Spectral radiometer to control variable-rate N applications for corn

Peter Scharf, Eduardo Souza, and Ken Sudduth
Department of Agronomy and Department of Biological Engineering, Univ. of Missouri and USDA Agricultural Research Service

Objectives and relevance:

- We have already done four years of research showing that corn color measured with a spectral radiometer can do a good job of predicting how much N is needed at sidedress time or for mid-season rescue applications.
- Our ultimate objective is to mount the radiometer on a variable-rate applicator to make real-time variable-rate N applications based on corn color.
- This technology can potentially be extended to variable-rate N applications for other crops as well.
- The radiometer senses and corrects for variations in incoming sunlight due to time of day and clouds, but it appears that these corrections need improvement for the radiometer to be practical in the field.
- Our objective for this project is to improve the radiometer’s corrections for variations in incoming sunlight so that it will give the same color reading (and same recommendation) for the same plants regardless of time of day or cloud conditions.

Procedures:

- Spectral radiometers will be mounted in a stationary position about ten inches above the canopy.
- Readings will be taken from morning until night over several days with a range of sky conditions (sunny, overcast, partly cloudy).
- Experiments will be done on corn ranging from knee-high to just before tasseling.
- Mathematical functions will be developed to compensate for the effects of changing sun angle and cloud conditions.
- A computer programmer will incorporate these functions into programs for translating radiometer readings into variable-rate N recommendations.
- These programs will ultimately be used in developing real-time control of variable-rate N applicators based on corn color measured with a spectral radiometer.
- We will also continue separately-funded experiments in which we collect GPS (global positioning system)-referenced radiometer readings in field-scale on-farm N rate experiments (three experiments in Missouri and three in Iowa).

Current status and importance of research area:

- Field-scale research has shown that corn N need often varies by 100 lb N/acre or more within a field (Malzer et al., 1996; Blackmer and White, 1998).
- Nitrogen-deficient corn is lighter in color than nitrogen-sufficient corn, and color measurements can be used to predict N need (Piekielek and Fox, 1992).
- Color has been mainly measured with a hand-held instrument in the past, which has limited its usefulness for N management in production fields; measurement on the go with an instrument on board a variable-rate applicator would make this idea much more
practical.
! A German company, Hydro, has already introduced a variable-rate N applicator for wheat based on this concept. However, reports from Kentucky, where one has been imported, are not favorable, nor is this applicator suited for use on corn.
! Our research group appears to be in the lead nationally in terms of hard data that can be used to translate radiometer measurements into N rate recommendations.
! Ten on-farm experiments in Missouri showed that corn color measured with a radiometer was related to optimum sidedress N rate (Figure 1).
! A radiometer could also be used to direct high-clearance rescue N applications when substantial N is lost during a wet May/June, as happened in northeast Missouri in 1998 (Figure 2).
! This technology could become very important for maintaining productivity if N fertilizer comes under regulation, because it allows precise application according to crop needs.

Figure 1. Corn color measured with a spectral radiometer can predict optimum sidedress N rate for on-farm experiments in Missouri.

Figure 2. Nitrogen deficiency was widespread over northeast Missouri in 1998 due to wet soil conditions in June leading to denitrification.

**Timetable for proposed research:**

April-June 2001  Plant corn at Bradford Farm near Columbia over a wide range of planting dates, so that we will have corn at a variety of stages at any given time.

June-August 2001  Take radiometer readings on corn from morning till night with a variety of sky conditions and corn growth stages.

Sept.-Nov. 2001  Analyze data and develop mathematical functions to correct for sun angle and sky/cloud conditions.

December 2001  Incorporate correction functions into a computer program that
translates radiometer readings into N rate recommendations.

January 2002 Final report

Strategy for application of knowledge:
We hope to partner with, or otherwise make the information that we generate, available to industry so that this technology can be commercialized in a way that will result in consistent and reliable N rate recommendations and applications. We are in contact with three companies with an interest in developing this technology for market: AGCO, Patchen, a former John Deere subsidiary based in California that manufactures weed vision/spraying systems, and Crop Circle, a startup manufacturer of spectral radiometers for agricultural use. We have had several discussions with Dave Murray of AGCO about the possibility of high-clearance variable-rate radiometer-directed N applications.

