Sensor-based variable rate N: Long-term performance in corn and cotton

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Objective:

The objective of this project is to evaluate long-term performance of sensor-based variable N rate recommendations for corn and cotton. Sensor-based N management is compared with typical producer N management and with other N rate decision systems.

Accomplishments for 2011:

- Two small-plot corn experiments were conducted as planned at Bradford Farm near Columbia.
- One small-plot cotton experiment was conducted as planned at the Delta Center near Portageville.

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Experiment 1: Long-term impact of nitrogen rate recommendation systems

- 2011 is the 5th year of this study, with each plot getting the same N decision and management system every year.
- This experiment is conducted in continuous no-till corn to magnify the effects of any problems related to N management.
- Populations and yields were very low in this experiment, and yield was determined almost entirely by population.
- Average population at harvest was 13,400 plants/acre, less than half of what we planted. There were three factors that contributed to these very low populations:
  - Wet soil conditions at planting followed by cold and rain after planting. Corn was planted on May 9 (see table) with average temperature of 79 degrees that day. In the first four days after planting, 1.25 inches of rain fell, then it turned cold with an average temperature of 53 degrees for May 13-19. From May 20-25, 2.7 inches of rain fell. These cold and wet conditions led to stand loss in all of our experiments, but they were worst in this experiment with continuous no-till corn. The corn residue holds water in the soil, leading to cooler and wetter soil conditions.
  - A hailstorm on July 3 that stripped most of the leaves off of the plants, killing some (see photo in Figure 1).
  - Drought stress following the hailstorm. Only 0.4 inches of rain fell from July 4 to July 29, accompanied by high temperatures, leading to the death of plants stressed by hail damage and by early-season conditions.
- Because of the very low populations, very low yields, and strong dependence of yield on population, we believe that nothing of value about nitrogen fertilizer management can be learned from the 2011 data in this study.
- The study will be continued in 2012 with the same treatments on the same plots.
- **For the period 2007-2010, the two systems based on crop color to guide sidedress N rate out-performed all-preplant systems by an average of $95/acre or more. This was mainly due to serious N loss with preplant N applications during the wet springs of 2008-2010.**

Experiment 2: Effect of pre-plant nitrogen on sensor-based N rate performance

- Experiment 2 is designed to complement Experiment 1 and address concerns that sidedress systems with no N applied preplant may cost yield.
  - 2011 is the second year for this experiment.
  - Three of the four treatments in Experiment 2 are shared with Experiment 1.
  - The key treatment is 50 lb N/ac applied pre-plant, followed by sidedress N at rates diagnosed by the Crop Circle sensor.
    - Results from this treatment can be compared to pre-plant N management (140 and 180 lb N rates) and sensor-based sidedress with no N pre-plant to evaluate its relative performance.
    - Any N stress experienced with the sidedress-only sensor-based treatments should be avoided.

- It is right next to Experiment 1, so soils and weather are very similar. Seed, herbicide, planting date, and application dates are identical to Experiment 1 (Table 2).

- Although the same adverse conditions affected this Experiments 1 and 2, populations did not suffer nearly as much in Experiment 2 as they did in Experiment 1. Average harvest population was 22,150. This experiment is in only its second year of no-till corn. Residue appeared similar in the two experiments but was probably heavier in Experiment 1 which is in its fifth year of no-till corn. Lower residue cover would lead to lower soil water content and higher soil temperature during germination, reducing the stress and mortality during that cold, wet period.

- Yields were low due to hail and drought. Nitrogen was not a yield-limiting factor for any of the treatments. Thus all treatments gave statistically equivalent yields (Table 1).

- One of the concerns with sidedress N management with no N applied pre-plant is that the crop development will be slowed. In years with a July drought, slower development could push reproductive stages farther into the drought, causing additional yield loss

- **Sidedress-only N management did not cause yield loss despite drought stress and the potential for slower development to push reproductive growth into a more stressful time.**

- **Over the 2 years of this study, there has been no indication that sensor-based N rate recommendations perform better with preplant N than without.**

- **Over 2 years, sensor-based N management out-yielded preplant N management by about 16 bushels and gave about $95/acre higher profit (Table 1).** This is due to 2010 results, since there were no differences between treatments in 2011.

