Sensor-based Sidedressing for Cotton

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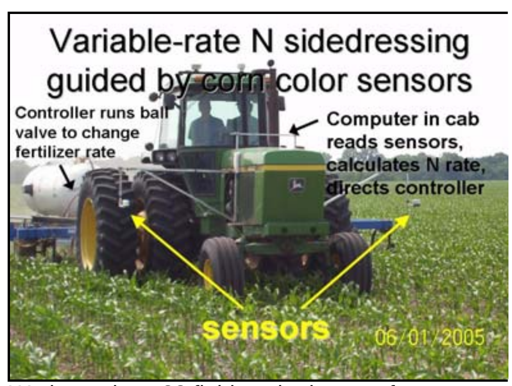
Objective:

- Develop reliable sensor interpretations as a basis for on-the-go variable-rate N sidedressing of cotton.
  - Extend promising results from 2006.
  - Determine sensor model, wavelength, and height that gives the best prediction of sidedress N need.
  - Determine the best growth stage for sensor-based sidedressing; depends on:
    - Accuracy of prediction (probably will be better later)
    - Ability to produce full yield (need to be careful not to wait too long)

Relevance:

- Cotton yield is sensitive to both under-supply and over-supply of N.
  - Economic penalty for being wrong in either direction.
  - Precision agriculture tools are most useful in this type of situation.
- When N supply is too low, cotton yield is reduced. Percentage yield reduction is not always large, but the value of the lost yield in general far outweighs the cost of applying additional N. There is some evidence that producers tend to overapply N.
- When N supply is too high:
  - Maturity and harvest may be delayed, increasing risk that yield and quality will decline. This can lead to substantial economic loss.
  - Excessive vegetative growth may require additional producer expense for growth regulator and defoliant.
  - Lush, high-protein tissue attracts more insects and may require additional producer expense for insecticide.
- Diagnosing and applying the right N rate is likely to increase profitability.
- Our experience in corn suggests that soil N release is spatially variable, meaning that the right N rate will also probably vary spatially.
- Reflectance sensors seem like the ideal tool for diagnosing and applying the right N rate everywhere in a cotton field.
- Sensors can measure crop color and control N rate on the go. We have extensive experience working with this system in corn, including 28 on-farm demonstrations from 2004-2006 (see photo).
- Sensors could easily be incorporated into existing sidedress practices of Missouri cotton producers.
- Missouri NRCS has recently approved sensor-based sidedressing of corn as a nutrient management practice that qualifies for program support. They are interested in approving this practice for sidedressing of cotton as well, but more research is needed before they can be confident that it will work.



We have done 28 field-scale demos of sensor-guided sidedressing for corn in Missouri.

- Producers will need support if they adopt these systems, creating a business opportunity for the fertilizer industry.

Procedures:

- Trials will be located at the University of Missouri Delta Center and Rhodes Farm.
- Three trials will be run each year on different fields with widely different soil textures:
  - Sandy loam
  - Silt loam
  - Clay (gumbo)
- Trials will be designed to determine the best N rate and to relate optimal N rate to sensor readings.
  - Most treatments will receive 50 lb N/acre at planting. This is typical producer practice.
  - A check plot will receive no N.
  - One treatment will receive a high N rate at planting.
    - This treatment will be used as a color reference for sensor readings.
  - Sidedress N rate treatments from 0 to 150 will be applied at the early square stage.
  - A few plots will also receive N applications at the early flower stage, the latest time that we think might be acceptable for sidedress N applications.
  - Sensor readings will be taken at the early square stage, the mid square stage, and the early flower stage. This is a span of about 20 days.
  - Four different types of sensor will be used:
    - Crop Circle active light sensors (Holland Scientific)
    - Crop Circle passive light sensors (Holland Scientific)
    - Greenseeker active light sensors (N-Tech)
    - Cropscan passive light sensors (Cropscan)
  - Sensor readings will be made from heights of 10", 20", and 40" above the plant canopy.
  - Analyses to produce a recommendation system will include:
    - Regression analysis will be used to mathematically describe yield response to sidedress N rate and to total N rate.
    - Response functions will be used to calculate optimal N fertilizer rate.
    - Optimal N rates will be regressed against sensor reflectance values to see which sensor, wavelengths, and height above the canopy provide the best prediction of optimal N rate.