References:

Budget:

The budget will be primarily for the salary of Eduardo Souza, a visiting professor of Agricultural Engineering from Brazil, who will conduct the experiments. He has been a visiting scientist at the University of Missouri since the summer of 2000. His support from his home institution runs out in June 2001. In order to keep him here through the field season to bring this project to completion, we propose six months’ salary at $3500/month for a total of $21,000.

We also propose four weeks of computer programmer time at $25/hour, for a total of (4 weeks) x (40 hours/week) x ($25/hour) = $4,000.

We have most of the equipment that we will need for the experiments (two different models of spectral radiometer, laptop computers, cables) but propose a budget of $1000 to be used for miscellaneous additional equipment needs such as fabrication of radiometer stands, replacement filters for radiometers, etc.

Budget summary:
Salary, visiting scientist
100% time for 6 months $21,000
Programmer contract time 4,000
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<td>Miscellaneous equipment</td>
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<td><strong>Total</strong></td>
<td><strong>$26,000</strong></td>
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</table>
Peter Clifton Scharf

Professional Interests

- developing, evaluating, and promoting tools to predict crop N needs, including variable-rate N management based on remote sensing or in-field radiometry
- minimizing environmental impacts of agricultural nutrients
- optimizing crop management; economic comparisons of production alternatives

Qualifications

Ability to communicate effectively, to cooperate with others, and to manage projects and people

Good knowledge of scientific literature, current research programs, and current practices in the area of nutrient management

Outstanding laboratory, field, project design, and data analysis skills

Excellent natural science background including soil science, physiology, genetics & breeding, chemistry, physics, microbiology, biochemistry, and ecology

Education

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<th>Degree</th>
<th>Date</th>
<th>Institution</th>
<th>Major</th>
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<tr>
<td>Ph.D.</td>
<td>May 1993</td>
<td>Virginia Tech</td>
<td>Agronomy</td>
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<tr>
<td>M.S.</td>
<td>July 1988</td>
<td>Virginia Tech</td>
<td>Agronomy</td>
</tr>
<tr>
<td>B.S.</td>
<td>August 1982</td>
<td>University of Wisconsin</td>
<td>Biochemistry, Genetics</td>
</tr>
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Professional Experience

1995 to present

Assistant Professor in the Agronomy Department of the University of Missouri. This is a tenure-track position in the area of nutrient management. Program emphasis is on improving nitrogen fertilizer efficiency:

- development, assessment, and dissemination of tools (including remote sensing and in-field radiometry) for matching N fertilizer rates with actual crop needs in corn and wheat
- nitrogen management to minimize losses

Other projects that I am working on or pursuing include:

- starter fertilizer for no-till corn and soybean
- P and K response of grain crops on different soils
- a subsoil P & K fertility map for Missouri
- soil pH effects on herbicide carryover in no-till and across landscapes
- P and K behavior in soils, soil-specific fertilization
phosphorus runoff from cropland
development of GIS-based software for whole-farm nutrient mgmt. planning

1993 to 1995

Post-doctoral Microbiologist in the Soil-Plant-Nutrient Research Unit of USDA-ARS located in Fort Collins, Colorado. Research on asymbiotic N fixation linked to cellulose degradation.

1988 to 1993

Graduate Project Assistant and Research Associate in the Department of Crop and Soil Environmental Sciences, Virginia Polytechnic Institute and State University. Developed field-specific nitrogen rate recommendations for winter wheat.

