Determining the Correct Nitrogen Rate for Cotton Following Soybeans

First Year (2003) Progress report

Bobby Phipps, Gene Stevens, and David Dunn
University of Missouri-Delta Center

Objectives

1) Determine the optimum rate of nitrogen fertilization for cotton in a cotton/soybean rotation.
2) Evaluate midseason plant N status monitoring methods.

Introduction

Cotton requires supplemental nitrogen fertilization to achieve maximum lint yields. Proper N rates are critical as lower rates may limit yields while higher rates promote excessive vegetative growth. This delays the harvest and reduces fiber quality. Higher than optimal N rates may also contribute to increased disease and insect pressure. Optimizing N rates also reduces environmental impacts by limiting the potential for run off or leaching. Studies at the University of Missouri-Delta Center have shown that our current soil test recommendations are valid for continuous cotton cultivation. University of Missouri soil test recommendations suggest lowering the N rate by 20-30 lbs/a N following soybeans. Cotton producers have raised concerns about the relevance of our N recommendations for cotton following soybeans.

Research methods

This evaluation was conducted on a silt loam and a clay soil at the University of Missouri-Delta Center. The following 5 Nitrogen treatments were evaluated:

1.	0 lbs N/a	
2.	Soil test recommended rate minus 50 lbs. N/a	60 lbs total N
3.	Soil test recommended rate minus 25 lbs. N/a	85 lbs total N
4.	Soil test recommended rate	110 lbs total N
5.	Soil test recommended rate plus 25 lbs. N/a	135 lbs total N

The soil test recommendation for nitrogen at both locations was 110 lbs N/a. With soybeans as the previous crop this rate could be reduced by 25 lbs to 85 lbs N/a. A pre-plant rate of 60 lbs N/a was applied to all plots except the untreated check using a four row liquid applicator. At pinhead square the remainder of the nitrogen, as ammonium nitrate, was applied by hand. Beginning at first square plant N status was monitored weekly using a Chlorophyll meter, Cardy meter and by petiole nitrate analysis. Petioles were randomly collected from each plot. For both sampling times 25 to 30 petioles and associated leaves were collected from the center two rows of each plot. These samples represent the fourth node below the uppermost fully expanded leaf. Prior to each sampling the Cardy and SPAD-502 meters were calibrated according to the manufactures instructions. SPAD-502 meter readings were conducted on each collected leaf. The petioles were then separated from the leaves and Cardy meter determinations were conducted on sap extracted from the lower one half of the petioles using a garlic press. The remaining half was dried and ground. The resulting sample was analyzed for NO3 using an Aluminum sulfate extraction and an Ion Selective Electrode determination.

Each plot was harvested and the lint yield measured. The cotton produced was ginned and the gin turnout calculated. The lint was then analyzed for the fiber quality properties: micronaire, length, strength, and trash percentage. These fiber quality properties were determined at the International Textile Research Center in Lubbock Texas using high volume instrument analysis.

Statistical analyses of the data were preformed with SAS (1990) using General Linear Modeling procedures. Fisher's Protected Least Significant Difference (LSD) was calculated at the 0.05 probability level for making treatment mean comparisons. Regression and correlation analysis were performed in accordance with procedures outlined by the SAS Institute (SAS, 1997). Returns to producers were calculated by using Commodity Credit Corporation Cotton loan rates for 2003 crop White Upland Cotton warehoused in Missouri. Discounts or premiums for fiber properties were applied to the base rate. Input costs for nitrogen were computed at a rate of $0.24 per lbs of N and an application cost of $5.00 per acre. Returns for cottonseed were calculated using a price of $110.00 per ton.

