Long-term Irrigation Methods and Nitrogen Fertilization Rates in Cotton Production: The Last Three Years of the Mcconnell - Mitchell Plots

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RESEARCH PROBLEM

Nitrogen (N) and water management are two very important aspects of successful cotton (*Gossypium hirsutum*, L.) production. If cotton becomes N deficient the plants may become chlorotic and not photosynthesize sufficiently to meet the demands of crop growth. Nitrogen deficiency of cotton typically results in reduced yields, premature cut-out, and reduced fiber quality. Few studies of the interactions of N fertilizer and irrigation have been conducted for cotton. This is especially true under the humid production conditions of southeast Arkansas (McConnell et al., 1988).

Objectives of these studies were to evaluate the growth, development, and yield of intensively managed cotton as a function of soil- and plant-N fertilization and dynamics under different irrigation methods.

BACKGROUND INFORMATION

Both over- and under-fertilization of cotton with N may result in reduced yield. Over-fertilization may also induce delayed maturity in cotton (Maples and Keogh, 1971). Reductions in yield and quality due to N deficiency may severely reduce the value of the crop and have adverse economic consequences for producers (Bondada et al., 1996; Radin and Mauney, 1984).

Generally, yields were found to increase with increasing N fertilization throughout the previous years of this test. The N treatments that usually resulted in the greatest yields were applications of 60- to 150-lb N/acre, depending upon the irrigation treatment and year. The yields of the High Frequency block during some years were significantly influenced by verticillium wilt. The disease was more virulent in the plots receiving higher N rates, thereby reducing yields with increasing N.

Adequate soil moisture is also necessary for cotton to achieve optimal yields. Early and mid-season water requirements of cotton should be met to avoid yield loss that may occur if the crop undergoes drought stress (Jordan, 1986; Wanjura, et al., 1996). If the soil becomes either too wet or too dry, cotton plants will undergo stress and begin to shed fruit (Guinn et al., 1981).

In the previous years of this study, irrigation generally increased cotton yields except during seasons when early season rainfall resulted in standing water that delayed the irrigated plants or when verticillium wilt was prevalent. The method of irrigation that maximized yield varied among years and therefore appeared to be less important than irrigation usage.

PROCEDURES

An experiment to examine the interactions of N-rates and irrigation methods was initiated at the Southeast Branch Experiment Station on an Hebert silt loam soil in 1982. This experiment, the McConnell-Mitchell Plots, is conducted on the oldest continuous plots in Arkansas. The experimental design was a split block with irrigation methods as the main blocks. Four irrigation methods were used from 1982 until 1987. Five irrigation methods were employed from 1988 to 1993. Only three irrigation methods have been used since 1993 (Table 1).

Ten total N treatments were tested within each irrigation method. Six different N rates (0, 30, 60, 90, 120, and 150 lb urea-N/acre) were tested with different application rates and timings (Table 2). N-fertilization was discontinued for the 2000 and subsequent growing season to examine the effects of residual soil nitrate-nitrogen (NO_3^-N) on cotton development. Soil samples were taken from the plots and analyzed for residual NO_3^- N to a depth of five feet (Table 3).

The McConnell-Mitchell Plots were planted 14 May 1999, 18 May 2000, and 23 April 2002. The 2001 growing season was marked by an early June hail storm that destroyed the stand of cotton. The cotton was replanted on 15 June 2001, but seedling disease decimated the stand a second time. The crop was not replanted again and the plots were fallowed, as it was deemed too late to get meaningful results.

RESULTS AND DISCUSSION

Interaction of irrigation with N-treatments and residual N significantly impacted yields all three years of the study (Table 4). During the last three years, high frequency center-pivot irrigation increased cotton yields compared to furrow irrigation or dryland production. Addtionally, furrow-irrigated cotton produced greater yields than dryland cotton during this period.

Yields were found to increase with increasing N fertilization in each irrigation block in 1999, although there were a few reversals and not all differences were significant. Yields were maximized in both high frequency center-pivot and furrow-irrigated cotton with 150 lb N/acre (split two ways). Yield response of the cotton in the dry land block was limited due to lack of rainfall.

Plant response to residual N in 2000 seemed to mirror the N-fertilization of previous years. Yields were again maximum where the 150- and 120-lb N/acre treatments had been applied in the center-pivot and furrow-irrigated blocks and were influenced little in the dryland block.

In 2001, the test site was fallow for the first time in the history of the McConnell-Mitchell plots. Hail and seedling disease prohibited a successful stand. Weeds were controlled on the site season long with Roundup®.

Cool, wet conditions in the 2002 growing season resulted in severe seedling disease but not stand loss. Near optimal growing conditions through the rest of the season resulted in acceptable yields, however, response to residual NO_3^--N was limited in 2002. Cotton grown under high frequency center-pivot irrigation did not significantly respond in yield to the residual soil NO_3^--N, and cotton under dryland and furrow irrigation had only minimal yield response. As the residual NO_3^--N is consumed by subsequent crops, it will have less impact on plant development and yield.

PRACTICAL APPLICATIONS

Irrigated cotton was generally found to produce higher yields than cotton grown under dryland conditions. Fertilizer nitrogen requirements of cotton for maximal yield tended to be greater under irrigated production conditions than under dryland production conditions. Residual soil N was sufficient the first year to maintain yields when previous years of N-fertilization were high. After two growing seasons and one fallow season, the yield response to residual NO_3^--N was much less.

ACKNOWLEDGMENTS

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Table 1. Duration, tensiometer thresholds and depths, and water application rates for three irrigation methods.

Irrigation methods	Duration	Tensiometer Threshold	Tensiometer Depth	Water applied
		-(cbar)-	-(in.)-	-(in.)-
High frequency center-pivot	Planting to P.B.[z]	35	6	0.75
	P.B. to Aug. 15	35	6	1.00
Furrow flow	Until Aug. 15	55	12	Not precise
Dryland	Not irrigated	--	--	--

[z] P.B.=Peak bloom

Table 2. Nitrogen (N) fertilization treatments and timing for the McConnell-Mitchell Plots at the Southeast Branch Experiment Station near Rohwer, Arkansas.

Total N-Rate	Preplant	First square	First flower
- (lb N/acre) -	(lb N/acre)		
150	75	75	0
150	50	50	50
150	30	60	60
120	60	60	0
120	40	40	40
90	45	45	0
90	30	30	30
60	30	30	0
30	15	15	0
0	0	0	0

Table 3. Residual nitrate-nitrogen (NO_3^-N) to a depth of five feet in six-inch increments from five fertilization rates (split applied, half pre-plant and half at first square) under three irrigation methods of the McConnell-Mitchell study in 2000.

Depth	Nitrogen fertilization rate 0	30	60	90	120	150	Mean
- (in.) -	(lb NO_3^-N/acre)						
Furrow irrigated							
0 - 6	2.0	1.7	2.3	2.0	2.7	3.0	2.3
6 - 12	1.7	2.3	1.3	1.7	2.0	2.0	2.3
12 - 18	2.0	3.0	2.7	2.0	3.0	4.3	3.8
18 - 24	3.0	2.7	3.3	2.3	4.3	7.3	4.8
24 - 30	2.7	3.0	3.0	2.7	4.3	6.7	4.5
30 - 36	2.0	3.0	3.0	2.7	4.7	6.3	4.1
36 - 42	2.7	2.7	2.7	2.7	4.3	7.0	4.1
42 - 48	2.7	2.3	2.7	2.3	4.3	9.0	4.0
48 - 54	2.7	2.7	2.7	2.7	3.7	7.7	3.9
54 - 60	2.3	2.0	3.3	2.0	6.7	5.7	3.6
Mean	2.4	2.5	2.7	2.3	4.0	5.9	
Dryland							
0 - 6	6.0	6.0	6.0	28.7	87.3	65.0	29.4
6 - 12	5.0	8.7	6.0	32.7	107.7	102.0	39.1
12 - 18	4.3	6.0	5.0	35.0	138.3	134.7	45.9
18 - 24	3.7	5.0	6.0	36.3	125.3	110.7	46.2
24 - 30	3.7	3.7	5.7	31.0	90.7	104.3	46.9
30 - 36	2.7	3.3	5.0	21.7	58.3	67.7	31.7
36 - 42	2.7	3.0	3.7	11.7	54.0	36.7	22.3
42 - 48	2.3	2.7	3.0	7.0	36.7	21.3	13.0
48 - 54	2.7	2.7	4.0	6.0	21.0	14.7	9.1
54 - 60	13.0	6.0	30.3	2.0	33.3	56.7	24.6
Mean	4.6	4.7	7.5	21.4	75.2	71.4	
Center Pivot Irrigated							
0 - 6	1.0	1.0	3.0	3.0	2.0	1.7	1.9
6 - 12	1.3	1.0	2.3	3.0	3.3	5.3	3.1
12 - 18	1.7	1.3	3.0	2.7	3.3	11.0	4.9
18 - 24	2.0	1.3	2.0	1.0	2.3	19.7	5.4
24 - 30	2.0	3.3	1.7	2.0	3.3	18.0	6.0
30 - 36	1.7	2.7	1.3	2.7	3.7	9.7	5.5
36 - 42	2.0	2.3	1.7	2.7	4.3	7.3	7.7
42 - 48	2.0	2.3	2.7	3.3	5.7	6.3	7.5
48 - 54	1.7	2.7	1.7	3.3	5.7	4.0	5.0
54 - 60	6.0	3.7	2.0	2.3	5.0	6.7	4.1
Mean	2.1	2.2	2.1	2.6	3.9	9.0	

Table 4. Seed cotton yield response of cotton to 10 nitrogen (N) fertilization rates and splits under three irrigation methods from 1999, 2000, and 2002 at the Southeast Branch Experiment Station near Rohwer, Arkansas.

N Rate						
PP[z]	FS[z]	FF[z]	HF[y]	FI[y]	DL[y]	Mean
	(lb/acre)		(lb seed cotton[x]/acre)			
1999						
75	75	0	3805	3548	1505	3166
50	50	50	3437	3287	1796	3138
30	60	60	3560	3306	1607	3008
60	60	0	3674	3098	1394	2960
40	40	40	3693	3533	1772	3172
45	45	0	3278	3045	1757	2839
30	30	30	3299	2817	1694	2777
30	30	0	3383	2812	1757	2834
15	15	0	2556	1912	1786	2202
0	0	0	2459	1550	1389	1964
LSD(0.05)=358[w]						
LSD(0.05)=549[v]						
Mean			3344	2890	1646	
2000						
75	75	0	2968	2161	1245	2207
50	50	50	3034	2126	1295	2152
30	60	60	3138	2223	1255	2205
60	60	0	2783	1923	1186	2042
40	40	40	2882	1999	1382	2112
45	45	0	2753	1951	1233	1979
30	30	30	2541	2003	1314	1949
30	30	0	2784	1885	1182	1977
15	15	0	2329	1665	1312	1744
0	0	0	2643	1677	1027	1721
LSD(0.05)=244[w]						
LSD(0.05)=880[v]						
Mean			2801	1961	1242	
2002						
75	75	0	3847	3413	2901	3379
50	50	50	3900	3464	3114	3485
30	60	60	3864	3369	3202	3470
60	60	0	3692	3466	2998	3378
40	40	40	3886	3214	3391	3489
45	45	0	3733	3342	3204	3419
30	30	30	3616	3330	3245	3395
30	30	0	4041	3146	3056	3407
15	15	0	3602	3037	3297	3304
0	0	0	3481	2867	2886	3071
LSD(0.05)=340[w]						
LSD(0.05)=493[v]						
Mean			3766	3265	3128	

[z] Pre-plant (PP), first square (FS) and first flower (FF).
[y] High frequency (HF), furrow irrigated (FI), dryland (DL).
[x] Lint yield may be estimated by dividing the seed cotton yield by 3.
[w] LSD(0.05) for comparing means within the same irrigation method.
[v] LSD(0.05) for comparing means within different irrigation methods.