RELATIONSHIPS BETWEEN COTTON NITROGEN STATUS AND SENSOR BASED READINGS

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Abstract

Previous research has shown that cotton (*Gossypium hirsutum* L.) yields can vary across the landscape based on the management system utilized; however, typical N fertilizer rates for cotton are applied uniformly across the field. Sensor technology previously utilized in other crops can potentially quantify cotton N status and relate sensor output to an N recommendation that will vary across the field and simultaneously improve cotton yields and profitability. An experimental site was established in a 22 ac. field in the Coastal Plain consisting of Typic and Aquic Paleudults that had management systems in place for 9 years. A split plot design was utilized with main plots consisting of two soil management systems (conventional-CT and conservation-NT) and split plots of 4 N rates (0, 40, 80, 120 lb/ac) with six replications of 12-ft. strip-transects (4-row widths) across the field that intersect management zones. At pre-determined sampling points (12 x 60 ft. grids stratified within each management zone) 25 upper-most mature leaves were collected along with plant heights, sensor measurements, and 3.28 ft. of whole plant biomass from the same pre-determined locations across landscape positions around 1st square and mid-bloom. Seed cotton yield was determined across the field with a spindle picker equipped with GPS and yield monitor. Although NDVI was well correlated with various plant parameters, no clear relationship exists between NDVI/Cum. GDD and lint yield for the 2008-2010 growing season.

Introduction

Typically, N fertilizer for cotton is applied uniformly across a field. Due to the variability in many cotton fields, this may result in over-application or under-application of an expensive production input, such as N. The under-application of N may result in loss of yield, while over-application can result in excessive vegetative growth that also decreases yield and increases susceptibility to insect damage and disease pressure. In addition, crop maturity may also be delayed.

Previous research has shown that cotton yields can vary across the landscape based on the management system utilized (Terra et al., 2006). If yields can vary across the landscape, the amount of N required to maximize cotton yields depending on the management system should also vary. The relationship is complicated by how cotton responds to different amounts of N, particularly excess N amounts. Ideally, in order to maximize profitability, cotton N rates should vary across the field as well as across crop years. Sensor technology can potentially quantify in-season crop N status and relate sensor output to an N recommendation, but relationships between sensor readings and plant N status need to be identified to determine proper N levels to apply that will maximize profit.

Material and Methods

The experimental site was an established ~20 acre field in the Coastal Plain located at the E.V. Smith Research and Extension Center near Shorter, AL. The site consists mostly of fine and fine-loamy, kaolinitic, thermic Typic and Aquic Paleudults with management systems that have been in place for nine years.

A split plot design had main plots consisting of two soil management systems (conventional-CT and conservation-NT) and split plots of 4 N rates (0, 40, 80, 120 lb/ac) with six replications consisting of 12-ft. strip-transects (4-row widths) across the field, intersecting management zones. These systems were in a cotton-wheat (*Triticum aestivum*

L.)-soybean (*Glycine max* L.) rotation, with the cotton phase and wheat/soybean phase present each year. Previously established management zones were identified with soil survey mapping, landscape characteristics, and output from soil electrical conductivity (EC) mapping.

The conventional management system consisted of disking, field cultivation, and in-row subsoiling in spring. No cover crop was used in winter and winter weeds were not controlled. The conservation system consisted of a rye (*Secale cereale* L.) cover crop, prior to cotton that was terminated using glyphosate and a cover crop roller. In-row subsoiling was utilized ahead of the cotton planting.

Crop Measurements

At pre-determined sampling points (12 x 60 ft. grids stratified within each management zone) that capture different landscape positions, 25 upper-most mature leaves were collected along with SPAD meter readings (a measure of chlorophyll), plant heights, and 3.28 ft. of whole plant biomass at 1^{st} square. Corresponding N rates were applied and NDVI measurements collected. All measurements were repeated at mid-bloom, but only the first set of measurements that include sensor readings, plant heights, leaf N %, and plant biomass will be discussed. Seed cotton yield was determined across the field with a spindle-harvester equipped with GPS and yield monitor. Lint yields were determined by using an estimated ginning outturn of 40%. All planting, sensing, and harvest dates are presented in Table 1 with relevant climate information that includes growing degree days (GDD) for each growing season.

All response variables were examined using the CORR procedure within SAS (release 9.2; SAS Institute Inc.; Cary, NC) to identify significant relationships among the variables. Correlations were considered significant if $P \leq 0.10$.

Results and Discussion

The 2008, 2009, and 2010 growing seasons were different based on rainfall and growing degree accumulation (Table 1). These growing seasons illustrate how climate can affect cotton lint yields, based on yield differences observed in Fig. 1A.

Pearson correlation coefficients (r) were presented for all measurements collected at 1st square during the 2008, 2009, and 2010 growing seasons across the 10 ac. area that corresponded to the entire cotton phase of the experiment (Table 2). NDVI measurements collected at 1st square were significantly correlated with plant height, leaf N, plant biomass, and lint yield across all growing seasons, but the degree of correlation varied with each growing season (Table 2).

No clear relationship existed to predict lint yields based on NDVI/Cum. GDD measured at 1st square across these three growing seasons (Fig. 1A). The 2008 and 2010 growing seasons indicated a possible linear relationship, but no cut-off point could be identified that indicates a sufficiency level had been reached (Fig. 1B and 1D). Landscape positions did not differentiate the relationship between lint yield and NDVI/Cum. GDD for any growing season (Fig. 1B, 1C, 1D) compared to the relationship for the whole field that ignored landscape position (Fig. 1A).

Table 1. Planting, sensing, and harvest dates including growing degree days and rainfall for the 2008, 2009, and 2010 cotton growing seasons.