Project Accomplishments 2003

Data collected in 2003 are presented in Tables 1-3 and Figure 1. The clay soil and the silt-loam sites responded differently to N fertilization in 2003. Nitrogen fertilization significantly increased lint yields at the clay soil site (Table 1). Yields for the recommended rate and the higher rate were statistically equivalent. This supports the current University of Missouri soil test recommendations. However the highest rate of N produced the numerically highest yields. In 2004 the treatment of soil test recommended N plus 50 lbs will be added. A reduction of N rates following soybeans on clay soils would not be warranted. There was no significant response to N fertilization at the silt-loam site. This would indicate that the previous soybean crop had supplied sufficient N to maximize cotton lint production. In terms of fiber properties increasing nitrogen rates at the clay soil site produced longer, stronger and more uniform fibers with higher micronaire readings (Table 1). Increasing nitrogen rates reduced turn out. At the silt-loam site increasing N rates generally increased micronaire readings, had a mixed effect on length, and no effect on fiber strength or uniformity. Gin turn out was highest for the zero nitrogen rate at the silt-loam site. Tables 2a and 2b shows total returns to producers. At the clay soil site yields soil test recommended N and the Soil test plus 25 lbs were statistically equivalent differences in the fiber properties length and uniformity resulted in higher returns to producers. Net returns to producers indicate that N fertilization was profitable. At the silt-loam site increasing N fertilization and application costs resulted in mostly negative returns for nitrogen expenditures. In Missouri the cultural practice is for the gin to retain the cottonseed as payment for the ginning process. Larger amounts of cottonseed associated with lower gin turnouts do have a value. This value, while not available to Missouri cotton producers, is calculated in Tables 3a and 3b. At the clay soil site the larger amount of seed obtained with increasing N added value to the crop. The writers speculate that increasing N rates would produce seed that is higher in protein content. Presently cottonseed is not sold for a premium based on protein. In the future a premium may be added for higher protein levels. At the silt-loam site gin turn out was not increased by N fertilization and total value of the crop was negatively affected.

Cardy meter readings were well correlated with laboratory NO_3 determinations (Figure 1). This indicated that Cardy meter could be used in place of the traditional method of petiole analysis to monitor crop N status during the growing season.

This information will be presented in poster form to cotton producers and researchers at the Belt-Wide Cotton Conferences, in San Antonio, TX January 5,6,7,8,9-2004. This information will also be presented as an oral presentation at the Missouri Cotton Producers Conference in Kennett, MO February 10, 2004.

Table 1. Average cotton lint yields, gin turnout, and cotton fiber properties for N treatments in 2003

N Treatment	Cotton lint yields lbs/acre		Turn out %		Micronaire		Length		Strength		Uniformity	
	Clay	Silt loam	Clay	Silt loam	Clay	Silt loam	Clay	Silt loam	Clay	Silt loam	Clay	Silt loam
0	491 d	761a	0.4ab	0.38a	4.63c	4.68a	1.047b	1.095bc	27.90b	28.58a	82.30c	82.95a
60	750 c	680a	0.41a	0.36b	4.67bc	4.47ab	1.047b	1.113a	28.45ab	29.07a	82.88bc	83.17a
85	956 b	721a	0.4ab	0.36b	4.88ab	4.23ab	1.08a	1.110ab	28.83ab	28.70a	83.55ab	83.23a
110	1059a	870a	0.39bc	0.36ab	4.90a	4.50ab	1.082a	1.080c	28.97ab	28.85a	83.88a	82.82a
135	1098a	764a	0.38c	0.36b	4.95a	4.18a	1.09a	1.095bc	29.63a	29.15a	83.52ab	83.05a
LSD 0.05	94	244	0.014	0.0019	0.21	0.45	0.03	0.016	1.29	1.072	0.89	0.94
CV %	7.1	20.4	2.3	3.4	2.8	6.5	1.7	0.9	2.9	0.7	0.7	0.6

Numbers followed by the same letter in each column are not significantly different at the alpha = 0.05 level.

Table 2a. Returns to producers based on fiber quality for N treatments on clay soil, 2003.

