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

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Objective & Relevance:
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 will be compared with typical producer N management and with other N rate decision systems.

This project is relevant to Missouri agriculture because nitrogen fertilizer management has profound effects on profitability and on the environment. Previous research has shown a wide range of optimal N rates for both corn and cotton in Missouri. Crop sensors are a promising technology for diagnosing and applying the correct N rate in a single pass through the field. Sensor measurements can predict the optimal N rate for both corn and cotton in a one-year experiment, but no one has proven that the system can beat conventional N management over the long term.

This project addresses the topic "Long term study on Variable Rate Technology on corn and cotton" identified in the Request for Proposals.

Procedures:
- Two small-plot experiments will be conducted, a corn experiment at Bradford Farm near Columbia and a cotton experiment at the Delta Center near Portageville.
- This project will build on our previous research to establish equations to calculate optimal N fertilizer rate from sensor measurements in both corn and cotton.
- The Columbia corn experiment has already been conducted for three years. This project will leverage what has already been accomplished to create a long-term (6-year) sensor N evaluation.
- After three years, the sensor N system has produced the highest returns in the Columbia experiment.
- Treatments for the corn experiment will include:
  1) Reflectance sensor, sidedress only. Nitrogen rate will be calculated using reflectance sensor measurements taken at growth stage V7 (knee high) and an equation from our previous research on these sensors.
  2) Reflectance sensor, split application. Sidedress rate will again be calculated from sensor measurements, but 50 lb N/acre will be applied pre-plant.
  3) Standard N rate of 140 lb N/acre. This is the rate that produced the Maximum Return To Nitrogen (the recommendation approach recently adopted by Iowa, Illinois, Minnesota, and Wisconsin) in 30 on-farm experiments all over Missouri.
  4) Preplant soil nitrate test. A nitrogen rate credit (as described in Missouri guidesheet G9177) based on a preplant soil nitrate test will be subtracted from the 140 lb base rate.
  5) Sidedress soil nitrate test. Nitrogen rate will be calculated using the Iowa State University interpretations.
  6) Chlorophyll meter. Nitrogen rate will be calculated using chlorophyll meter measurements taken at growth stage V7 (knee high) and an equation from our previous research.

7) High rate: 180 lb N/acre Columbia, 240 lb N/acre Portageville.
8) Low rate: 100 lb N/acre, 140 lb N/acre Portageville.
9) Check treatment. No N fertilizer applied.

- The existing corn experiment includes all treatments listed above except for treatment 2. We have observed substantial early season N stress in the current sensor treatment (zero N preplant), and are concerned that this may have limited yields in good years. We will add a small adjacent experiment including sensor-determined N rates with and without preplant N (treatments 1 and 2) along with the standard rate (140) and the high rate (180). This will allow us to comparatively evaluate sensors + preplant N without disturbing the existing experiment.
- Treatments for the cotton experiment will include:
  1) Reflectance sensor, topdress only. Nitrogen rate will be calculated using reflectance sensor measurements taken at the mid-square growth stage and an equation from our previous research on these sensors.
  2) Reflectance sensor, split application. Topdress rate will again be calculated from sensor measurements, but 30 lb N/acre will be applied pre-plant.
  3) Standard N management of 50 lb N/acre preplant and 50 lb N/acre topdressed at early square stage.
  4) Soil test system. A preplant soil nitrate test will be used to calculate an N credit which will be subtracted from the standard preplant application.
  5) Petiole nitrate system. A preplant application of 50 lb N/acre will be followed by petiole nitrate testing at early square, mid square, and early flower stages. An additional 50 lb N/acre application will be triggered by deficient petiole nitrate levels.
  6) High rate: 50 lb N/acre preplant + 80 lb N/acre early square.
  7) Low rate: 20 lb N/acre preplant + 50 lb N/acre early square.
  8) Check treatment. No N fertilizer applied.
- Both experiments will use a randomized complete-block design with six replications.
- Sensor N rates will be based on sensor measurements in the individual plot. All other N rate systems will be used to produce a single N rate which will be applied to all plots of that treatment.

