▸ Use Of Active Sensors To Monitor In-Season Nitrogen Status Of Cotton

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Summary

Monitoring of cotton N status is important in guiding in-season N fertilization. Historically, this has been done with petiole nitrate analysis. Recently, hand-held or tool-bar mounted spectroradiometers have been tested for this purpose. These canopy reflectance sensors have their own light source, and are therefore called "active" sensors. This is in contrast to reflectance sensors that rely on natural light, which is a limitation on cloudy days. Reflectance in two wavelengths is measured, a near infrared (NIR) and a visible (red or amber) region. The ratio of NIR to visible reflectance, e.g. Normalized difference vegetation index (NDVI) was correlated to both cotton biomass and N status, i.e. Leaf N or total N uptake (TNU). We also tested two different in-season N management approaches for irrigated cotton, based canopy reflectance. Every two weeks from first square to mid bloom, active sensor measurements were made. Reflectance-based N management generally resulted in modest N fertilizer savings compared to conventional, soil-test based N management. No loss of lint or seed yield was observed with sensor management.

Methods

The study was conducted at the Texas A&M Research and Extension Center farm near Lubbock, TX on an Acuff sandy clay loam. Drip tape was in the center of every other furrow at a depth of 12 and water flowed at a rate of 1 L min-1 at 0.08 MPa. AFD 5065 B2F was planted on 6 June in 2007 and on 13 May in 2008. Harvest was in November each year. The experimental design was a randomized complete block design, one-way factorial with three replications or blocks. Blocks consisted of 40, 40-in. rows that were 600 feet long. Each block was divided into five, 8-row plots that were randomly assigned to the five N-fertilized treatments:

N Treat.	N rate	Other details
1	0.5 X soil test	Soil test algor = 120 lb N/ac – 2 ft NO3 – irrig. water NO3
2	1.0 X soil test	Soil test algor = 120 lb N/ac – 2 ft NO3 – irrig. water NO3
3	1.5 X soil test	Soil test algor = 120 lb N/ac – 2 ft NO3 – irrig. water NO3
4	Reflectance based	Starts out at 0.5 X, referenced to 1.0X
5	Reflectance based	Starts out at 1.0 X, referenced to 1.5X
6	Zero-N	1 replicate/station only

Every week canopy reflectance measurements were made with the CropCircle and GreenSeeker radiometer at 40 inches above the canopy on one row per plot. Normalized difference vegetative index (NDVI) was calculated as:

(Reflectance at NIR - Reflectance at visible)/(Reflectance at NIR + Reflectance at visible)

When the NDVI in the reflectance-based strategy 1 treatments fell significantly below the NDVI in the soil test based management treatment, the N injection rate was increased to the soil test treatment N injection rate. When the NDVI in the reflectance-based strategy 2 treatments fell significantly below the NDVI in the 1.5 * soil test based management treatment, the N injection rate was increased to the 1.5 * soil test treatment N rate. Plant samples were taken at early bloom and at mid bloom for biomass measurements, leaf and stem N analysis.

Results and Discussion

Correlations between NDVI and N Rate and leaf N were strong in 2007, and moderate in 2008

(Table 1). Lint yield correlations with NDVI were greatest in 2008. Correlation between NDVI and biomass were less than with leaf N in 2007 but similar to leaf N in 2008. These results are similar to the magnitude of the correlations we previously reported with passive sensors on LEPA, subsurface drip and surface drip irrigations (Bronson et al., 2003). Lint yields in 2007 were similar among all N-fertilized treatments and were greater than the zero-N yields (Table 2). In 2008, lint yields in the 0.5 x Soil Test treatments were significantly lower than the other N-fertilized treatments. Reflectance strategy 1resulted in modest N fertilizer savings of 18 and 16 lb N/ac vis a vis the soil test treatment, respectively. The reflectance strategy 2 resulted in 10 lb N/ac greater N rate than the soil test approach in 2007 and the same N rate in 2008. Lint yields did not differ among soil test and reflectance strategies 1 and 2 in either year. In summary, the reflectance strategy 1 resulted in modest savings of N fertilizer without hurting yields, compared to the current soil test based recommendations. This result is similar to our earlier work with a passive sensor on LEPA, subsurface drip and surface drip irrigation (Chua et al., 2003 Yabaji et al., 2009)

Table 1. Correlations between NDVI from active sensors and cotton N status and yield parameters,

	Early Bloom		Mid Bloom	
	Amber NDVI	Red NDVI	Amber NDVI	Red NDVI
		2007		
N fert rate	0.75	0.46	0.60	0.64
Leaf N	0.77	0.53	0.62	0.55
TNU	0.55	0.35		
Biomass	0.27		0.36	0.44
Lint Yield	0.43	0.42	0.48	0.28
		2008		
N fert rate	0.47	0.43	0.50	0.50
Leaf N	0.52		0.35	0.28
TNU	0.39	0.37		
Biomass	0.29	0.36	0.45	0.36
Lint Yield	0.58	0.30	0.59	0.53

Table 2. Lint yield and N fertilizer applied as affected by reflectance based N management, Lubbock, TX,

	2007		2008	
	N rate	Lint yield	N rate	Lint yield
	lb N/ac	lb/ac	lb N/ac	lb/ac
1.5 x Soil Test	120	1347	94	1532
Soil Test	80	1326	62	1495
Refl Strag 1	62	1372	46	1538
Refl Strag 2	90	1330	62	1584
0.5 x Soil test	40	1365	31	1283
Zero-N	0	1062	0	1006

References

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Making The Most Of GPS Guidance Technology On Your Farm

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Precision agriculture technologies can be categorized into two groups, those technologies that require less management requirements than the status quo and those that require additional management requirements than the status quo. Technologies such as automated guidance and lightbars have reduced the management and operator skill required to perform field operations and can be thought of as embodied-knowledge technologies (Griffin et al., 2004). Technologies such as using yield monitor, soil test, and other sensor data for analysis requires additional management abilities and can be thought of as information-intensive.

Of all the precision agricultural technologies, GPS navigation technologies such as automated guidance and lightbars have had the greatest level of adoption and clearest profitability potential. GPS guidance has allowed farmers to make the most efficient use of their equipment and to raise their production management to the highest levels ever documented. The benefits of GPS guidance technologies have been quantified with respect to substituting for larger equipment complements. The whole-farm benefits of adopting GPS guidance to an existing farm including profitability from machinery management and agronomics, quality of life, and changes to acreage capacity of the given equipment set.

Although GPS guidance has had a faster level of adoption than information-intensive technologies, site-specific sensors that can measure spatial variability of yield, soils, and other environmental factors are becoming more useful for farm management decision making. Sensors such as those measuring electrical conductivity have been successfully used to characterize soil properties to include in the analysis of on-farm field-scale experiments that many farmers, consultants, and researchers perform.

The benefits of sequentially adopting embodied-knowledge and information-intensive precision agriculture technologies will be examined and described such that the most can be made of precision agriculture data.

Notes: