EFFECTS OF TILLAGE SYSTEMS AND COVER CROPS ON NITROGEN FERTILIZER REQUIREMENTS OF COTTON

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INTRODUCTION

Conservation tillage systems and winter cover crops can reduce soil erosion on highly erodible cotton fields. Estimates of soil erosion on loess soils in northeast Louisiana indicate that these practices may reduce soil erosion by over 85% compared to conventional tillage practices (Hutchinson et al., 1991). Research conducted in Louisiana from 1987-1992 has shown that cotton yields in conservation tillage systems are usually equal to conventional tillage (Hutchinson, et al., 1991; Hutchinson, et al., 1993). In most instances performance of cotton in no-till (NT) and ridge-till (RT) systems was significantly improved with winter cover crops (Hutchinson, et al., 1993). Several studies in other states have demonstrated similar yield improvements when cotton followed winter cover crops in conservation tillage systems (Brown, et al., 1985; Keeling, et al., 1989) while others, showed no benefits from winter cover crops (Stevens, et al., 1992). Cover crop mulches are very effective for conserving soil moisture. Thus, yield benefits from winter cover crops are more likely to occur under non-irrigated conditions on drought-prone soils where moisture stress is a limiting factor on yields.

Several researchers have studied the use of legume cover crops as a N source for cotton in conservation tillage systems (Brown et al., 1985; Dumas, 1980; Touchton et al., 1984). In some instances the legume cover crops provided adequate N for optimum yields while in others additional N was needed. Results from these studies indicate that N fertilizer responses of cotton following legumes may be quite variable due to differences in biomass production of the cover crop, and due to soil and environmental factors that influence decomposition and mineralization rates and leaching of N below the cotton rooting zone. Information on N fertilization of conservation-tillage cotton following small grain cover crops is limited, however, several researchers have found that conservation-till cotton following small grain cover crops requires higher N fertilizer rates than cotton following winter fallow (Brown et al., 1985; Touchton and Reeves, 1988).

This study was initiated to develop N fertilization guidelines for NT and conventional-till (CT) cotton following selected winter cover crops on a loessial soil of the Macon Ridge region of northeast Louisiana. Results of these studies are needed to optimize yields and reduce the environmental risks associated with over fertilization of cotton in CT and NT production systems.

MATERIALS AND METHODS

A field experiment was conducted from 1991-93 on a Gigger silt loam soil (fine-silty, mixed, thermic Typic Fragiudalf) at the Macon Ridge Branch Research Station at Winnsboro, Louisiana to study the effects of tillage systems and winter cover crops on N fertilizer requirements of cotton. Winter cover crops were native winter vegetation, hairy vetch, or winter wheat. Tillage systems included NT and CT. Nitrogen fertilization rates ranged from 0 to 140 pounds/acre in 35 pound/acre increments. All treatments were maintained in the same location each year of the study.

Hairy vetch and winter wheat (cultivar 'Florida 302') cover crops were NT planted with a grain drill after cotton harvest each year. Seeding rates for vetch and wheat were 25 and 90 pounds/acre. respectively. Planting dates were October 23, 1990; November 5, 1991; and October 19, 1992. A rotary stalk cutter was used to shred the cotton stalks immediately after the cover crops were planted each year.

Hairy vetch and wheat cover crops were terminated either with herbicides (NT treatments) or tillage (CT treatments) on April 24, 1991 and on April 10 in 1992 and 1993. Plots were retreated with herbicides or tillage 11 to 14 days later. The hairy vetch cover crops were adequately controlled with two applications of paraquat (0.5 lb ai/acre). The wheat cover crop received two applications of

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Table 1. Effects of tillage systems on seedcotton yield averaged across cover crops and N rates.

Tillage System	Seedcotton 1991	1992	1993
	--lb/acre--		
Conventional-till	2671	2626	2806
No-till	2687	2688	2731
LSD (0.051	NS	NS	NS

Table 2. Effects of winter cover crops and N rates on seedcotton yield averaged across tillage systems.