Table 1. Nitrogen rates recommended and corn yields produced by different recommendation systems in Experiment 2, 2010-11

Nitrogen Recommendation System	2011 preplant N rate, lb N/ac	2011 Sidedress N rate at V8[1], lb N/acre	2011 Total N rate, lb N/ac	2011 yield, bu/ac[3]	2011 Gross - N cost, $/ac[3,4]	2010 preplant N rate, lb N/ac	2010 Sidedress N rate at V7.5[1], lb N/acre	2010 Total Nitrogen rate, lb N/ac	2010 yield, bu/ac[3]	2010 Gross - N cost, $/ac[3,4]	2 yr. average N rate, lb N/ac	2 yr Avg. yield, bu/ac[3]	2 yr Avg. Gross - N cost, $/ac[3,4]
Crop Circle sensor[2]	0	145,116,137 92,158,137 Avg. rate = 131	145,116,137 92,158,137 Avg. rate = 131	83 A	$349 A	0	135,113,108 84,163, 167 Avg. rate = 128	135,113,108 84,163, 167 Avg. rate = 128	135 A	$608 A	130	108 A	$479 A
50 lb N pre + Crop Circle sensor[2]	50	93,103,69 117,137,74 Avg. rate = 99	143,153,119 167,187,124 Avg. rate = 149	81 A	$333 A	50	60, 74, 60 157, 160,96 Avg. rate = 101	110,124,110 207,210,146 Avg. rate = 151	139 A	$616 A	150	110 A	$475 A
Yield goal/ MRTN	140	0	140	78 A	$318 A	140	0	140	104 B	$450 B	140	91 B	$384 B
High	180	0	180	80 A	$310 A	180	0	180	107 B	$445 B	180	94 B	$378 B

[1] Growth stage V7.5 is just above knee high, stage V8 is about thigh high corn
[2] 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 automatically while fertilizing a field, and we felt that this ability would be most accurately reflected by diagnosing N rate for each plot separately.
[3] Values within a column that are followed by a shared letter are not statistically different from one another with 90% confidence.
[4] Gross calculated using $5/bu. corn price, $0.50/lb. N cost as estimates of current (2011) corn prices and N cost.

Figure 1. Hail damage typical of 2011 corn experiments two weeks after the hailstorm.

Table 2. Procedures for long term sensor N rate experiments on corn (experiments 1 & 2).		
Description	Experiment 1	Experiment 2
Previous Crop	Corn 70-75% Residue cover	Corn 70-75% Residue cover
Fall Prep Work	Stalks shredded Fall 2010	Stalks shredded Fall 2010
Pre-plant Soil Sampling (2' depth)	4/1/2011	none
Tillage	No-till	No-till
Early Nitrogen Application	3 Fixed rate treatments & pre-plant soil nitrate test treatment 4/6/2011	3 Fixed rate treatments & pre-plant soil nitrate test treatment 4/7/2011
Weed Control Broadcast Herbicide Application	Burn down, Round-up 32 oz./ac 17 lbs.AMS/100 gal water 4/9/2011	Burn down, Round-up 32 oz./ac 17 lbs.AMS/100 gal water 4/9/2011
Plant Plots	Planter: JD7000 w/finger pickup Variety:Pioneer P1395XR RR2, HXX, LL, Cruiser Seed drop: 31,300 Depth: 1.25" – 1.50" Conditions: Damp Emergence – Slow, stand poor 5/9/2011	Planter: JD7000 w/finger pickup Variety:Pioneer P1395XR RR2, HXX, LL, Cruiser Seed drop: 31,300 Depth: 1.25" – 1.50" Conditions: Damp Emergence – Slow, stand fair 5/9/2011
Weed Control Broadcast Herbicide Application	Residual, Lexar 3.0 qts/ac 5/10/2011	Residual, Lexar 3.0 qts/ac 5/10/2011
Soil Sample	sidedress soil nitrate test 6/22/2011	None
Sensor Measurements	Crop Circle 210 sensor, chlorophyll meter 6/23/2011	Crop Circle 210 sensor 6/23/2011
Weed Control Broadcast Herbicide Application	Burn down, Round-up 32 oz./ac 17 lbs.AMS/100 gal water 6/24/2011	Burn down, Round-up 32 oz./ac 17 lbs.AMS/100 gal water 6/24/2011
Side-dress N Treatment Applications	Chlorophyll meter, crop sensor & side-dress soil nitrate test treatments applied 6/28/2011	Crop sensor treatments applied 6/28/2011
Harvest	10/4/2011	10/4/2011

