EFFECTS OF TILLAGE SYSTEMS AND WINTER COVER CROPS ON YIELD AND MATURITY OF COTTON ON A LOESS SOIL IN NORTHEAST LOUISIANA

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INTRODUCTION

Cotton is the major cash crop grown on the loess soils of the Macon Ridge in northeast Louisiana. Soils of this region are typically low in organic matter and have poor physical structure due to many years of continuous row crop production. The topography of the Macor Ridge is gently undulating with maximum slopes of 3 to 5% (Martin et al., 1981). In addition, these silt loam soils are classified as highly erodible, having erodibility (K) values of 0.41 or greater, and a soil loss tolerance of 3 t/A/year. Using the universal soil loss equation (USLE), Soil Conservation Service technicians estimated that soil losses with conventional tillage on Gigger silt loam soils with slopes of 0.5 or 2.0% exceeded 7 and 16 t/A/year, respectively (Hutchinson et a1., 1991). No-till planting into killed native vegetation reduced estimated erosion on both sites by 63% compared with conventional tillage, while no-till planting into wheat cover crop residue reduced erosion by over 85%.

The major soil series of the Macon Ridge have subsoils with dense fragipans, low pH, and high concentrations of exchangeable aluminum and manganese. As a result, most crop roots are limited to the top 12 to 18 inches of soil. Drought stress limits crop yields most years due to low water holding capacities of the soils and shallow plant root development. The fertility and water holding capacity of the plow layer are usually much higher than the subsoil. Therefore, erosion of topsoil is especially damaging to long-term soil productivity. In addition, movement of soil particles with adsorbed pesticides and nutrients into surface waters poses a threat to surface water quality.

Conservation tillage includes any tillage or planting system that maintains at least 30% of the soil surface covered with plant residue after planting. These systems, which include no-till (NT), ridge-till (RT), mulch-till (MT) and various modifications, offer an effective means of reducing soil erosion by maintaining large amounts of plant residue on the soil surface. Several studies across the cotton belt have shown that cotton yields in conservation tillage systems are usually equal to or higher than conventional tillage (Bradley, 1992; Brown et al., 1985; Harman et al., 1989; Hutchinson et al., 1991; Keeling et al., 1989; Stevens et al., 1992). Furthermore, several researchers have shown that winter cover crops improved cotton performance in conservation tillage systems (Brown et al., 1985; Keeling et al., 1989), while others showed little or no benefit (Stevens et al., 1992). A combination of factors, including soil type, rainfall distribution, cover crop species, cover crop management, and cotton production practices, are probably responsible for the inconsistent cotton yield response to winter cover crops. Although winter cover crops have several beneficial effects on soils, moisture conservation resulting from increased surface residue is probably the most important (Unger, 1978; Unger and Wiese, 1979; Van Doren and Triplett, 1973).

Proper management of winter weeds and winter cover crops is essential to the success of conservation tillage systems with cotton. Poor cotton stands following winter cover crops, especially legumes like hairy vetch and crimson clover, are often a result of cutworm damage (Gaylor et al., 1984; Hutchinson et al., 1991; Leonard et al., 1992), increased incidence of seedling diseases (Rickerl et al., 1986), or dry soil conditions at planting depth (Hutchinson et al., 1991). In addition, organic allelochemicals released from legume cover crop residues may result in poor germination and cotton growth (Bradow, 1991; Bradow and Connick, 1988). Most of these problems are minimized or eliminated if cover crops and other winter vegetation are killed at least 3 weeks prior to planting. However, in most studies where stands and/or yields were adversely affected by winter cover crops, the cover crops were killed with herbicides less than 2 weeks prior to planting.

A long-term study was initiated at the LSU Agricultural Center, Macon Ridge Research Station in

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the fall of 1986 to evaluate the agronomic and economic feasibility of alternative tillage systems and winter cover crops for cotton on a highly erodible loess soil. Other goals of this study were to identify soil, environmental, and biotic factors that influence cotton response to alternative tillage systems and winter cover crops.

MATERIALS AND METHODS

A field study was conducted from 1986 through 1992 to evaluate the effects of alternative tillage systems and winter cover crops on cotton stands, maturity, and yield on a Gigger silt loam (fine-silty, mixed, thermic Typic Fragiudalf) with a 2% slope. The experimental design was a randomized complete block with a factorial arrangement of three tillage regimes and four winter cover crop treatments and four replications. Plots were eight rows (40-inch spacing) wide and 50 ft in length. Tillage regimes were conventional-till (CT), ridge-till (RT), and no-till (NT). Cover crop treatments were native vegetation, Dixie crimson clover, hairy vetch, and Florida 302 winter wheat. Treatments were maintained in the same plots each year of the study.

Cover crop seeds were broadcast into standing cotton stalks in mid-October after harvest each year. The stalks were then cut with a rotary mower. Seeding rates for the crimson clover, hairy vetch, and winter wheat cover crops were 15, 25, and 90 lb/A, respectively.

