Cotton Response to Nitrogen Fertilization in a Silt Loam

M. Mozaffari, M.A. Henslee, N.A. Slaton, J.S. McConnell, E. Evans, and C. Kennedy

RESEARCH PROBLEM

Proper nitrogen (N) nutrition is a fundamental requirement for successful cotton (*Gossypium hirsutum* L.) production. Nitrogen deficiency limits cotton lint yield by limiting vegetative growth whereas excessive N will limit lint production by promoting excessive vegetative growth. A replicated field study was conducted to investigate the effect of N fertilizer application rate (0 to 120 lb N/acre) on cotton yield and petiole-N concentration.

BACKGROUND INFORMATION

Research conducted since the 1920s has clearly demonstrated that cotton yield in many Arkansas soils can be increased by application of N fertilizer (Maples et al., 1990). Nitrogen fertilization of cotton in Arkansas is based on preplant soil-test NO_3-N levels and petiole NO_3-N concentrations between first bloom and boll opening. Application of this diagnostic approach has enabled many Arkansas growers to produce high cotton yields. However, there have been many changes in cotton production practices during the past three decades that could potentially influence cotton response to N fertilization. Nitrogen requirements of new shorter-season varieties may be different than older cultivars previously used. Continuous research is needed to provide Arkansas growers' with up-to-date technical information concerning the response of new cotton cultivars to N fertilization. Therefore continuous evaluation of the effectiveness of the petiole-N monitoring program, as a decision aid tool for in-season N fertilizer application, is also necessary. The objectives of this research were to evaluate cotton yield and petiole NO_3-N response to N fertilization.

PROCEDURES

A replicated field experiment was conducted on a Loring silt loam soil at the University of Arkansas Cotton Branch Experiment Station (CBES) located in Marianna, AR, during 2002. Prior to planting, two composite soil samples were collected from the top 6 inches of each plot, each composite sample consisted of eight 1-inch diameter samples from each of the eight cotton rows. Soil samples were extracted with Mehlich-3 solution (1:10 ratio) and concentration of elements in the soil extract was measured by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Nitrate, pH, and EC were measured by standard University of Arkansas soil testing procedures. Cotton ('Stoneville 4892') was planted on 21 May. The experimental design was a randomized complete block with four N rates (0, 60, 120, and 180 lb N/acre side-dressed at pinhead square stage as NH_4NO_3) and four replications of each treatment. Individual plots were 200 ft long and 25 ft wide. Phosphorus and K were applied as prescribed by University of Arkansas soil-test recommendations. Standard cultural practices for pest control and irrigation, as recommended by the University of Arkansas Cooperative Extension Service, were followed. Cotton petiole samples were collected for 10 consecutive weeks starting on 3 July and ending on 5 September. The first two weeks, 24 petioles from the fifth node from the top were randomly collected from each plot. The final eight weeks, 16 petioles from the fifth node from the top were randomly collected from each plot. Cotton petioles were dried overnight at 70°C and ground to pass a 1-mm sieve. A 0.1 g sub-sample was mixed with 30 mL aluminum sulfate spiked with 10 mg NO_3-N/kg and shaken for 30 minutes while stirring. Petiole NO_3-N concentration was determined using an ion specific electrode. At maturity, seedcotton yield was determined from the center four rows of each plot with a 4-row cotton picker equipped with an AgLeader™ yield monitor. Analysis of variance was performed to evaluate the effect of N fertilizer rate on cotton yield and petiole NO_3-N concentration and significant treatment means were separated with the Waller-Duncan test.

RESULTS AND DISCUSSION

Selected chemical properties of soil in the experimental plots are listed in Table 1. According to current University of Arkansas guidelines, optimal cotton production at this site required 60 lb N/acre. However, seedcotton yields were not significantly increased by N application with yields ranging from 2420 to 2580 lb/acre (calculated lint yield ranged from 848 to 902 lb/acre, Table 2).