Current status and importance of sensor-based variable-rate nitrogen:

- Sensors to diagnose and control N fertilizer rate are maturing as a commercial product.
  - Greenseeker sensors have been available to control N rate for about five years, but have only been purchased by multiple farmers in Missouri over the past two years.
  - Crop Circle sensors have been available for five years but are just now being commercialized by Ag Leader as a system for agricultural N application.
  - AGCO and TopCon have formed a partnership and released a test version of a sensor that they intend to introduce for N diagnosis and control.
  - Prices for sensors are coming down, with rumors that they will come down more.
- Several years of widespread N loss in corn across the midwest, with superior yields from in-season N applications, has increased interest in supplying N in-season.
  - Minimal use of sidedress N for corn outside of the southeastern U.S. has been a limiting factor for sensor-based N management.

- Sensors fit current N management practices for cotton fairly well, since most producers use in-season applications of N.
- Our research shows wide variability within fields, between fields, and between years in how much N is needed.
  - Sensors offer the potential to diagnose these differences and apply N rates that are more profitable.

Timetable:

March 2010	Prepare experimental areas. Acquire a sensor, chlorophyll meter, and telescoping soil probe for the Delta Center and fertilizer materials for all experiments.
April 2010	Take preplant soil samples. Apply preplant N treatments. Plant corn.
May 2010	Plant cotton.
June-July 2010	Take sidedress soil samples and petiole samples. Take N sensor and chlorophyll meter measurements. Apply sidedress & topdress treatments.
September 2010	Harvest corn, defoliate cotton.
October 2010	Harvest cotton
Nov-Dec 2010	Analyze data.
December 2010	Progress report.
March ‘11-Dec ‘11	Repeat March ‘10-Dec ‘10 tasks
March ‘12-Dec ‘12	Repeat March ‘10-Dec ‘10 tasks
December 2012	Final report.
Jan-Feb 2013	Develop educational programs, present results at Extension meetings.

Strategy for application/transfer of knowledge:

- Written and oral (presentation) educational materials will be developed to promote understanding and application of results.
- Written materials will include newsletter and farm press articles and possibly guidesheets.
- Presentations will be used in Extension meetings, sent to regional Extension Agronomists for their use, and shared with anyone who requests them.
- Results will be posted on the University of Missouri Nutrient Management website

Budget:

Category	Amount budgeted in:		
	2010	2011	2012
corn experiment labor and benefits	$3000*	$8000	$8000
cotton experiment labor and benefits	8000	8000	8000
labor for data analysis and website	500	500	1500
soil and petiole sample analyses	500	500	500
field supplies and fuel	500	500	500
sensor for cotton experiment	4700		
chlorophyll meter for cotton experiment	2000		
telescoping soil probe for cotton exp't.	400		
TOTAL	$19,600	$17,500	$18,500

*Labor for the main experiment in 2010 is already supported on another grant (which ends in 2010). The $3000 will be to establish the new adjacent experiment including a sensor N treatment with preplant N.

3-year total budget **$55,600**

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Research and Extension education interests

- developing, evaluating, and promoting tools to predict crop N needs, including variable-rate N management
- evaluating N management alternatives including source and timing
- minimizing environmental impacts of agricultural nutrients
- coordinated management of soil, fertilizer, and manure nutrients
- tailoring fertilizer and lime recommendations to account for soil properties
- economic comparisons of production alternatives

Education

Degree	*Date*	*Institution*	*Major*
Ph.D.	May 1993	Virginia Polytechnic Inst. and State University	Crop & Soil Environmental Sciences
M.S.	July 1988	Virginia Polytechnic Inst. and State University	Agronomy
B.S.	August 1982	University of Wisconsin	Biochemistry, Genetics

Recent Research Publications

Scharf, P.C., and J.A. Lory. 2009. Calibrating reflectance measurements to predict optimal sidedress nitrogen rate for corn. Agron. J. 101:615-625.

Williams, J.D., N. R. Kitchen, P. C. Scharf, and W. E. Stevens. 2009. Within-field nitrogen response in corn related to aerial photograph color. Online. Precision Agric. DOI 10.1007/s11119-009-9137-x.

Hong, N., P.C. Scharf, J.G. Davis, N.R. Kitchen, and K.A. Sudduth. 2007. Economically optimal nitrogen rate reduces residual soil nitrate. J. Environ. Qual. 36:354-362.