The CT plots were disked twice in early-April and again in mid-April each year. After the final disking, the CT plots were bedded with disk hippers. A reel-and-harrow bed conditioner was used for seedbed preparation immediately ahead of the planter.

The RT plots received two preplant herbicide applications each spring to kill winter annual Vegetation and/or winter cover crops. The first application was applied in early-April and the second 7 to 10 days later. In most instances, two applications of paraquat (0.5 lb ai/A) were used on the crimson clover and hairy vetch cover crops. Glyphosate (1.0 lb ai/A) followed with paraquat (05 lb ai/A) 7 to 10 days later provided excellent control of wheat cover crops and most winter annual vegetation. At planting, a modified Buffalo RT row cleaner was used to clear the vegetation from an 18- to 20-inch wide band and remove about 1 inch of soil from the center of the bed. This "row cleaning" procedure provided a smooth residue-free surface that was suitable for planting with a conventional planter.

No-till treatments received the same preplant herbicide applications described for the RT treatments. In addition, the wheat cover crop was mowed to a stubble height of 10 inches prior to planting cotton. The NT treatments were planted directly into the previous season's beds with no seedbed preparation.

All treatments were planted with a John Deere 7100 or 7300 planter. Ripple coulters were mounted on the planter for no-till planting. Stoneville 825 cotton was planted each year from 1987 through 1990. Stoneville 453 was planted in 1991 and 1992. All plots were planted in early-May at a seeding rate of 6 seed/ft row (78,400 seed/A). Aldicarh (0.5 lb ai/A), terraclor (1.0 lb ai/A), and terrazole (0.25 lb ai/A) were applied in the seed furrow at planting.

Preemergence weed control consisted of fluometuron (0.6 lb ai/A) and metolachlor (0.75 lb ai/A) applied on a 20-inch band behind the planter. Nonionic surfactant (0.5% by volume) was added to the herbicide mixture to enhance contact activity on small emerged weeds. Postemergence weed control in all treatments consisted of mechanical cultivation (usually three trips) with a conservation tillage cultivator and postemergence directed applications of fluometuron + MSMA (0.6 + 1.0 lb ai/A), and prometryn + MSMA (0.28 + 1.0 lb ai/A) applied on a 20-inch baud. The last cultivation was used to rebuild and shape the RT beds for the following growing season.

All treatments received 70 lb/A of nitrogen as 32% UAN solution applied in a dribble surface band 10 inches from the cotton row. In addition, treatments following either a wheat cover crop or native vegetation received an additional 30 lb/A of nitrogen as foliar urea or soil-applied nitrogen solution.

All plots were defoliated in mid- to late-September each year when the latest maturing treatments reached approximately 60% open bolls. The center four rows of each plot were harvested twice with a spindle picker. The first harvest was usually performed when 80 to 90% of the harvestable bolls were opened, the second about 2 weeks later. Relative differences in maturity between treatments were determined by calculating the percentage of total yield harvested at the first picking.

RESULTS AND DISCUSSION

Cotton stand density was influenced hy tillage systems each year except 1987 and 1991 (Table 1). Stands were adequate for optimum yields in all treatments each year except for several of the NT

Table 1. Effects of tillage systems and cover crops on plant population of cotton on a Gigger silt loam soil; Macon Ridge Research Station, Winnsboro, LA, 1987-1992.

		Plant Population						1987-92
Tillage System	Cover Crop	1987	1988	1989	1990	1991	1992	Mean
		plants/A x 1000						
Conventional	Native vegetation	26.0	56.2	42.6	45.6	32.6	32.0	39.2
	Crimson Clover	23.7	49.2	32.7	50.5	33.3	32.1	36.9
	Hairy Vetch	25.0	54.1	42.9	50.1	29.5	36.1	39.6
	Wheat	30.2	47.9	36.1	47.0	29.1	33.4	37.3
Ridge-Till	Native vegetation	25.2	22.1	61.5	45.4	27.8	33.5	35.9
	Crimson Clover	22.5	40.0	57.0	44.4	34.5	37.0	39.2
	Hairy Vetch	21.2	26.0	62.9	43.6	30.2	32.5	36.1
	Wheat	32.8	42.3	59.4	45.2	36.9	33.9	41.8
No-Till	Native vegetation	25.2	17.9	53.4	39.9	28.9	22.0	31.2
	Crimson Clover	26.6	9.3	62.6	34.5	27.2	23.6	30.6
	Hairy Vetch	20.6	9.5	60.3	36.9	28.0	25.4	30.1
	Wheat	31.2	31.4	55.0	44.9	34.6	20.7	36.3
Tillage means across cover crops								
Conventional		26.2	51.8	38.6	48.3	31.1	33.3	38.2
Ridge-Till		25.4	32.6	60.2	44.7	32.3	34.2	38.2
No-Till		25.9	17.0	57.8	39.0	29.7	22.9	32.1
Cover crop means across tillage systems								
	Native vegetation	25.4	32.1	52.5	43.6	29.8	29.2	35.4
	Crimson Clover	24.3	32.8	50.7	43.1	31.7	30.9	35.6
	Hairy Vetch	22.3	29.8	55.4	43.6	29.2	31.3	35.3
	Wheat	31.4	40.5	50.2	45.7	33.6	29.3	38.5
LSD (0.05) Tillage System x Cover Crops		NS	13.7	NS	NS	NS	NS	4.2
LSD (0.05) Tillage Systems		NS	6.9	8.5	3.3	NS	3.2	2.1
LSD (0.05) Cover Crops		5.4	7.9	NS	NS	NS	NS	2.4
C.V%		25.0	28.1	22.8	11.0	14.2	14.8	20.6

