EVALUATION OF PRESIDEDRESS SOIL NITRATE TEST FOR COTTON PRODUCTION IN ARKANSAS

M. Mozaffari
University of Arkansas Soil Testing and Research Laboratory
Marianna, AR
N. A. Slaton
University of Arkansas
Fayetteville, AR
Josh Long
Doug Carroll
University of Arkansas Soil Testing and Research Laboratory
Marianna, AR
Cindy G. Herron
University of Arkansas
Marianna, AR

Abstract

Current nitrogen fertility recommendation for cotton production (*Gossypium hirsutum* L.) in Arkansas is based on NO_3-N levels in a preplant soil sample collected from the 0-6" depth. Nitrogen use efficiency can be improved if fertilizer recommendation is based on analysis of a soil sample collected from the 0-12" depth, before the period of high N demand by a growing cotton crop begins. Replicated field experiments were conducted at multiple locations in Arkansas during the 2006 cropping seasons to evaluate the effect of sidedressed N-fertilizer rate on seedcotton yield and to evaluate the potential for using a presidedress soil NO_3-N test to predict the need for sidedress application of N. Nitrogen fertilizer was applied in split applications at total-N rates of 0, 30, 60, 90, 120, and 150 lb N/acre or 0, 35, 70, 105, and 140 lb N/acre. Prior to, or at planting, 20 lb N/acre as ammonium sulfate was applied to all treatments except the 0 lb N/acre treatment. The balance of each total-N rate was sidedressed at first square stage. Prior to the application of sidedressed N, soil samples were collected by replication from the 0-12" soil depth and soil NO_3-N were measured. Sidedress application of N significantly increased seedcotton yields at six of seven sites. Seedcotton yields ranged from 1278 to 3501 lbs/acre for 0 lbs N/acre and 2407 to 3658 lbs/acre for the greatest applied N rate. The numerically highest yield was produced with the greatest N rate, 140-150 lbs N/acre, at 3 of the 7 sites. However, when the presidedress soil NO_3-N test (PSNT) was >21 ppm, we observed minimal or no response to N-fertilizer. When PSNT was ≤ 21 ppm near maximal seedcotton yields were produced by application of 60 to 120 lbs N/acre. The results suggest that PSNT can potentially be used to improve N fertility recommendations for cotton production in Arkansas.

Introduction

Supplemental application of N is needed to produce optimum economic cotton (*Gossypium hirsutum* L.) yields in many cotton production fields in Arkansas. Earlier research on cotton response to N in Arkansas was conducted by Maple and Keogh (1973) and Maple and Frizzle (1985). These and similar efforts during the 1970s and 1980s resulted in development of the current cotton nitrogen fertility recommendations in Arkansas, which are based on concentration of NO_3-N in a soil sample collected before planting from the 0-6" soil depth.

Under application of the N fertilizer will limit crop yield, whereas over application of N is not only an economic loss to the growers, but also poses a potential environmental problem. The renewed interest in biofuels and other economic factors have resulted in record fertilizer prices and cotton prices are currently low. Nitrogen fertilization has become a major input cost for cotton production in Arkansas. Thus, improving N fertilizer use efficiency will improve the growers' profit margin. Current N fertility recommendation for cotton in Arkansas is based on soil NO_3-N level in a soil sample collected from the top 6" of the soil before planting.

Denitrification and leaching losses of N may occur between the preplant soil sampling time and the period of high N demand by cotton (i.e., first square). Additionally, cotton roots can obtain nutrients from deeper than 6-inches in the absence of a physical barrier to root penetration. Therefore, there is a potential to improve N use efficiency by basing N fertilizer application rates on analysis of soil samples collected immediately before the first square from a greater depth (e.g., top 12-inches). This approach is referred to as the presidedress soil NO_3-N test (PSNT). The

PSNT was originally developed for corn *(Zea mays* L.) and has significantly improved the accuracy of N rates for corn production (Magdoff et al., 1984). In this approach a small (<40 lbs N/acre) amount of N may (or may not, optional) be applied at planting. A soil sample for PSNT is collected when corn is 6-12 inches tall (4-6 leaf stage), shortly before the period of high N demand. The balance of the recommended N rate, which is based on PSNT, is made as a sidedressed application. The success of PSNT in corn fertilization raises the possibility of its success for improving cotton N fertility management in Arkansas. The objectives of this study were to evaluate 1) the effect of sidedressed N-fertilizer rate on seedcotton yield and 2) evaluate the potential for using PSNT to identify soil NO3-N levels beyond which no agronomic yield response to N fertilizer will be expected.