Scharf, P.C., N.R. Kitchen, K.A. Sudduth, and J.G. Davis. 2006. Spatially variable corn yield is a weak predictor of optimal nitrogen rate. Soil Sci. Soc. Am. J. 70:2154-2160.

Cromley, S.M., W.J. Wiebold, P.C. Scharf, and S.P. Conley. 2006. Hybrid and planting date effects on corn response to starter fertilizer. Online. Crop Management doi:10.1094/CM-2006-0906-01-RS.

Scharf, P.C., S.M. Brouder, and R.G. Hoeft. 2006. Chlorophyll meter readings can predict nitrogen need and yield response of corn in the north-central U.S. Agron. J. 98:655-665.

Scharf, Peter C., Newell R. Kitchen, Kenneth A. Sudduth, J. Glenn Davis, Victoria C. Hubbard, and John A. Lory. 2005. Field-scale variability in optimal N fertilizer rate for corn. Agron. J. 97:452-461.

Recent Extension Publications

Scharf, Peter and John Lory. 2006. Best Management Practices for nitrogen fertilizer in Missouri. 12 p. MU Extension publication IPM1027.

Lawton, Kurt. 2009. Does this stuff really work? Progressive Farmer January 2009 p. PF-1 to PF-2. Using information from Peter Scharf.

Hoskins, Tim. 2008. Aerial survey estimates crop losses due to nitrogen deficiency. Iowa Farmer Today, Dec. 17, 2008. Using information from Peter Scharf. This story also ran in Farm & Ranch Guide and in Tri-State Neighbor.

Lory, John, and Peter Scharf. Managing high phosphorus prices. Integrated Pest & Crop Management 18:113.

Morrison, Liz. 2008. Extend Your N: 15 Tips For Improving Your Nitrogen ROI. Corn & Soybean Digest, Sept. 1, 2008. Using information from Peter Scharf.

Lory, John and Peter Scharf. 2008. Rescue nitrogen applications on corn can still be profitable. Integrated Pest & Crop Management 18:80.

Scharf, Peter. 2008. Soil samples show nitrogen loss. Integrated Pest & Crop Management 18:74.

Scharf, Peter. 2008. Nitrogen loss scoresheet. Integrated Pest & Crop Management 18:68.

Lory, John and Peter Scharf. 2008. Is my nitrogen still there? Integrated Pest & Crop Management 18:27,35.

Scharf, Peter and David Dunn. 2008. Nitrogen loss in wheat. Integrated Pest & Crop Management 18:22,25.

Scharf, Peter. 2008. Nitrogen prices through the roof again. Integrated Pest & Crop Management 18:25.

Scharf, Peter and David Dunn. 2008. Potential for N loss with heavy rains on wheat. Mid-America Farmer Grower, March 25, 2008, p. 13.

Oltman, Brian. 2008. Wheat N timing. Ag Professional, Jan. 2008. Using information from Peter Scharf.

University of Missouri Portageville, MO
Delta Center

Andrea Jones

Education

Southeast Missouri State University
Cape Girardeau, MO
Bachelor of Science in Agronomy

Presently enrolled at Arkansas State University
Jonesboro, AR
Masters in Plant Science

Research Experience

Research Associate
University of Missouri Delta Center

- Implement and conduct field trials
- Organize cotton meetings and variety trial field days
- Train and manage full time, temporary, and summer staff
- Maintain and analyze data
- Communicate with farmers cooperating with off-station trials
- Participate in field days and research tours
- Prepare and distribute annual Missouri Cotton Performance booklet
- Write, organize, and distribute reports for all test
- Collect data including plant mapping, yield, ginning, and fiber data
- Collect and submit data for COTVAR. COTVAR is a program for integrating cotton variety test data from five states in the region
- Maintain experiments, chemical applications, and irrigation
- Collect funding to pay two full time and two part time employees
- Collect funding for operation cost

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EDUCATION:

Degree: M.S. Geology (with emphasis in soils development) 1985
Institution: Iowa State University
Professor: Dr. Carl F. Vondra

Degree: B.S. Geology, 1980
Institution: Iowa State University

PROFESSIONAL EXPERIENCE:

