REFLECTANCE SENSORS TO PREDICT MID-SEASON NITROGEN NEED OF COTTON

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Cotton and nitrogen

- Under-application of N limits yield
- Over-application of N can result in excess vegetative growth
  - Delayed maturity (reduced quality, price)
  - Increased need for growth regulator, defoliant, and insecticide
  - Also the money spent on N is wasted
Objective

- Calibrate canopy reflectance sensors to predict the amount of N fertilizer needed by a cotton crop
Methods

- Six N rate experiments
  - 3 in 2006, 3 in 2007
  - Loamy sand, silt loam, clay each year
- Three sensor types (Greenseeker, Crop Circle, and Cropscan)
- Three stages (early square, mid square, and first bloom)
- Three heights above the canopy (10, 20, and 40 inches).
Color sensors to diagnose N rate:
Early square

Greenseeker
Crop Circle

Cropscan

06.23.2006
Results: optimal N rates

Loamy sand 2006

Optimal N rate = 60
## Optimal N rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Soil texture</th>
<th>Optimal N rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Clay</td>
<td>200</td>
</tr>
<tr>
<td>2006</td>
<td>Loamy sand</td>
<td>60</td>
</tr>
<tr>
<td>2006</td>
<td>Silt loam</td>
<td>0</td>
</tr>
<tr>
<td>2007</td>
<td>Clay</td>
<td>175</td>
</tr>
<tr>
<td>2007</td>
<td>Loamy sand</td>
<td>45</td>
</tr>
<tr>
<td>2007</td>
<td>Silt loam</td>
<td>80</td>
</tr>
</tbody>
</table>
Predicting optimal N rates from sensor measurements

- **MID SQUARE**
  
  \[ y = 226.16x - 189.89 \]
  
  \[ R^2 = 0.58 \]

- **FIRST FLOWER**
  
  \[ y = 231.6x - 212.09 \]
  
  \[ R^2 = 0.69 \]
GROWTH STAGE

- Early square readings:
  - Correlations generally low ($R^2 < 0.50$).
  - The effect of N status on reflectance is more obvious later in the season.

- Mid square + early flower readings:
  - Strong relationships to Optimal N rate.
  - Mid square: 18 variables predicted N rate with an $R^2 > 0.50$.
  - Early flower: 28 variables had $R^2 > 0.50$. 
Regression analysis, sensor vs. optimal N rate

- 20 inch height worked best
- Equations for mid-square and first flower were not different
- NDVI and Vis/NIR worked equally well
DIURNAL VARIATION OF REFLECTANCE MEASUREMENTS
Objectives

(I). Quantify variability during the day for passive and active sensors

(II). Assess variability impact on diagnosing N need

(III). Correction equation
METHODS; LIKE THIS BUT WITH COTTON
RESULTS
Sensor-base N rate; lots of variability

<table>
<thead>
<tr>
<th>Visible/NIR-based N Rate</th>
<th>NDVI-based N Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop Circle</td>
<td>SD = 13.8 a</td>
</tr>
<tr>
<td>SD = 53.3 b</td>
<td>SD = 19.2 a</td>
</tr>
<tr>
<td>Greenseeker</td>
<td></td>
</tr>
<tr>
<td>SD = 11.8 a</td>
<td></td>
</tr>
<tr>
<td>Cropscan</td>
<td></td>
</tr>
</tbody>
</table>

Solar Time (difference from solar noon)
Equation using solar time, temperature, and solar radiation improved Greenseeker

<table>
<thead>
<tr>
<th>N rate (kg ha⁻¹)</th>
<th>Visible/NIR-based N Rate Before Correction</th>
<th>Visible/NIR-based N Rate After Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SD=53.3</td>
<td>SD=24.1</td>
</tr>
</tbody>
</table>

Solar Time (difference from solar noon)
Longer duration = more error
(How long can you go before re-checking the high-N area?)
Water Effect on N rate
(active sensors)

Crop Circle Vis/NIR-based N Rate

Water sprayed

N rate kg ha$^{-1}$

Time

12:00 12:10 12:20 12:30 12:40 12:50 13:00
Field-scale sensor demo in 2008

- June 30 (mid-square)
  - 40 acres
- Urea with Agrotain and ammonium sulfate
- 80 foot strips, alternating producer rate with sensor variable rate
- Crop Circle sensors, 20” above canopy
  - Vis/NIR equation
Producer N rate
82 lbs/acre

Average
Sensor- Based N rate
36 lbs/acre

As-Applied N rate in lbs/acre
- 25 - 30
- 30 - 41
- 41 - 54
- 54 - 71
- 71 - 100
- 100 - 125

Field Boundary
July 18 aerial photo

• Looking good!
• Sensors saved 45 lb N/acre
• Can’t distinguish from producer rate strips
Sensor-based strips defoliated better.
NEW RESEARCH QUESTION 2008: N at mid-square or early flower OK?
CONCLUSION

- Reflectance sensor readings related well to optimum N rate.
  - Potential for accurate on-the-go prediction.
  - All three sensor types appear to be potentially useful.
  - Mid square or early flower seem to be the best stages for accurate sensor-based sidedressing.
  - 50 cm is the most reliable height.
CONCLUSION

- passive and active sensors had variability during the day
  1. greater error in sensor-based N recommendation
- Linear equation based on temperature, solar radiation, and solar time improved Greenseeker Vis/NIR and NDVI
- increasing the duration over which readings are taken = greater error for predicted N rate
- Spraying water resulted in lower N rates for active sensors and higher N rates for the passive sensor