Methods and Materials

Seven replicated field experiments were conducted at multiple locations on soils commonly used for cotton production in Arkansas in 2006 and 2007. Experimental sites were either located on the University of Arkansas Agricultural Experiment Station (AES) research farms or on commercial fields. Information on soil series, previous crop, cotton cultivar(s), and agronomically important dates are provided in Table 1.

Table 1. Selected agronomic information for cotton N-fertilization experiments conducted at Agricultural Experiment Stations and commercial fields in Arkansas in 2006.

Site ID	Soil Series	Previous crop	Cultivar(s)	Planting date	N application dates		Harvest date
					1st	2nd	
GR61	Lafe silt loam	Cotton	ST4554	13-May	17-May	12-June	25-Oct
LE64	Convent silt loam	Cotton	DPL445 ST5599	20-May	10-April	29-June	14-Oct
LE66	Convent silt loam	Cotton	Dyna-Grow 2520	20-May	10-April	29-June	14-Oct
MS61	Sharkey-Steele complex	Soybean	DPL444 ST4892	3-May	4-May	27-June	9-Oct
MS63	Sharkey silty clay	Cotton	ST5599	16- May	4-May	27-June	9-Oct
PH62	Dubbs silt loam	Cotton	ST5599	16-May	16-April	22-June	10-Oct
PO63	Dundee silt loam	Cotton	DPL444 ST5599	19-May	28-April	13-June	2-Oct

Prior to fertilizer application and planting, composite soil samples were collected from the 0-6" soil depth of each replication. Soil samples were processed and extracted with Mehlich-3 solution (Mehlich, 1984) and the concentration of elements in the soil extracts measured by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Soil nitrate was extracted with aluminum sulfate and measured with a specific ion electrode (Donahue, 1992). Soil pH was measured in a 1:2 (weight:volume) soil-water mixture extraction (Donahue, 1983). Particle size analysis was performed by the hydrometer method (Arshad et al., 1996). Selected soil property averages for each site are listed in Table 2. Nutrients other than N were applied when needed according to the current University of Arkansas recommendations for cotton production. All sites were irrigated. Pest management practices closely followed the University of Arkansas recommendations for irrigated-cotton production to ensure yield was not affected by pest damage. Irrigation timing was managed by the University of Arkansas Cooperative Extension Service Irrigation Scheduler program (University of Arkansas Cooperative Extension Service, 2007).

Each experimental plot was 45-ft long and 4-rows wide. Nitrogen fertilizer was applied in split applications at total-N rates of 0, 30, 60, 90, 120, and 150 lb N/acre or 0, 35, 70, 105, and 140 lb N/acre (LE66 and MS61 sites). Prior to, or at planting, 20 lb N/acre as ammonium sulfate was side-dressed at all sites to all treatments except the 0 lb N/acre treatment. The balance of each total-N rate was sidedressed as urea by hand at first square stage. Prior to the application of sidedressed N, soil samples were collected by replication from the 0-12" soil depth, composited by replication, and processed as described previously for measurement of soil NO_3-N concentrations. At AES sites, the two center rows of each plot were harvested with a plot picker. At the commercial farms, plants in one 15 ft-long section of one center row were cut, bagged, and cotton was hand picked in the laboratory.

In studies with two cultivars, the experimental design was a randomized complete block, with a split-plot treatment structure where the cultivar was the main-plot factor and N rate was the subplot factor. In the studies with one cotton cultivar, the experimental design was a randomized complete block. Treatments were replicated four times in all studies. Analysis of variance (ANOVA) was performed using the GLM procedure of SAS. Sites were analyzed separately. Mean separations were performed by the Waller Duncan minimum significant difference (MSD) test at a significance level of 0.05 and 0.10.

Results and Discussion

Preplant soil samples showed that the soil texture among sites ranged from clay to loam and soil pH ranged from 6.1 to 6.7 (Table 2). Mehlich-3 extractable P and K were generally in the Medium or Optimum soil-test levels. Preplant soil NO_3-N in the 0- 6" soil depth ranged from 3-51 ppm. Current University of Arkansas cotton N fertilization guidelines recommend N fertilizer application when the preplant NO_3-N is <12 ppm in the top 6-inches. The PSNT levels ranged from 8-51 ppm and were >30 ppm at two sites (Table 3).

Table 2. Selected soil chemical property means (0-6" soil depth) from samples taken before planting in cotton N-fertilization trials conducted at Agricultural Experiment Stations and commercial fields in Arkansas in 2006.