Sensor-based variable rate N: Long-term performance in cotton

- Recent experiments in Missouri and other states have shown that:
  - Optimal N rate for cotton varies widely from field to field
  - Crop sensors can provide relatively reliable estimates of optimal N rate
- This has created a need to evaluate how sensor-based N rates perform when used routinely and on the same land over an extended period.
- We initiated this experiment in 2010 to meet that need.
- 2010 yield data were not included in the 2010 report as analyses had not been completed. Analyses for both 2010 and 2011 are now completed and included in this report.
- Yield in the zero-N (check) treatment was high in both years, averaging 1180 lb lint/acre over the two years (Table 3).
  - This is a very good yield.
  - It indicates that the soil supplied a substantial amount of N to the crop, even in the second year after receiving no N fertilizer in the first year.
- Yield in the fertilized treatments averaged 1290 lb lint/acre over the two years (Table 3), an average yield response of only 110 lb lint/acre.
  - Any of the N treatments should have been able to supply enough N to the crop to support a 110 lb response
  - **Differences in yield from plot to plot under these conditions are probably due mostly to spatial variability in the soil where the experiment is planted, rather than to the effectiveness of the N treatments.**
- In this situation there is potential for N applications to hurt yields, quality, or harvestability. However, **we did not see any evidence that N over-application caused problems with yield or quality in either year.** Significant differences in quality parameters were rare.
- The best treatment under these conditions will probably be the one with the lowest N rate applied, partly due to savings on N and partly due to reduced risk that excess N will cause yield, quality, or harvestability problems.
  - By this criterion, the sensor-based N (with no N applied pre-plant) treatment is the best treatment, since only 25 lb N/acre was applied.
  - **The sensors correctly diagnosed that the soil was supplying a high level of N in both years and that minimal fertilization was needed.**
- **Only 3 treatments were significantly more profitable than the check (zero N) treatment over 2 years (Table 3):**
  - **Standard N management**
  - **Soil nitrate test-based N management**
  - **Sensor-based N management with no N preplant**

Table 3. Nitrogen rates recommended and cotton yields produced by different recommendation systems in 2010-11

Nitrogen Recommendation System	2011 Nitrogen Rate lbs. N/ac @ Each timing			2011 Total Nitrogen Rates	2011 Yields	Gross - N Cost	2010 Nitrogen Rate lbs. N/ac @ Each timing			2010 Total Nitrogen Rates	2010 Yields	Gross - N Cost	2 yr. N rate	2 yr Avg. Yields	2 yr Avg. Gross - N Cost
	PP[1]	ES[1]	MS[1]	lbs./ac	lbs./ac [2]	\$/ac [2, 3]	PP	ES	MS[1]	lbs./ac	lbs./ac [2]	\$/ac [2, 3]	lbs./ac	bu./ac [2]	\$/ac [2,3]
Standard	50	50	0	100	1286 ^{A}	1874 ^{A}	50	50	0	100	1392 ^{A}	2044 ^{A}	100	1341 ^{A}	1962 ^{A}
Soil Test	60	20	0	80	1260 ^{A}	1845 ^{AB}	60	20	0	80	1385 ^{A}	2044 ^{A}	80	1325 ^{AB}	1947 ^{AB}
Sensor	0	0	23, 33, 30 29, 28, 30 Avg. rate = 29	29	1242 ^{AB}	1848 ^{AB}	0	0	23, 23, 24 25, 20, 17 Avg. rate = 22	22	1329 ^{AB}	1989 ^{AB}	25	1287 ^{ABC}	1918 ^{AB}
Sensor with Pre-plant N	30	0	25, 23, 21 25, 18, 13 Avg. rate = 20	50	1269 ^{A}	1874 ^{A}	30	0	20, 26, 25 20, 25, 12 Avg. rate = 22	52	1253 ^{BC}	1860 ^{BC}	51	1263 ^{BC}	1869 ^{ABC}
Low	20	50	0	70	1236 ^{AB}	1814 ^{AB}	20	50	0	70	1297 ^{ABC}	1918 ^{ABC}	70	1269 ^{ABC}	1868 ^{ABC}
High	50	80	0	130	1240 ^{AB}	1790 ^{AB}	50	80	0	130	1314 ^{AB}	1912 ^{ABC}	130	1278 ^{ABC}	1853 ^{ABC}
Petiole nitrate test	50	0	0	50	1225 ^{AB}	1812 ^{AB}	50	0	0,0,0 0,0, 25 Avg. rate = 4	54	1267 ^{BC}	1881 ^{BC}	52	1248 ^{CD}	1847 ^{BC}
Check	0	0	0	0	1136 ^{B}	1703 ^{B}	0	0	0	0	1215 ^{C}	1830 ^{C}	0	1178 ^{D}	1767 ^{C}

[1]A PP=pre-plant ES=early square stage MS= mid-square stage (about 10 days after early square stage)
[2] Values within a column that are followed by a shared letter are not statistically different from one another with 90% confidence.
[3] Gross calculated using \$1.50/lbs. cotton price, \$5.00/ac cost for 2nd N application, \$0.50/lb. N cost as estimates of current cotton prices and N cost during these years.
[4]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 automatically while fertilizing a field, and we felt that this ability would be most accurately reflected by diagnosing N rate for each plot separately.