Cover Crop	Cotton N Fertilizer Rate	Seedcotton Yield 1991	1992	1993
	-----lb/a-----	------------------------------lb/a------------------------------		
Native	0	2261	1993	1674
Native	35	2687	2490	2483
Native	70	2775	2941	3025
Native	105	2801	2920	3093
Native	140	2627	2747	2982
Vetch	0	2769	2802	2949
Vetch	35	2666	2848	3092
Vetch	70	2757	2939	3145
Vetch	105	2801	2738	3080
Vetch	140	2807	2938	3173
Wheat	0	2398	1891	1796
Wheat	35	2473	2399	2287
Wheat	70	2661	2643	2678
Wheat	105	2772	2774	2984
Wheat	140	2936	2796	3094
Cover Crop Means Across N Rates				
Native		2630	2618	2651
Vetch		2760	2853	3087
Wheat		2648	2500	2568
N Fertilization means across cover crops				
	0	2476	2229	2139
	35	2608	2579	2620
	70	2731	2841	2949
	105	2791	2811	3052
	140	2790	2827	3083
LSD 10.05) To compare N rates within cover crop species		246	257	299
LSD (0.05) Cover crops averaged across N Rates		110	138	134
LSD (0.051 N rates averaged across cover crops		142	178	173

glyphosate 1.0 lb ai/acre) in 1991 and 1992. In 1993 paraquat (0.5 lb ai/acre) was substituted for the second application. Native winter vegetation in NT plots received an application of glyphosate (1.0 lb ai/acre) on April 24 and May 7 in 1991. In 1992 these plots received paraquat 10.5 lb ai/acre) on March 3 and glyphosate 1.0 lb/acre) on May 5. In 1993 glyphosate (1.0 lb ai/acre) was applied on April 10 followed by paraquat (0.5 lb ai/acre) on April 21.

All CT plots were disked twice on April 24, 1991 and on April 10 in 1992 and 1993. The CT plots were disked twice again 11 to14 days later and bedded with disk hippers. A reel and harrow bed conditioner was used for seedbed preparation in CT treatments.

The experimental design was a split plot in a randomized complete block design with four replications in 1991 and three replications in 1992 and 1993. Main plots were tillage systems. Sub-plots were a factorial arrangement of cover crop and N rate combinations. Plots were eight rows wide 140-inch spacing) and 45 feet in length.

Stoneville 453 cotton was planted with a John Deere 7100 planter in 1991 and 1992 and with a John Deere 7300 planter in 1993. The seeding rate for all treatments was approximately six seed per foot of row. Ripple coulters were mounted ahead of each planter unit for planting the NT treatments. Dates of planting were June 4, 1991; May 4, 1992; and May 7, 1993. In-furrow granular pesticide applicators mounted on each planter unit were used to apply aldicarb 10.5 lb ai/acre) plus Ridomil PC (10 lb product/acre) at planting.

Soil samples taken from each plot (0-6 inches) in the spring of 1991 indicated medium to high levels of P, K, Ca, and Mg. The soil pH was 6.3 and organic matter was 1.2%.

Nitrogen fertilizer was applied as 32% N urea-ammonium nitrate solution (UAN) on June 21, 1991; May 22, 1992; and May 28, 1993. Thus, applications were made from 17 to 21 days after planting. The liquid fertilizer was applied approximately 10 inches from the drill. In 1991 a surface dribble band was applied and immediately incorporated with a conservation-tillage cultivator. In 1992 and 1993 the N fertilizer was knifed-in behind a coulter at a depth of 3 inches.

The entire test was irrigated on an as-needed basis according to neutron soil moisture probe readings and visual inspection of soil cores. Total amounts of water applied in 1991, 1992, and 1993 were 6.25, 9.0, and 9.1 inches, respectively.

Preemergence weed control in all treatments consisted of broadcast applications of fluometuron (1.2 lb ai/acre) plus metolachlor (1.5 lb ai/acre) in 1991 and 1992. Fluometuron (1.2 lb ai/acre) plus pendimethalin (1.0 lb ai/acre) was used in 1993. Postemergence weed control was accomplished with two mechanical cultivations with a conservation-tillage cultivator and post-directed applications 120-inch band) of fluometuron (0.6 lb ai/acre) plus MSMA (1.0 lb ai/acre) and prometryn 0.3 lb ai/acre) plus MSMA (1.0 lb ai/acre).

The entire test area was scouted at least twice each week for insects. Recommended insecticides were used to keep all pests below economic thresholds.

All plots were defoliated on October 4, 1991; September 10, 1992; and September 17, 1993. The center four rows of each plot were harvested for seedcotton yield with a spindle picker on October 11 and 22 in 1991; September 18 and 25 in 1992; and September 24 and October 4 in 1993.

