MANAGING N WITH SENSORS: SOME PRACTICAL ISSUES

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Introduction

Adoption of precision agriculture practices in cotton has been fast for some technologies and slow for others. As old cotton pickers are replaced, many farmers are including yield monitors in their new equipment. Also, government programs such as EQIP have helped cotton farmers off-set the costs of grid soil sampling and variable rate applications of lime, P and K. Nitrogen management is one of the technologies lagging behind. This is unfortunate considering the hikes in N fertilizer costs.

Remote sensing and "on-the-go" equipment-mounted sensors are the two most studied precision technologies for determining nitrogen needs in cotton. In the Mid-South, attempts using aerial and satellite imagery have produced limited success due to interference from cloud cover at critical times in the growing season. The time demand for someone to process image data into N application maps is another restraint. Equipment companies are now starting to manufacture commercial scale machinery that can accurately vary N rates on-the-go based on the leaf color reflectance. The beauty of mounting sensors on application equipment is that there is no time delay between detecting N deficiency and fertilizer application to correct the problem. Regardless of the plant detection method (remote sensing or equipment sensors), field calibration research is needed to find nitrogen fertilizer response algorithms for the technologies. Algorithms are used to prescribe the minimum amount of N needed to allow the cotton to reach its maximum economical yield potential.

The objective this experiment is to provide cotton growers with information on using GreenSeeker ™, Crop Circle ™, and CropScan ™ equipment-mounted sensors for applying nitrogen in cotton on silt loam, sandy loam, and clay soils.

Methods and Materials

Two field experiments are being conducted. The first test evaluates cotton leaf color and yield response as affected by nitrogen fertilizer rates and soil type. The second test studies differences in leaf reflectance between cotton varieties. In both tests, sensor measurements are collected in 10-day intervals from mid-June to late-August. A high-clearance tractor with multi-spectral sensors mounted on a boom is being driven through all plots. Data loggers in the tractor cab record cotton leaf reflectance data collected from Crop Circle Model ACS-210 (Holland Scientific; Lincoln, NE), GreenSeeker (N Tech Industries; Stillwater, OK) and CropScan MSR87 (CropScan; Rochester, MN). At each sampling date, leaf chlorophyll meter readings from the fourth node from the apex is collected with a SPAD-502 meter (Minolta Camera Co, LTD.; Tokyo, Japan) and petiole nitrate concentration also from the fourth node.

Nitrogen and Soil Types. Field test sites are located on Tiptonville silt loam, Malden sandy loam, and Sharkey clay soils at Portageville and Clarkton, Missouri. Cotton was planted using a ridge-till production system at each location and winter wheat in the middles at Clarkton. Treatments include three preplant nitrogen rates (0, 25, 50, and 150 lb N/acre) with four replications. At pinhead square growth stage, additional N treatments (0, 25, 50, 75, 100, 125, and 150 lb N/acre) were superimposed over preplant N treatments. Two additional N treatments are included with N applied on an "as needed basis" based on what we learn as the study progresses.

Cotton Variety Leaf Color. This study evaluates sensor sensitivity to variety differences in leaf color. Three cotton varieties were planted (DP 445BR, ST 4554 B2F, and FM 958 LL) on a Tiptonville silt loam soil. To study the effect of leaf shape on sensor readings, an okra-leaf variety (FM 800 RR) was also be included. Each variety received fertilizer from three nitrogen programs- untreated check, medium, and high (no N , 30 lb N preplant/ 50 lb N pinhead square, and 60 lb N preplant/100 lb N pinhead square).

Results and Discussion

We found a good potential for accurate on-the-go prediction on N status in cotton. All three sensor types appear to be useful for indicating optimum N rate at mid square and early flower growth stages (Figure 1). However, readings at first square was too early to measure N stress in cotton. Strong correlations were found with optimal N rate, especially using visible/NIR ratios. All three heights of sensors above the canopy had strong relationships to optimal N rate with 20 inches showing more consistent results than 40 and 10 inch heights. Highest cotton yields were produced with 125 lb N acre^{-1} on the Bosket sandy loam, 175 lb N acre^{-1} on the Tiptonville silt loam, and 200 lb N acre^{-1} on the Sharkey clay soil (Tables 1 and 2).

Table 1. Cotton yields in 2007 as affected by N rate and timing on a Bosket sandy loam soil at Clarkton, Missouri, and Tiptonville silt loam soil at Portageville, Missouri.

Preplant	Early square	Early flower	Total N	Sandy loam	Silt loam
----------------------lb N acre^{-1}---------------------				-----lb lint acre^{-1}----	
0	0	0	0	723	904
25	0	0	25	747	1018
50	0	0	50	817	1004
50	25	0	75	905	1119
50	50	0	100	762	1122
50	75	0	125	999	1133
50	100	0	150	874	1090
50	125	0	175	960	1242
50	150	50	200	988	1197
50	0	50	100	769	1127
50	CM†	CM	50	948	1085
150	0	66	150	796	1123

† CM= early square and early flower N rates were applied based SPAD Chlorophyll meter readings. No additional N was applied after preplant on either soil.