Current status and importance of sensor-based sidedressing for cotton:

- Researchers at Mississippi State and Texas A&M have shown that cotton N status is related to crop reflectance measured by sensors.
- Texas A&M has developed a system for triggering fertigation based on sensor values, but no one has yet developed a system for making sidedress N rate decisions based on reflectance sensing.
- We recently re-analyzed experiments by Gene Stevens and Glenn Davis of the University of Missouri and found that the best N rate could be predicted fairly well using leaf color as measured with a hand-held chlorophyll meter that clamps on individual leaves.
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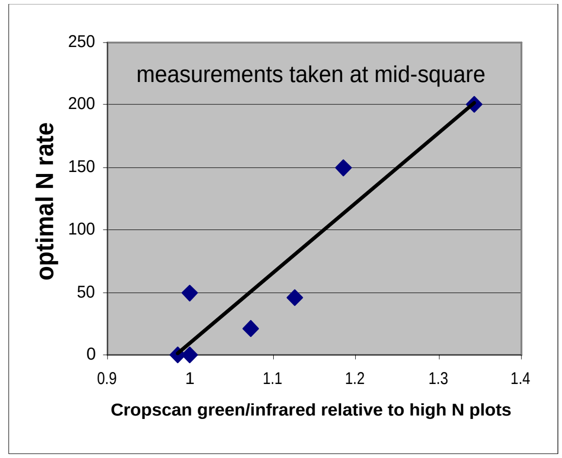
2006 Missouri cotton N rate experiment results.		
Soil texture in experiment	N rate predicted from chlorophyll meter	Best N rate based on yield results
Sandy loam	27	46
Silt loam	0	0
Clay (gumbo)	182	200

This proves the concept that cotton N rate can be predicted from color, but this meter is too slow, labor-intensive, and hard on the back to be used to manage large areas.

  - We tested this rate recommendation system in three 2006 experiments. It predicted N rates very close to the actual best rates, and also demonstrated the very wide spread in optimal N rate that can occur in cotton (see table).



- In these same experiments, we tried leaf reflectance sensors for the first time (see photo). The results were promising for making high-quality N rate recommendations at mid square (see graph). With good preliminary results, we are optimistic that we can develop a system that will fit with producer needs, avoid overapplication of N and the associated costs, while protecting yield and profit.

Timetable:

March 2007	Select experimental locations, prepare seedbeds.
May 2007	Plant cotton, apply preplant N rate treatments including high-N reference areas.
June 2007 (early square)	Take readings from three heights (10", 20", 40") with three or four different models of reflectance sensors. Apply sidedress N rate treatments. Take chlorophyll meter, soil nitrate, petiole nitrate, and leaf N samples.
July 2007	Repeat sensor readings at mid square.
July 2007 (early bloom)	Repeat sensor readings, chlorophyll meter readings. Take petiole nitrate and leaf N samples, apply N to a few treatments.
July-Aug 2007	Rate nodes above white flower.
September 2007	Rate open bolls and natural defoliation, defoliate.
October 2007	Harvest.
Nov-Dec 2007	Cotton fiber quality analyses, analyze data, write report.
2008, 2009	Repeat 2007 timetable

Strategy for application/transfer of knowledge:

Our main strategy for transfer of knowledge will be to support interested producers and service providers in testing these systems, as we have done with corn. This support might include consultation, loan of sensors and computers, and help with interpreting outcomes. If these systems are performing well, we will also pursue funds to hire one or two additional people to work on technology transfer and to help farmers to try out the systems that we are developing.

In addition to supporting early adopters, we will build educational programs for producers and agribusiness personnel to help them understand how these systems work, what their advantages and disadvantages are (including experiences and results of early adopters), and what is needed to succeed in applying them. Scharf has an Extension appointment and his time will go to presenting results at Extension conferences, field days, and winter meetings. Programs will also be delivered through regional extension specialists, newsletters, farm press, press releases, and the internet.

Budget:

- We have budgeted for a graduate student stipend in this project, however this category will be salary and benefits for whoever is needed and available to work on this project. This could be a graduate student, research associate, or hourly workers.
- Salary money will be used to accomplish plot design and layout, treatment application, collecting and processing sensor readings, harvest, and data analysis.
- Lab analyses will include soil nitrate and ammonium, petiole nitrate, and possibly leaf N.
- Travel will be for Scharf travel from Columbia to Portageville (hotel, meals, mileage) and for attending cotton meetings.
- We already own at least two each of the four different types of sensors that will be used in the project (purchased from corn research projects). Purchase price of the eight sensors would be approximately $18,000. A high-clearance tractor is available for mounting the sensors during data collection into a ruggedized tablet computer ($3,000). We have developed custom software that allows collection of data from all four sensor types into a single computer. These items are available for use in this project as our in-kind contributions.

Budget summary:

Graduate student stipend + benefits	15,550
Lab analyses	3,000
Travel	2,000
Fertilizer and other supplies	500
Total request for 2007	$21,050
3-year total request	$63,150