N Treatment	Yield lbs/acre	Penalty or premium (basis points)			Price $/lbs	Gross Return	N cost	Application cost	Net returns to Producers
		Length	Strength	Uniformity					
0	491	-0.0115	0.0000	0.0000	0.512	$251.39	$0.00	$0.00	$251.39
60	750	-0.0115	0.0000	0.0000	0.512	$384.00	$14.40	$5.00	$364.60
85	956	0.0180	0.0000	0.0025	0.544	$520.06	$20.40	$10.00	$489.66
110	1059	0.0180	0.0000	0.0025	0.544	$576.10	$26.40	$10.00	$539.70
135	1098	0.0325	0.0035	0.0025	0.562	$617.08	$32.40	$10.00	$574.68

Table 2b. Returns to producers based on fiber quality for N treatments on silt-loam soil, 2003.

N Treatment	Yield lbs/acre	Penalty or premium (basis points)			Price $/lbs	Gross Return	N cost	Application cost	Net returns to Producers
		Length	Strength	Uniformity					
0	761	0.0325	0.0000	0.0000	0.556	$423.12	$0.00	$0.00	$423.12
60	680	0.0325	0.0000	0.0025	0.5585	$379.78	$14.40	$5.00	$360.38
85	721	0.0325	0.0000	0.0025	0.5585	$402.68	$20.40	$10.00	$372.28
110	870	0.0180	0.0000	0.0000	0.5415	$471.11	$26.40	$10.00	$434.71
135	764	0.0325	0.0000	0.0025	0.5585	$426.69	$32.40	$10.00	$384.29

Table 3a. Total returns, lint plus seed, to cotton industry for N treatments on clay soil, 2003. Value of crop due to N fertilization is also presented.

N Treatment	Lbs Seed	Seed Value	Lint Value	Total Value	Added Value of N
0	737	$40.51	$251.39	$291.90	$0.00
60	1079	$59.36	$364.60	$423.96	$132.06
85	1434	$78.87	$489.66	$568.53	$276.63
110	1656	$91.10	$539.70	$630.80	$338.90
135	1791	$98.53	$574.68	$673.21	$381.31

Table 3b. Total returns, lint plus seed, to cotton industry for N treatments on silt-loam soil, 2003. Value of crop due to N fertilization is also presented.

N Treatment	Lbs Seed	Seed Value	Lint Value	Total Value	Added Value of N
0	1242	$68.29	$423.12	$491.41	$0.00
60	1209	$66.49	$360.38	$426.87	-$64.54
85	1282	$70.50	$372.28	$442.78	-$48.63
110	1547	$85.07	$434.71	$519.77	$28.37
135	1358	$74.70	$384.29	$459.00	-$32.41

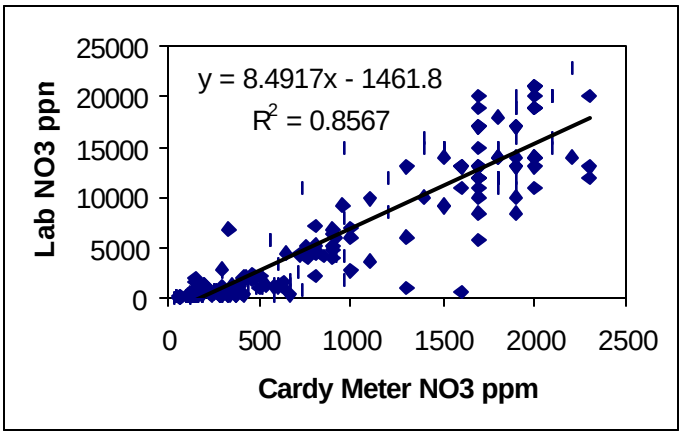

Figure 1 Relationship between laboratory cotton petiole analysis and Cardy meter NO_3-N determinations for both sites in 2003.

Budget

Expenses		**Year**	
	2003	**2004**	2005
Res. Specialist salary (0.25)	6,750	**6,953**	7,162
Fringe benefits	1,688	**1,739**	1,791
Student Labor (.125)	2,000	**2,060**	2,122
Fringe benefits	160	**165**	170
Supplies	2,000	**2,060**	2,122
Plant and soil analysis	2,600	**2,678**	2,758
Travel	1,200	**1,236**	1,273
Total	**$16,398**	**$16,891**	**$17,398**