Location	Soil pH[a]	Soil NO_3-N[b]	Mehlich-3 extractable nutrients							Textural Analysis			
		NO3-N	P	K	Ca	Mg	Mn	Cu	Zn	Sand	Silt	Clay	Texture
		(ppm)								%			
GR61	6.6	19	97	236	1256	226	202	1.1	3.3	4	75	21	silt loam
LE64	6.1	3	32	104	1170	224	191	1.1	2.1	8	69	22	silt loam
LE66	6.4	3	44	115	1311	259	161	1.6	2.9	5	70	25	silt loam
MS61	6.0	15	51	172	2455	431	84	2.8	4.4	48	21	32	Sandy clay loam
MS63	6.6	9	72	235	3743	664	57	4.1	5.4	34	24	42	clay
PH62	6.2	51	80	250	1295	132	408	1.7	4.3	12	65	23	silt loam
PO63	6.7	19	40	121	1772	206	95	1.2	2.9	39	38	23	loam

[a] Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.
[b] NO_3-N measured by ion-specific electrode.

Table 3. Soil NO_3-N concentration and pH means (0-12" soil depth) from samples taken shortly before sidedress N application in cotton N-fertilization trials conducted at Agricultural Experiment Stations and commercial fields in Arkansas during 2006.

Site ID	Soil pH[a]	NO_3-N[b]
		--- (ppm) ---
GR61	6.1	21
LE64	5.2	13
LE66	5.1	20
MS61	6.1	16
MS63	6.5	8
PH62	6.2	51
PO63	5.4	42

[a] Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.
[b] NO_3-N measured by ion-specific electrode.

For sites with two cultivars, the main effect of cultivar or the interaction between cultivar and N rate were not significant (P>0.10), therefore, seedcotton yields were averaged across the cultivars. Sidedressed N-fertilizer rate significantly (P0.05) increased seedcotton yields at all sites except the POG63 site (Table 4) where the PSNT level was 42 ppm (Table 3). Seedcotton yields ranged from 1278 to 3501 lbs/acre for 0 lbs N/acre and 2407 to 3658 lbs/acre for the greatest applied N rate. The numerically highest yield was produced with the greatest N rate, 140-150 lbs N/acre, at 3 of the 7 sites. The N rate that produced the statistically (MSD=0.10) greatest seedcotton yield varied among sites including 0 lbs N/acre for PO63, 30 lbs N/acre for PH62, 60 lbs N/acre for GR61, 105 lbs N/acre for LE66 and MS61, and 150 lbs N/acre for LE64 and MS63 (Table 4). The N rate required to produce the statistically greatest seedcotton yield at each site generally increased as the PSNT soil NO_3-N concentration decreased (Table 3) suggesting that the PSNT shows great promise in refining N rates for cotton. The preplant soil NO_3-N concentrations, measured on 6-inch deep soil samples, had numerically similar NO_3-N concentrations as the PSNT 12-inch deep samples for all sites except PO63, LE64, and LE66 which had considerably lower preplant NO_3-N concentrations. Thus, the PSNT samples appear to be more accurate than routine samples taken before planting for predicting the optimum N rate for cotton. The results of this one year multi-location field study suggest that PSNT can potentially be used to improve N fertility recommendation for cotton production in Arkansas. Additional field research at multiple site-years are needed to develop a robust data base for developing N fertility recommendations based on PSNT.

Table 4. Effect of soil-applied, N-fertilizer rate on seedcotton yield from seven trials conducted at Agricultural Experiment Stations and commercial fields in Arkansas during 2006 and 2007.

N rate	GR61	LE64	MS63	PH62	PO63		N rate	LE66	MS61
(lb/acre)	-- Seedcotton yield (lb/acre) --						(lbs/acre)	Seedcotton yield (lb/acre)	
0	2684	1315	1278	3501	2441		0	1479	1547
30	3553	1900	1569	3993	2587		35	1733	1865
60	3816	2526	1674	3737	2485		70	2083	2208
90	4294	2673	2058	3580	2743		105	2216	2274
120	4166	3025	1992	3364	2467		140	2584	2407
150	2585	3115	2428	3658	2552		-	-	-
P value	0.0018	<0.0001	<0.0001	0.0193	0.2659			0.0022	<0.0001
MSD at 0.05[a]	706	312	372	372	-			464	212
MSD at 0.10[b]	589	289	310	310	-			389	181

[a, b] Minimum significant difference at P=0.05 and 0.10 as determined by Waller-Duncan Test.

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