RESULTS

Cotton Yield

Seedcotton yields of NT and CT cotton averaged across cover crops and N rates were similar in 1991, 1992, and 1993 (Table 1). Furthermore, we found no significant interactions between tillage and cover crops or tillage and N rates.

Significant cover crop x N rate interactions were noted each year of the study. In 1991 cotton yield following native vegetation was increased significantly as the N rate was increased from 0 to 35 lb/acre (Table 2). No further yield increase was observed with higher N rates. In 1992 and 1993 optimum cotton yield following native vegetation was obtained with 70 lb N/acre. Each year cotton yield following native vegetation with 140 lb/acre was numerically less than the 105 lb/acre N rate.

Table 3. Effects of tillage systems on cotton maturity averaged across cover crops and N rates.

Tillage System	First Harvest 1991	1992	1993
	---%---		
Conventional-till	82.7	81.2	91.4
No-till	82.3	76.9	92.0
LSD (0.05)	NS	2.2	NS

Table 4. Effects of winter cover crops and N rates on cotton maturity averaged across tillage systems.

Cover Crop	Cotton N Fertilizer Rate	First Harvest 1991	1992	1993
	-----lb/a-----	---%---		
Native	0	80.0	84.3	93.3
Native	35	84.9	84.7	93.3
Native	70	82.6	80.3	91.2
Native	105	83.6	80.5	89.8
Native	140	80.1	80.5	90.5
Vetch	0	85.1	80.7	91.5
Vetch	35	84.2	79.7	90.3
Vetch	70	82.2	75.2	89.8
Vetch	105	81.4	77.7	90.7
Vetch	140	82.4	78.1	91.7
Wheat	0	83.1	81.0	94.3
Wheat	35	82.1	84.8	94.5
Wheat	70	81.9	17.3	92.3
Wheat	105	83.0	73.1	91.5
Wheat	140	81.0	67.2	91.0
Cover Crop Means Across N Rates				
Native		82.2	82.1	91.6
Vetch		83.1	78.4	90.8
Wheat		82.2	76.8	92.7
N Fertilization means across cover crops				
	0	82.8	82.0	93.1
	35	83.8	83.1	92.7
	70	82.3	77.6	91.1
	105	82.7	77.3	90.7
	140	81.2	75.4	91.1
LSD (0.05) To compare N rates within cover crop species		3.3	6.0	NS
LSD (0.05) Cover crops averaged across N Rates		NS	2.7	1.0
LSD (0.05) N rates averaged across cover crops		NS	3.5	1.3

Cotton following hairy vetch cover crops did not require fertilizer N in 1991, 1992, or 1993 (Table 2). These data indicate that adequate N was mineralized from the vetch residue to produce optimum yields without additional N fertilizer. Furthermore, yields of cotton following hairy vetch with 0 N were equal to yields of cotton following native vegetation or wheat cover crops with optimum levels of fertilizer N. It is interesting to note that yields of cotton following hairy vetch did not decline even with highest rates of fertilizer N. The N contribution of above ground vetch residue averaged 93, 99, and 124 lb N/acre in 1991, 1992, and 1993, respectively (Breitenbeck and Hutchinson, 1994).

In 1991 and 1993, cotton following wheat cover crops required at least 105 lb/acre of fertilizer N to produce optimum yields (Table 2). In 1992 yields of the 70, 105, and 140 lb/acre N rates were not significantly different, however, yield tended to increase numerically with increases in N rates. These data suggest that cotton following wheat cover crops may require approximately 35 lb/acre more N to produce optimum yields than cotton following native vegetation.

Maturity

Maturity of cotton was not influenced significantly by tillage systems in 1991 or 1993 (Table 3). In 1992, however, CT cotton was significantly earlier than NT; however, this difference was probably less than three or four days. Cover crop and N rate effects on earliness varied from year to year (Table 41. In most instances N fertilization rates that provided optimum yield resulted in slightly later maturity than lower N rates. Increasing N rates above the level needed to produce optimum yield usually resulted in a significant delay in maturity with no increase in yield. Although the delays in maturity measured as percent first harvest were generally quite small, considerable visual differences were apparent between N deficient, sufficient, and excessively fertilized plants. N deficient plants showed varying degrees of chlorosis as early as the first week of bloom. This was especially severe with cotton following wheat and receiving 0 N. Sufficiently N fertilized cotton following native vegetation or wheat, and cotton following vetch with 0 N fertilizer began to exhibit significant leaf chlorosis approximately 40 to 45 days after first bloom. Excessively fertilized plants remained dark green up to the time of defoliation.

