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

Peter Scharf, Vicky Hubbard, Larry Mueller, and David Kleinsorge
University of Missouri, Plant Sciences Division

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 2012:

- Two small-plot corn experiments were conducted as planned at Bradford Farm near Columbia.
- Unfortunately, the planned cotton experiment was not conducted in 2012 due to miscommunication. The corn experiment will be extended for an extra year to make up for this omission.

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

- 2012 is the 6th year of this study, with each plot getting the same N timing and N rate decision system every year.
  - Four of the treatments are fixed preplant N rates: 0, 100, 140, and 180 lb N/ac
  - The 140 lb N/acre rate is the MRTN (Maximum Return to Nitrogen) rate for Missouri and is also the Univ. of Missouri N rec for 135 bushel corn with 2.8% soil organic matter
  - A fifth preplant N treatment has the 140 lb N/acre rate as a base, with soil nitrate credits subtracted based on a 2-foot soil nitrate sample
  - Three treatments have N applied sidedress; rates are based on:
    - Sidedress soil nitrate test (Iowa State University interpretation)
    - Chlorophyll meter (University of Missouri interpretation)
    - Crop Circle 210 canopy sensor (University of Missouri interpretation)
  - All treatments are surface-applied ammonium nitrate
- This experiment is conducted in continuous no-till corn to magnify the effects of any problems related to N management.
- Extreme drought occurred in this experiment in 2012.
  - Three irrigations totaling 3.6 inches were applied with a linear-move irrigation system in July to avoid complete crop failure.
- Even so, all treatment mean yields were 82 bu/acre or less due to water limitation.
- Yield differences between treatments were minimized due to this water limitation.
- Yields for the eight N system treatments are shown in the table on the next page.

Nitrogen Recommendation System	N timing Stage[1]	2012 N Rates lbs./ac	2012 [2] Yield bu/ac	2012 [4] Yield value Minus N cost $/ac	2007-12 [3] Avg. rate lbs./ac	2007-12 [3] Avg. Yield bu/ac	2007-12 [3,4] Yield value Minus N cost $/ac
Chlorophyll meter	V7	160	79	392	169	133	730
Crop Circle sensor	V7	67, 146,168 133,162,191 **avg rate = 144**	79	403	148	129	721
Sidedress soil test	V7	116	76	404	121	120	679
High	Preplant	180	81	391	180	94	475
Yield goal/ MRTN	Preplant	140	77	393	140	84	439
Preplant soil test	Preplant	140	82	425	135	83	438
Low	Preplant	100	72	390	100	75	409
Check	Preplant	0	34	218	0	45	287

[1] Growth stage V7 is about knee high corn

[2] Yields are different from one another (90% confidence) if they are more than 5 bushels apart

[3] 2011 data was not included due to insufficent stand count and uniformity

[4] Partial profit analysis based on mid-Dec. 2012 prices. Corn - $ 6.40/bu. Nitrogen cost - $ 0.71/lb.

- Six of the N treatments yielded between 76 and 82 bushels with N rates between 116 and 180 lb N/acre. Because water availability limited yields so severely, most N timing & rate combinations appeared to deliver enough N to the crop to maximize yield within the constraint of limited water.
- Only the 0 and 100 lb N/acre rates clearly yielded less than the other treatments. Although the 100 lb N rate would seem to be enough to produce 80 bushels like the other treatments, N delivery from soil to roots is inefficient when soil is dry.
- **Treatments in the table above are ordered based on profitability for the period 2007-2012.**
- **For this period, the two systems based on crop color to guide sidedress N rate out-performed the best preplant system (180 lb N rate) by about $250/acre.**
  - They produced 35-40 bushels more corn with 10-30 lb less N than the 180 lb N/acre preplant treatment.
  - This was mainly due to serious N loss with preplant N applications during the wet springs of 2008-2010.
- The color-based systems for choosing sidedress N rate also out-performed the soil test system for choosing sidedress N rate by $40-50/acre.
  - This was due to under-recommendation by the sidedress soil test system in 2007 and 2010, resulting in lower yields.
- **Based on results from 2007-2012, long-term performance of sensor-based variable-rate N in corn appears to be good.**

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.
  - 2012 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. Experiment 2 received the same supplemental irrigation (total about 3.6 inches) as Experiment 1.
- Despite irrigation, yields were strongly water-limited and treatment mean yields did not exceed 79 bushels/acre.
- 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 3 years of this study, there has been no indication that sensor-based N rate recommendations perform better with preplant N than without.**
- **Over 3 years, sensor-based N management out-yielded the best preplant N management by about 8 bushels and gave about $85/acre higher profit (see table below).** This is due to higher yields with sensor-based N management than preplant N management in 2010. Yield differences between treatments were minimal or non-existent in 2011 & 2012. Average N savings over the 3-year period were 40 and 55 lb N/acre for the two sensor-based N systems while still producing higher yield than the most profitable preplant N system.

Nitrogen rates recommended and corn yields produced by four different recommendation systems in 2012

Nitrogen System Used	Nitrogen [1] Application Timing	2010 [2] Crop Circle N Rates lbs/ac	2010 [2] Total N Rates lbs/ac	2010 Yield bu/ac	2010 [3] Gross - N cost $/ac	2011 [2] Crop Circle N Rates lbs/ac	2011 [2] Total N Rates lbs/ac	2011 Yield bu/ac	2011 [3] Gross - N cost $/ac	2012 [2] Crop Circle N Rates lbs/ac	2012 [2] Total N Rates lbs/ac	2012 Yields bu/ac	2012 [3] Gross - N cost $/ac	3 yr Avg. N Rates lbs/ac	3 yr Avg. Yields bu/ac	3 yr Avg. [3] Gross - N cost $/ac
Crop Circle sensor	V8	135,113 108, 84 163,167 avg. rate 128	135,113 108, 84 163,167 avg. rate 128	135	$773	145,116 137,92 158,137 avg.rate 131	145,116 137,92 158,137 avg.rate 131	83	$438	155,134 93,92 90,127 avg.rate 115	155,134 93,92 90,127 avg.rate 115	73	$386	125	97	$532
50 lbs./N + Crop Circle sensor	Pre-plant + V8	60, 74 60,157 160,96 avg. rate 101	110,124 110,207 210,146 avg. rate 151	139	$782	93,103 69,117 137,74 avg.rate 99	143,153 119,167 187,124 avg. rate 149	81	$413	78, 54 79, 53 66, 85 avg.rate 69	128, 104 129, 103 116, 135 avg. rate 119	73	$383	140	98	$526
Yield goal MRTN	Pre-plant	140	140	104	$566	140	140	78	$400	140	140	64	$310	140	82	$425
High	Pre-plant	180	180	107	$557	180	180	80	$384	180	180	79	$378	180	89	$440

[1] Growth stage V6-V7 is about knee high corn, Growth stage V8-V10 is about thigh to waist 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] Gross calculated using $6.40/bu. corn price, $0.71/lb. N cost as estimates of average corn prices and N cost during these years.