Sensor-Guided Nitrogen Application: A Changing Landscape

Peter Scharf
Kent Shannon, Harlan Palm, Ken Sudduth, Newell Kitchen, Luci Oliveira, Scott Drummond, Charles Ellis, Larry Mueller, Vicky Hubbard, and Matt Volkmann
Variable-rate N sidedressing guided by color sensors

Controller runs ball valve to change fertilizer rate

Computer in cab reads sensors, calculates N rate, directs controller

sensors

06/01/2005
Why?
Why use nitrogen sensors?

• Crop need for fertilizer N is variable

• N is expensive

• Yield payoff is big when N is needed

• N gets into water
Crop N need is variable: from one field to another

- Twenty on-farm N rate experiments in Missouri, corn after soybean, no manure
- Most profitable N rates were 109, 114, 175, 0, 90, 190, 244, 63, 119, 300, 0, 146, 146, 180, 52, 175, 112, 149, 136, 114 lb N/acre
Crop N need is variable: within a field

Optimal N rates (lb acre\(^{-1}\))
- 0 to 80
- 80 to 120
- 120 to 160
- 160 to 200
- 200 to 250

Yield (bu acre\(^{-1}\))
- \(N_{\text{opt}}\)

N rate (lb acre\(^{-1}\))
- 0
- 75
- 150
- 225
Crop N need is variable: from year to year

Minnesota corn: the places that needed the most and least N were not the same in the two years

Overapplication = leftover N in soil

Wasted $

Environmental risk
N gets into water

Huge algal bloom

Mouth of Mississippi River
Spatially intensive diagnosis is needed

How?
# Diagnosing where to put more N

<table>
<thead>
<tr>
<th>Predictor</th>
<th>% of variability in N need explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>2 to 20</td>
</tr>
<tr>
<td>Soil nitrate</td>
<td>17 to 25</td>
</tr>
<tr>
<td>Soil N quick tests</td>
<td>0 to 18</td>
</tr>
<tr>
<td>Soil conductivity</td>
<td>8</td>
</tr>
<tr>
<td>Corn color</td>
<td>53 to 77</td>
</tr>
</tbody>
</table>
Translating sensor measurements to N rates

• Tricky
• No agreement at a national scale
• Still a slight obstacle to successful sensor use
Translating sensor measurements to N rates

Oklahoma State,
N-Tech:
sensor
↓
yield
↓
yield increase to N
↓
N rate
Translating sensor measurements to N rates

Oklahoma State, N-Tech:
- sensor
- yield
- yield increase to N
- N rate

Missouri, Pennsylvania, international:
- sensor
- best N rate
Translating sensor measurements to N rates

Use equation of line(s) to translate sensor values to N rates

Missouri research

New Pennsylvania research

Green/near infrared relative to high-N plots

Optimum sidedress N rate
Sensors for N management

• Research shows promise
• Next step: try it in production fields with production equipment
Locations of sensor demonstration fields 2004-2008

Total: 92
21 with USDA Spra-Coupe, 2004-2007
56 with producer-owned applicators, 2005-2008
15 with retailer-owned applicators, 2006-2008
Demo Objectives

1. Support producers, retailers, & consultants in planned sidedress operations from 1 foot to 6 foot height

2. Evaluate outcome using sensors relative to outcome with current producer practice (strip trials)
Demo Program

- What we provide:
  - Loan of sensors, computer, cables, stand
  - Brackets to place sensors in the right place
  - Computer program to translate sensor readings to N rates
  - Expertise
  - Data analysis

- Help overcome the steep learning curve
- Give producers & retailers a chance to ‘demo’ this practice without a large investment of time & money
Nitrogen sensor demo
What kind of N applicator can you use sensors with?
Injecting anhydrous ammonia
injecting solution
(tractor)
injection solution (high-clearance)
Dribbling solution
Spinning on dry N
(easier to get a wide range of rates)
Spinning on dry N

• Kansas producer 2006-2008: 4000 acres of corn fertilized in seven days using high-clearance spinner, sensors, & our N recommendation equation.
# On-farm sensor demos 2004-2007

<table>
<thead>
<tr>
<th>N rate system</th>
<th>Average yield</th>
<th>Average N rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer rate</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>Sensor-controlled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$ to sensor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# On-farm sensor demos 2004-2007

<table>
<thead>
<tr>
<th>N rate system</th>
<th>Average yield</th>
<th>Average N rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer rate</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>Sensor-controlled</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>$ to sensor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## On-farm sensor demos 2004-2007

<table>
<thead>
<tr>
<th>N rate system</th>
<th>Average yield</th>
<th>Average N rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer rate</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>Sensor-controlled</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>$ to sensor</td>
<td>-$2</td>
<td></td>
</tr>
</tbody>
</table>
# On-farm sensor demos 2004-2007

<table>
<thead>
<tr>
<th>N rate system</th>
<th>Average yield</th>
<th>Average N rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer rate</td>
<td>157</td>
<td>145</td>
</tr>
<tr>
<td>Sensor-controlled</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>$ to sensor</td>
<td>-$2</td>
<td></td>
</tr>
</tbody>
</table>
### On-farm sensor demos 2004-2007

<table>
<thead>
<tr>
<th>N rate system</th>
<th>Average yield</th>
<th>Average N rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer rate</td>
<td>157</td>
<td>145</td>
</tr>
<tr>
<td>Sensor-controlled</td>
<td>157</td>
<td>122</td>
</tr>
<tr>
<td>$ to sensor</td>
<td>-$2</td>
<td></td>
</tr>
</tbody>
</table>
## On-farm sensor demos 2004-2007

<table>
<thead>
<tr>
<th>N rate system</th>
<th>Average N rate</th>
<th>Average N yield</th>
<th>2007 prices: +$13/ac to sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer rate</td>
<td></td>
<td>$15</td>
<td></td>
</tr>
<tr>
<td>Sensor-controlled</td>
<td></td>
<td>$13</td>
<td></td>
</tr>
<tr>
<td>$ to sensor</td>
<td>-$2</td>
<td>+$15</td>
<td></td>
</tr>
</tbody>
</table>
## On-farm sensor demos 2004-2007

<table>
<thead>
<tr>
<th>N rate system</th>
<th>Average yield</th>
<th>Average N rate</th>
<th>2002 prices:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer rate</td>
<td>1</td>
<td>1</td>
<td>+$3/ac to sensors</td>
</tr>
<tr>
<td>Sensor-controlled</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$ to sensor</td>
<td>-$2</td>
<td>+$5</td>
<td></td>
</tr>
</tbody>
</table>
Increasing N prices have made sensors more economically viable
What about water quality?
Missouri EQIP support available

• 2007: $20/acre x 3 years = $60/acre
• 2008: $19/acre x 2 years = $38/acre
• 2009: $33/acre x 2 years = $66/acre
What else happened in 2008?
2008: Sidedress N kicks butt

180 N at planting

110 N sidedress V7.
2008: Sensors applied more N than producer rate in most demo fields (normal background N lost due to high rainfall)

Good odds for increased yield
2008: Our first cotton demo

2006-07: Calibration research, looks great

2008 demo: Saved 45 lb N/acre, looks great!!
Keys to success

• Research base
• Programmer
• Learn with producers
  – There are lots of twists you won’t think of in small-plot research
What have we learned?

• Power of visual reinforcement
  – The machine does what they would do
  – Dark crop = low N rate, light crop = high N
  – But automated to reduce operator fatigue

• Importance of preparation
  – Everything has to be slick
  – We calculate producer time at $11,000/day during spring & fall rush times
What have we learned?

• Sensors can maintain productivity while reducing N use
  – Cut back in smart places

• Sensors can identify places/years that need more N (than the normal producer rate)
What have we learned?

• Obstacles:
  – Good recommendation equations
  – Weed interference (control early)
  – Limited range of rates with liquid
  • New spring-loaded nozzle bodies will help
What have we learned?

• Obstacles:
  – High-N reference area
    • Hassle of installing
    • Bad results if installed poorly (too late or unmarked or too early)
  – Drift of sensor rates during the day
    • Hassle of driving back to high-N reference area to correct this drift
      – May be avoided with crosswise high-N strips
Crosswise high-N strips

High-N reference strips

With a plane, you could do a lot of these in a hurry

Can update value for high-N corn every time you drive across the strip.
Adoption

- Slow but increasing
- Adopters doing contract work for neighbors
The Future

• More Missouri demos in 2009
  – Let me know if you or a customer may be interested
The Future

- Greenseeker available
  - Record Harvest in Nevada is a dealer
The Future

• Greenseeker available
  – Record Harvest in Nevada

• Crop Circle
  – Sales via Ag Leader
  – New model/new wavelengths (be careful!)
The Future

• Greenseeker available
  – Record Harvest
• Crop Circle
  – Sales via Ag Leader
  – New model/new wavelengths
• Toshiba entering the market?
  – Re-engineered Yara (Hydro) sensor
The Future

• N prices, environmental pressures will continue to push tighter N management
Corn yield is not as sensitive to late N application timing as you might think.

28 small-plot trials in producer fields, Missouri, 1997-1999

vegetative stage of 200 lb/ac N application
Sensor Benefits:

- Make sure enough N is applied
- Avoid unneeded N application
N application to head-high corn

N rate map

June 20, 2007
Sensor Benefits:

- Make sure enough N is applied
- Avoid unneeded N application
Pounds of Nitrogen As Applied Via UAN on 6/13/07
Becker Farm - Laddonia, MO

As Applied
- 60-81
- 82 - 111
- 112 - 137
- 138 - 164
- 165 - 180
August 1 Aerial Photo after the June 13 UAN Application
## Yield of Three Combine Passes Per 80 Ft Swath of the RoGator

<table>
<thead>
<tr>
<th>Bu/A</th>
<th>Avg Bu/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>156 - 192</td>
<td>208.6</td>
</tr>
<tr>
<td>192 - 204</td>
<td>210.2</td>
</tr>
<tr>
<td>204 - 213</td>
<td>208.5</td>
</tr>
<tr>
<td>213 - 222</td>
<td>206.6</td>
</tr>
<tr>
<td>222 - 247</td>
<td>206.6</td>
</tr>
</tbody>
</table>

### Fixed
- 214.1
- 208.0
- 208.5
- 212.4
- 215.5

### Variable
- 215.4
- 212.1
- 204.2
- 212.4
- 215.5

**Test Area**

---

80' RoGator Swaths