Awards

<table>
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<tr>
<th>Year</th>
<th>Award</th>
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<tbody>
<tr>
<td>1994</td>
<td>Sigma Xi Dissertation Award, VPI&amp;SU chapter</td>
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<td>1992</td>
<td>Obenshain Scholarship, VPI&amp;SU Dept. of Crop &amp; Soil Environmental Sciences</td>
</tr>
<tr>
<td>1987</td>
<td>Potash and Phosphate Institute Fellowship</td>
</tr>
<tr>
<td>1986</td>
<td>National Science Foundation Fellowship</td>
</tr>
<tr>
<td>1982</td>
<td>Graduated from U. of Wisconsin honors program with highest distinction</td>
</tr>
<tr>
<td>1981</td>
<td>Henry Steenbock Fellowship, University of Wisconsin College of Agriculture and Life Sciences</td>
</tr>
<tr>
<td>1980</td>
<td>National Science Foundation Undergraduate Research Participation Award</td>
</tr>
<tr>
<td>1979,80,81</td>
<td>M.S. Peterson Scholarship, U. of Wisconsin Dept. of Biochemistry</td>
</tr>
</tbody>
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Publications


VITAE

EDUARDO GODOY DE SOUZA

• Born January 10, 1958, in Brazil.
• Married; three children.
• Home address: 1021 Southpark Dr. Apt.4.
• Columbia, MO 65201 U.S.A.

POSITION AND PROFESSIONAL ADDRESS:

Visiting Associate Professor at the University of Missouri-Columbia.
257 Agricultural Engineering Bldg.
Columbia, MO  65211 U.S.A. Email: souzaE@missouri.edu

EDUCATION

• Post-Dr, Agricultural Engineering, University of Nebraska - Lincoln, USA. 1995.

• PhD, Mechanical Engineering, State University of Campinas (UNICAMP), BR. 1989.

• MS, Mechanical Engineering, UNICAMP, BR. 1987.

• Specialization, Agricultural Engineering, German Institution to International Development, Germany. 1983.

• BS, Mechanical Engineer, State University of São Paulo (USP), BR. 1981.

Areas of Expertise

• Precision agriculture, remote sensing, spatial variability, geoestatistics.

PROFESSIONAL EXPERIENCE

• Adjunct professor of the Dept. of Agricultural Engineering of the Universidade Estadual do Oeste do Paraná, UNIOESTE, Brazil, since February 1992.

• Director of the Technological Innovations Center of the UNIOESTE.

• Coordinator of the Master in Agricultural Engineering.

PARTICIPATION IN INTERNATIONAL MEETINGS, presenting technical papers


PUBLICATIONS


KENNETH A. SUDDUTH
Agricultural Engineer
Cropping Systems and Water Quality Research Unit
USDA Agricultural Research Service
269 Agricultural Engineering Bldg., U. of Missouri
Columbia, MO  65211
573.882.4090    fax 573.882.1115    ksudduth@showme.missouri.edu

Employment

1989 - present  USDA Agricultural Research Service, Columbia, MO.  Agricultural Engineer, Cropping Systems and Water Quality Research Unit.  Leader of a multidisciplinary team conducting precision agriculture research.  Engineering research focuses on sensors, instrumentation, and data management and interpretation, including sensing of soil properties and grain yield, variable rate chemical application, and development of data analysis techniques.  Cooperative research includes field-scale implementation of precision agriculture systems and evaluation of economic and environmental effects of precision agriculture.  Also Adjunct Assistant Professor, Biological and Agricultural Engineering Department, University of Missouri.

1985 - 1989  USDA Agricultural Research Service, Urbana, IL.  Agricultural Engineer, Crop Protection Research Unit.  Research on sensors and instrumentation applied to crop production.  Developed and patented a near-infrared soil organic matter sensor; developed propulsion, data acquisition, and automated cone penetrometer systems for a wide-frame instrumentation carrier.


Education


B.S.  Dual degree in Agriculture and Agricultural Engineering (honors scholar), University of Missouri, Columbia, MO, 1979.
Professional Honors and Awards

C 1995 Young Member of the Year Award, Missouri Section of ASAE and 1996 Young Member of the Year Award, Mid-Central Conference of ASAE
C USDA Invention Award and Federal Inventor’s Incentive Award for U.S. Patent 5,038,040.
C Member of Alpha Epsilon, Tau Beta Pi, Alpha Zeta, Gamma Sigma Delta, Phi Kappa Phi, and Sigma Xi Honor Societies.

Publications