Petiole-N concentration increased early in the season, peaked one week after first bloom (24 July), and then decreased until one week after the cutout date, regardless of N rate (Table 3). Petiole-NO_3-N significantly increased with increasing N rate, regardless of sampling date. At first bloom, petiole-NO_3-N concentration was 30% higher at 180 lb N/acre compared to 60 lb N/acre and as the season progressed this difference became larger. Two weeks after cutout, petiole-NO_3-N in plants amended with 180 lb N/acre was seven times higher than plants amended with 60 lb N/acre (Table 3). Petiole-NO_3-N concentrations in the unfertilized control were consistently below the Arkansas lower sufficiency range indicating additional N was needed for optimal yield production, but we did not observe a yield response to sidedress N application rate. Foliar N application would have been erroneously recommended for plots amended with 60 lb N/acre after 31 July. These evidences suggest that the current Arkansas lower sufficiency levels for cotton petiole-NO_3-N may be too high for the shorter-season varieties currently in use.

PRACTICAL APPLICATIONS

In this field experiment petiole-NO_3-N concentrations increased as N rate increased. Petiole-NO_3-N in control plots was consistently below the current critical levels for Arkansas. However, plants with petiole-NO_3-N levels higher than the established lower sufficiency range did not produce higher cotton yields. This suggests that the current petiole-NO_3-N monitoring program may need revisions to be applicable to fast-fruiting cultivars currently in use.

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Table 1. Selected chemical properties before fertilizer application of the top 15 cm of a Loring silt loam used for an N-rate trial at the Cotton Branch Experiment Station during 2002.

		Mehlich-3 extractable nutrients[z]					
N rate	pH	NO_3-N	P	K	Mg	Ca	B
(lb N/acre)		(lb/acre)					
0	6.4	31	105	266	308	2200	1.4
60	6.4	28	104	280	308	2200	1.1
120	6.4	26	107	276	316	2050	1.2
180	6.4	30	110	274	315	2180	1.2

[z] Modified Mehlich-3 extraction (1:10 extraction ratio).

Table 2. The effect of N fertilizer application rate on cotton yield at the Cotton Branch Experiment Station in 2002.

N rate	Seedcotton yield	Lint yield	Lint yield
(lb/acre)	(lb/acre)		(bale/acre)
0	2420	848	1.77
60	2580	902	1.88
120	2530	885	1.85
180	2465	863	1.79
Significance	NS[z]	NS	NS

[z] NS = not significant at P = 0.05 probability level.

Table 3. Effect of N fertilizer application rate on cotton petiole NO_3-N concentration in an N rate trial conducted at the Cotton Branch Experiment Station during 2002.

	Seedcotton	Sampling date								
N rate	yield	July 10	July 17[z]	July 24	July 31	Aug. 7	Aug. 14[y]	Aug. 21	Aug. 28	Sept. 5
(lb N/acre)	(lb/acre)	[Petiole NO_3-N (mg/kg)]								
0	2420	3570	4189	11313	3520	1012	478	727	475	1417
60	2580	6264	6246	18469	8859	3313	862	1343	755	1209
120	2530	7447	8377	20828	12804	7878	3516	4427	1893	1527
180	2465	12535	9713	23138	15172	11005	5987	6171	3300	2260
Lower sufficiency level[x]		5000	>10000	>9000	>7000	>5000	>3000	>2000	>2000	>1000
Significance		**[w]	**	**	**	**	**	**	*	+
MSD (0.05)[v]		2476	2269	3697	3406	2865	1812	2311	1957	923

[z] First bloom on 19 July.
[y] Cut-out occurred on 17 Aug; first boll opened on 9 Sep.
[x] Recommendations for Arkansas published by Snyder et al., 1995.
[w] **, *, + significant at P = 0.01, 0.05, and 0.10 probability level, respectively.
[v] Minimum Significant Difference as determined by Waller-Duncan Test