Sidedress N applications for corn based on corn color

Peter Scharf and John Lory
Agronomy Department, University of Missouri – Columbia

INTRODUCTION

- Nitrogen-deficient corn reflects more light over the entire visible spectrum than nitrogen-sufficient corn.
- Our objective was to calibrate the relationship between remotely-sensed corn color and the nitrogen need of the corn.
- Corn color measurements were made two ways:
  - Aerial photographs
  - In-field spectral radiometer
- A successful calibration would allow:
  - Variable-rate sidedress nitrogen applications that precisely meet the needs of the crop.
  - Precise response to in-season N loss (Figure 1).
- Data reported here are preliminary. We are correcting aerial photo data for vignetting and may need to correct radiometer data for non-linearity at low incident light intensity.

Figure 1: We observed widespread nitrogen deficiencies in 1998 in northeastern Missouri, eastern Iowa, and western Illinois. May and June were generally wet in these areas, which may have led to substantial denitrification losses. Remotely sensed corn color could be used to direct precision rescue nitrogen applications in cases like this.

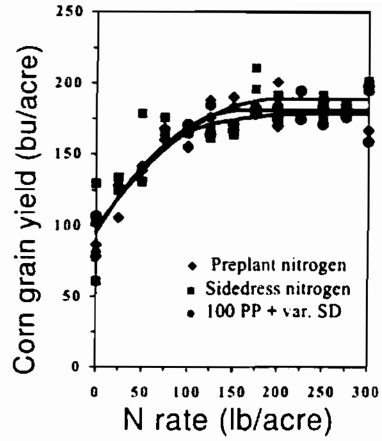
METHODS

There were three major components to these experiments.

I: Corn N fertilizer response experiments.

We conducted thirteen N fertilizer response small-plot experiments on producer fields in the major corn growing regions of Missouri in 1997, and ten more in 1998. At each location N rates from 0 to 300 lb N/acre were applied to small plots, then grain yield was measured. Figure 2 shows yield response to N rate at one experimental location. From the response functions we can determine the economically optimum sidedress N rates, with either 0 or 100 lb N/acre at planting. Plots with late N applications were also included to evaluate the potential for rescue applications based on corn color.

Figure 2. At each experimental location, corn yield response to N rates from 0 to 300 lb N/acre was measured. A complete range of N rates were applied with each of three management strategies: all preplant, all sidedress, or 100 lb N/acre at planting followed by sidedress applications. From the response functions we calculated optimum sidedress N rate with 0 N at planting and also with 100 N at planting.



II: In-field spectral radiometer readings.

- The Cropscan radiometer measures incident & reflected radiation at 8 wavelengths: visible (510, 560, 610 & 660 nm) and near-infrared (710, 760, 810 & 830 nm).
- We used two orientations (Figure 3)
- Readings were taken from plots receiving 0, 100, and 200+ lb. N/acre at growth stage V6 (knee-high) & again at two later stages (usually V9 & V12)
- This technology has potential as an applicator-mounted on-the-go sensor of N need.

Figure 3:

Angled Orientation		**Down Orientation**	
what it looks like	what it sees	what it looks like	what it sees

III: Aerial photography.

- Photographs were obtained in small-plane flyovers at an altitude of about 500 feet using 3 types of 35 mm film: color, color-infrared, and [black & white with a narrow-band green filter (560-600 nm)] (Blackmer et al., 1996).
- Photos were taken at growth stages V6 and two later stages
- Photos were processed with Adobe Photoshop to quantify red, green, and blue light intensity from ten plots receiving 0, 100, and 200+ lb. N/acre at planting.

Measurements were taken from the center two rows of each plot in two ways: the whole area or just the selected plant pixels. Resolution of our photographs was approximately one inch, allowing us to separate plant pixels from soil pixels.

This technology has potential for creating N fertilization maps for GPS equipped variable rate fertilizer spreaders.

RESULTS AND DISCUSSION

SPECTRAL RADIOMETER

Corn reflectance values measured with an in-field spectral radiometer were strongly related to N need at many wavelengths. The most strongly related was the green/near infrared (560nm/810nm) ratio, relative to the same ratio in high-N plots (Figure 4). This is the same as the Nitrogen Reflectance Index developed by Bausch and Duke (1996). The down orientation of the radiometer gave slightly better prediction of N need than the angled orientation.

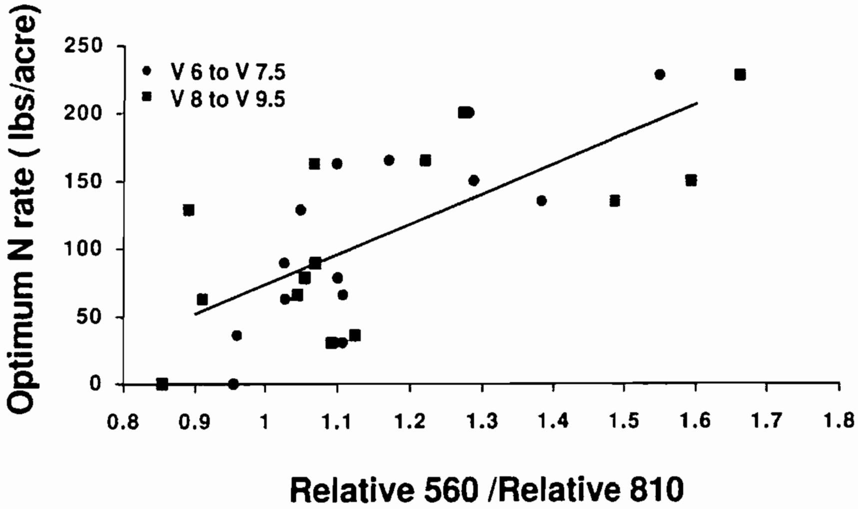


Figure 4. Relationship between corn reflectance, measured at 560 and 810 nm bands with a Cropscan radiometer in the down orientation, and optimum sidedress N rate.

AERIAL PHOTOGRAPHS

- Color relative to high N plots at growth stage V6-V7 was a good predictor of N need for all colors (red, green, and blue) measured on just the plant pixels; data for green light recorded on color film are shown in Figure 5. Separating out plant pixels from soil is not currently practical for commercial application due to image resolution and computational intensity.
- Preliminary analysis of our data appears to indicate that:
  - The quality of the relationship between corn color and N need improves as the corn gets bigger.
  - Color photographs provide better indicators of N need than color-infrared or green-only photographs.

Data presented in Figure 5 are preliminary. We observed a high level of vignetting (lighter near the center and darker at the edges of the photos), probably due to the very low altitudes from which our photos were taken. We are currently correcting the photo data for this effect.

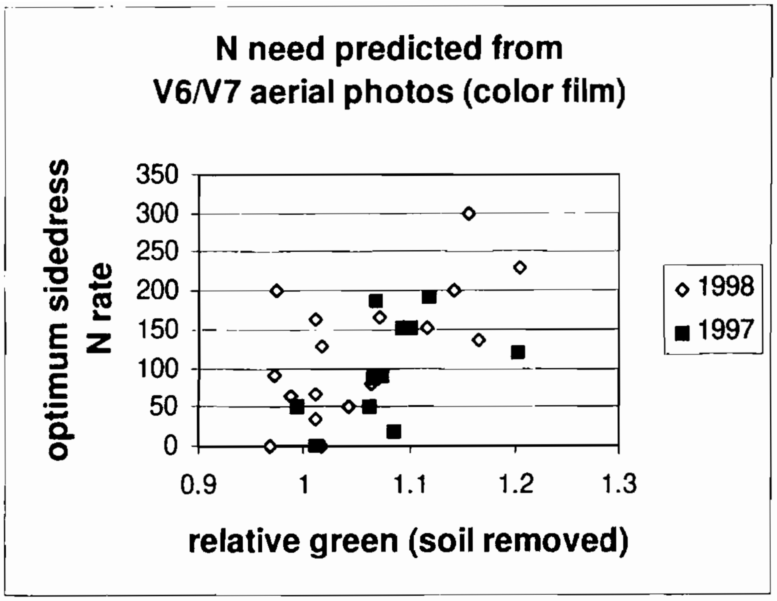


Figure 5. Green light intensity in color aerial photos relative to high-N plots was the best predictor of corn N need at growth stage V6-V7. At this stage, about half of the image is soil and half is plant; removal of the soil pixels from the images considerably improved the quality of the relationship between measured color and N need.

SUMMARY

- Corn color was determined two ways:
  - from low altitude aerial photographs
  - by measuring light reflectance at 8 wave lengths between 510 and 830 nm with an in-field radiometer.
- Both methods proved to be good indicators of N need and have potential to be used to guide variable-rate N applications.
- It seems likely that color comparison to high-N reference areas will be necessary to produce good N rate recommendations.

ACKNOWLEDGEMENTS

This research was made possible through support from:

- University of Missouri Agricultural Experiment Station
- University of Missouri Outreach/Extension - Commercial Agriculture Program
- Farmland Industries
- Missouri Precision Agriculture Center

REFERENCES

Bausch, W.C. and H.R. Duke. 1996. Remote sensing of plant nitrogen status of corn. Trans. ASAE 39:1869-1875.

Blackmer, T.M., J.S. Schepers, G.E. Varvel, and G.E. Meyer. 1996. Analysis of aerial photography for nitrogen stress within corn fields. Agron. J. 88:729-733.

PROCEEDINGS OF THE

TWENTY-NINTH NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY CONFERENCE

Volume 15

November 17-18, 1999
St. Louis Westport Holiday Inn
St. Louis, Missouri

Program Chair:

Dr. Ed Lentz
Ohio State University Extension
952 Lima Avenue
Findley, OH 45840
419/422-6106

Published by:

Potash & Phosphate Institute
772 – 22nd Avenue South
Brookings, SD 57006
605/692-6280