wet Emergence 21 - 24 days Planted 5/6/2008	Planter: John Deere 7000 w/finger pickup Variety: Pioneer 34A20 RR2 Herculex xtra Seed drop: 27,700 Depth: 1.25" - 1.50" Conditions: Very Moist Emergence 18 - 21 days Planted 5/6/2008	Planter: John Deere 7000 w/finger pickup Variety: Pioneer 34A20 RR2 Herculex xtra Seed drop: 27,700 Depth: 1.25" - 1.50" Conditions: Very Moist Emergence 18 - 21 days Planted 5/6/2008
In-season weed control (broadcast herbicide)	none	Roundup 20 oz/ac 6/19/2008	Roundup 20 oz/ac 6/19/2008
Side-dress Treatment Applications	June 30	July 2 July 11	none
Harvest	October 19	October 12	October 13

Objective for 2009

Repeat these three experiments:

- N rate recommendation systems
- Foliar vs. soil-applied N
- New N products/additives

Budget for 2009

Research Specialist time	$15,000
Benefits	4,500
Soil sample analysis	200
Field supplies and fuel	800
Total	**$20,500**