	Growing Season		
	2008	2009	2010
Planting	5-13-08	6-2-09	5-7-10
Sensing Date	6-19-08	7-9-09	6-21-10
Growing Degree Days	655	766.5	792
Cumulative Rainfall, inches	2.97	4.80	5.67
Harvest	10-15-08	11-6-09	10-4-10
Total Rainfall, inches	20.47	26.74	18.39

Table 2. Pearson correlation coefficients (r) observed between sensor readings and plant parameters across the entire field. Red values are significant (P≤0.10).

	NDVI	Height	Leaf N	Plant biomass
		Growing Season		
		2008		
Height	0.8379			
Leaf N	-0.5328	-0.4402		
Plant biomass	0.7614	0.9260	-0.4549	
Lint yield	0.3768	0.2336	-0.0918	0.1316
		2009		
Height	0.6600			
Leaf N	-0.1696	0.1644		
Plant biomass	0.6341	0.6863	-0.1054	
Lint yield	0.1960	-0.0851	-0.0375	0.1695
		2010		
Height	0.8832			
Leaf N	-0.2905	-0.5347		
Plant biomass	0.6867	0.8216	-0.5911	
Lint yield	0.6827	0.6147	-0.0314	0.4208

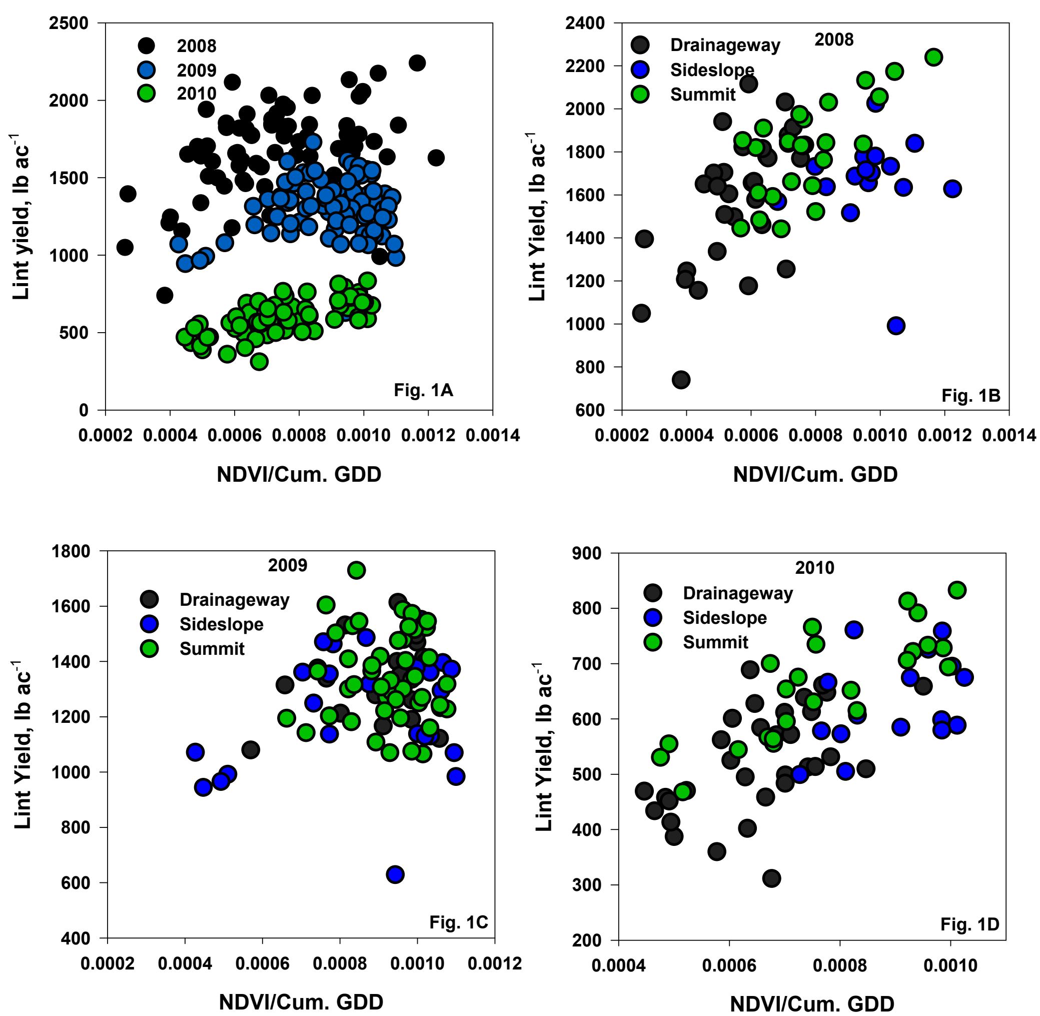

Figure 1. Scatterplots that correlate lint yield with NDVI/Cum. GDD for three landscape zones (drainageway, sideslope, summit) during the 2008, 2009, and 2010 growing seasons.

Summary

NDVI correlations with different plant parameters were strong across years, but a consistent relationship that includes NDVI measurements at 1st square to predict lint yield was not observed across these three growing seasons. Utilizing landscape positions to reduce variability did not appear necessary, since NDVI measurements seemed to distinguish variability across the field easily. Future research will continue to determine if sensor-based, variable rate N application can be used for cotton production in the Coastal Plain.

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References

Terra, J.A., J.N. Shaw, D.W. Reeves, R.L. Raper, E. Van Santen, E.B. Schwab, and P.L. Mask. 2006. Soil management and landscape variability affects field-scale cotton productivity. Soil Sci. Soc. Am. J. 70: 98-107.