Table 2. Cotton yields in 2007 as affected by N rate and timing on a Sharkey clay loam soil at Portageville, Missouri.

Preplant	Early square	Early flower	Total N	Clay loam
----------------------lb N acre^{-1}---------------------				lb lint acre^{-1}
0	0	0	0	240
50	0	0	50	488
0	50	0	50	493
100	0	0	100	666
50	50	0	100	663
33	33	33	100	663
150	0	0	150	724
75	75	0	150	719
50	50	50	150	674
200	0	0	200	861
50	CM†	CM	150	822
66	66	66	200	724

† CM= early square and early flower N rates were applied based SPAD Chlorophyll meter readings. Additional N (50 lb N acre^{-1}) was applied at early square growth stage.

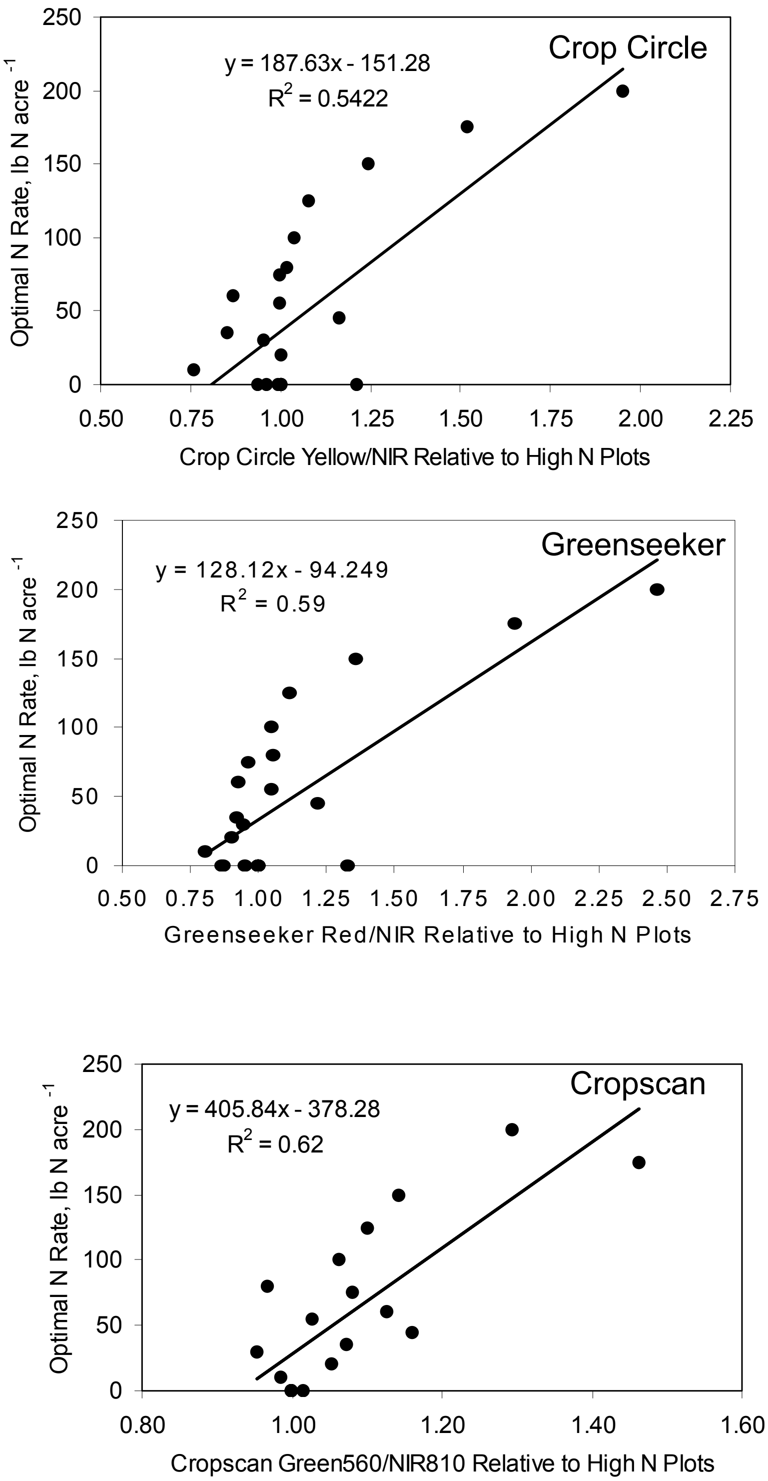

Figure 1. Algorithms using Crop Circle, Greenseeker and Cropscan sensors for optimum N rates based on cotton lint yields and midsquare readings in 2006 and 2007 with sensors positioned 20 inches above crop canopy on equipment tool bars.