Plant Height

Mature plant height of cotton was significantly greater in NT plots than CT in 1991 and 1992 (Table 5). Plant heights for both tillage regimes were similar in 1993. Cotton vegetative growth was strongly influenced by cover crops and N fertilization each year. In addition, the cover crop x N rate interaction was significant each year (Table 6). Averaged over N rates, cotton following vetch was consistently taller than cotton following native vegetation and was usually taller than cotton following wheat. This was due largely to the fact that cotton following vetch produced maximum or near maximum plant height even at 0 and 35 lb/acre of N while cotton following wheat and native vegetation produced short plants at the lowest N rates. In most instances cotton following native vegetation reached maximum plant height with either 70 or 105 lb N/acre. Cotton following wheat usually required 105 to 140 lb/acre for maximum plant growth. It is interesting to note that cotton plant height rarely exceeded 48 inches regardless of the treatment. Thus, rank vegetative growth caused by excessive N fertilization was not observed in this study as has been reported in many cotton fertilization studies where above-optimum N rates were applied. This was probably a result of several factors including the selection of a short-statured, fast fruiting cultivar and excellent insect control throughout the growing season, which allowed maximum retention of early fruiting forms.

SUMMARY

Yields of CT and NT cotton were similar each year of the study. Furthermore, interactions between tillage and cover crops and between tillage and N rates were not significant. Cotton following hairy vetch did not require any N fertilizer to produce optimum yields in this study in any of the three years. Cotton following native winter vegetation produced optimum yields with 70 to 105 lb N/acre. Cotton following wheat cover crops required approximately 35 lb/acre more N to produce optimum yield than cotton following native vegetation.

Maturity of CT and NT cotton was usually similar. In one year out of three, NT was

Table 5. Effects of tillage systems on mature plant height of cotton averaged across cover crops and N rates.

Tillage System	Mature Plant Height		
	1991	1992	1993
		inches	
Conventional-till	42.4	36.2	42.4
No-till	45.3	40.2	43.8
LSD (0.05)	1.2	1.6	NS

Tabla 6. Effects of winter cover crops and N rates on mature plant height of cotton averaged across tillage systems.

Cover Crop	Cotton N Fertilizer Rate	Mature Plant Height		
		1991	1992	1993
	lb/a		inches	
Native	0	39.9	27.2	27.7
Native	35	42.4	34.3	38.2
Native	70	43.4	38.9	44.7
Native	105	44.4	39.9	48.7
Native	140	42.1	36.8	46.3
Vetch	0	45.3	40.1	43.4
Vetch	35	43.7	40.5	47.1
Vetch	70	44.9	42.9	48.9
Vetch	105	47.0	43.6	50.1
Vetch	140	42.4	39.3	48.5
Wheat	0	41.4	27.8	27.6
Wheat	35	43.2	34.9	36.6
Wheat	70	44.9	40.8	42.9
Wheat	105	46.2	42.8	45.8
Wheat	140	46.7	43.6	49.2
Cover Crop Means Across N Rates				
Native		42.5	35.4	41.1
Vetch		44.6	41.3	47.6
Wheat		44.5	38.0	40.4
N Fertilization means across cover crops				
	0	42.2	31.7	32.9
	35	43.1	36.6	40.7
	70	44.4	40.9	45.5
	105	45.9	42.1	48.2
	140	43.7	39.9	48.0
LSD (0.05) To compare N rates within cover crop species		3.2	4.3	4.8
LSD (0.05) Cover crops averaged across N Rates		1.4	1.9	2.2
LSD (0.05) N rates averaged across cover crops		1.8	2.5	2.8

significantly later than CT. In most instances N fertilization resulted in some delay in maturity compared to no fertilization. Application of higher than optimum rates of N usually resulted in additional delays in maturity compared to optimum fertilization. Although late-season insect control was excellent in this study, it is probable that the excessively fertilized plants remained more attractive to late-season insect pests than plants with optimum or deficient N. Thus, management of N fertilizer rates to produce optimum yields and maturity may also be beneficial for minimizing late-season insect control costs and boll damage some years.

No-till cotton often produced taller plants than CT in this study. At optimum N fertilization rates, plant heights of cotton following native vegetation, vetch, and wheat were usually similar. Fertilizer N rates above those necessary to produce optimum yields did not result in excessive vegetative growth, lodging, or boll rot in this study, although, past research has demonstrated that the potential for these problems does exist.

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