Supervisor: Soil Testing Lab 1997-present
University of Missouri-Delta Center, Portageville, Missouri
Responsibilities:
1) Communicate to public the role of an integrated soil fertility program in crop production and environmental protection.
2) Provide relevant and understandable soil and plant analysis results to customers.
3) Maintain quality control of laboratory results while ensuring that results are available to customers in timely manner.
4) Supervise and train administrative and support staff, develop and implement annual working budget, maintain and purchase supplies and equipment as needed.
5) Develop and administer a soil fertility research program.
6) Provide research assistance to other multidisciplinary University of Missouri staff

PROFESSIONAL SOCIETY MEMBERSHIPS:

American Society of Agronomy
Soil Science Society of America
Rice Technical Work Group

GRANT SUPPORT:

Enhancing capabilities of Delta Regional Soil Testing Lab

Investigators: DAVID DUNN AND John Gardener
Funding Source: USDA Rural Development
Amount Received: $404,000 *Dates:* 09/2001 - 12/2003
Objectives: Upgrade and improve capabilities of Delta Regional Soil Testing L

Improving soil and plant analyses for efficient fertilizer use on rice

Investigators): WILLIAM STEVENS, and DAVID DUNN
Funding Source: USA Rice Foundation
Amount Received: $6,000, *Dates:* 01/2002 - 12/2002
Other Collaborators: Paul Bell (Louisiana State University)
Objectives: Compare methods of phosphorus extracting solution for rice.

Conservation tillage systems and liming materials

Investigators): WILLIAM STEVENS and DAVID DUNN
Funding Source: Missouri Fertilizer/Lime Board
Amount Received: $17,200, *Dates:* 01/2002 - 12/2002
Objectives: Determine the soil depth that surface applied lime in conservation tillage systems will neutralize soil acidity on clay and silt loam soils.

RECENT PUBLICATIONS:

Refereed Publications:

Dunn, D, and G Stevens. 2007, Phosphorus Management in a Dry-seed, Delayed Flood Production System in Missouri, Better Crops International, (in press)

Aide, M., C. Aide, D. Dunn, and G. Stevens. 2006. Fragipan genesis in the eastern Ozarks of Missouri. Soil Science. 171: (in press)

Stevens, G., T. Gladbach, P. Motavalli, and D. Dunn. 2005. Soil calcium and magnesium ratios and lime recommendations for cotton. J. Cotton Science. 9:65-71.

Dunn, D., G. Stevens, and A. Kendig. 2005. Boron fertilization of rice with soil and foliar applications. Crop Management. [Online] doi:10.1094/CM-2005-0210-01-RS http://www.plantmanagementnetwork.org/pub/cm/research/2005/boron/

Conley, S., G. Stevens, and D. Dunn. 2005. Grain sorghum response to row spacing, crop density, and planter skips. Crop Management. doi:10.1094/CM-2005-0718-01-RS.

Wrather, J., W. Stevens, D. Dunn, R. Cartwright, G. Sciumbato, and D. Beighley. 2005. Tillage effects on stand and yield in a rice monoculture system. Crop Management [Online] doi:10.1094/CM-2005-0103-01-RS

Dunn, D., and G. Stevens. 2005. Rice potassium research progress. Better Crops. No. 1, pg. 15-17.

Agricultural Bulletins and Extension Publications:

D. Dunn, G. Stevens, Beighley, D. 2005. Sulfur Fertilization of Rice. Missouri Rice Research Update. Dexter, Mo, 16 Feb. pg 25-28.

Stevens, G. and D. Dunn. 2005. University of Missouri soil test recommendations for rice production. Missouri Rice Research Update. Dexter, Mo, 16 Feb. pg 10-11.

Dunn, D. and G. Stevens. 2005. P and K fertilization of water-seeded rice. Missouri Rice Research Update. Dexter, Mo, 16 Feb. pg 12-14.

D. Dunn. 2005. Comparison of Avail Coated and Non-coated Super Triple Phosphate Fertilizers for Rice.Missouri Rice Research Update. Dexter, Mo, 16 Feb. pg 18-24.

Stevens, G., P. Motavalli, P. Scharf, M. Nathan, and D. Dunn. 2002. Crop nutrient deficiencies and toxicities, Integrated Pest Management Plant Protection Program, IMP1008