NS = Nonsignificant at the 0.05 probability level.

treatments in 1988. Poor stands with NT cotton following native vegetation, crimson clover, and hairy vetch in 1988 were a result of cutworm damage during the first few days after crop emergence. In addition, erosion of the NT beds during the previous winter resulted in narrow beds that were poorly suited for NT planting. Averaged over years, stands of NT cotton following native vegetation, crimson clover or hairy vetch were significantly lower than most other treatments. However, this was largely a result of poor stands with these NT treatments in 1988. In most instances from 1987 through 1992, stands of CT and RT treatments were similar to the NT treatments.

Cotton stands following native vegetation, crimson clover, and hairy vetch were usually similar. However, in 1987, 1988, and in the 1987-92 average, wheat cover crops resulted in higher cotton stand densities than other cover crop treatments. Although the tillage x cover crop interaction was statistically significant only in 1988 and in the 1987-92 average, the wheat cover crops consistently increased stands of NT and RT but had no effect on CT stands. In addition, the wheat cover crops tended to reduce the year-to-year variation in stands with the RT and NT treatments. Although the exact reasons for stand improvements with the wheat cover crop were not determined, it is likely related to beneficial mulch effects that conserved soil moisture, eliminated surface crusting, and protected the seedlings from wind and "sandblasting" injury.

Yields were significantly influenced by tillage systems each year except in 1990 (Table 2). Averaged across cover crops, yields of NT cotton were significantly higher than CT in 1989 and 1991. Conversely, CT yields were significantly higher than NT in 1988. Averaged across years, yields of NT and CT were similar. The RT treatments, with the exception of RT cotton following a wheat cover crop, generally produced lower yields than NT and CT treatments.

Although winter cover crops significantly affected cotton yield only in 1987, 1989, and 1992, yields following wheat or hairy vetch consistently averaged higher than cotton following native vegetation or crimson clover. Furthermore, cotton yield responses to cover crops, especially wheat, were larger with NT and RT compared with CT. This relationship is confirmed by the significant tillage X cover crop interactions in 1988,1989, and in the 1987-92 average. Performance of NT and RT cotton following a wheat or vetch cover crop were usually equal to or slightly higher than CT yields, while other NT and RT treatments tended to produce lower yields than CT treatments. Although growth of crimson clover was excellent in this study, cotton yields following this cover crop were usually reduced compared with native vegetation, hairy vetch, and wheat. The poor early growth of cotton following crimson clover (data not shown) suggests that toxic allelochemicals present in the clover residue may have been responsible for the poor performance of cotton following this cover crop.

Maturity (%first harvest) of cotton was influenced significantly hy tillage each year of the study (Table 3). In 1987,1990, and the 1987-92, average maturity of NT and CT cotton were similar. No-till cotton was significantly earlier than CT in 1989, 1991, and 1992. Conventional-till cotton was earlier than NT only in 1988. It is likely that the large delay in maturity of NT cotton in 1988 was a result of the poor stands in most NT treatments. Poor cotton stands often result in delayed maturity because a higher percentage of the crop is produced on vegetative branches that develop in response to low stand densities. In most instances, the differences in maturity between CT and NT were small; probably less than 3 to 4 days.

During the first 3 years of the study, RT cotton was usually later in maturity than NT or CT. This was due largely to the late maturity of RT cotton following crimson clover cover. Conversely, RT cotton following a wheat cover crop was usually earlier than other RT treatments. In 1990, 1991, and 1992, maturity of RT treatments were usually similar to NT and CT. These data suggest that under some conditions a wheat cover crop may enhance earliness of RT cotton, while crimson clover may delay maturity.

CONCLUSIONS

Research conducted on a Gigger silt loam soil from 1987 through 1992 indicates that yields and maturity of NT and RT cotton following winter wheat or hairy vetch cover crops were similar to CT. Winter wheat and hairy vetch were superior to native vegetation and crimson clover as cover crops with RT and NT cotton. Wheat cover crops generally improved stands of NT and RT cotton.

Adoption of alternative production systems that include conservation tillage and winter cover crops on highly erodible fields of the Macon Ridge offers a means of drastically reducing soil erosion without sacrificing yield. Reducing soil erosion on many fields is essential for preserving the productivity of these soils for future crop production and for reducing contamination of surface waters with sediments,

Table 2. Effects of tillage systems and cover crops on yield of cotton on a Gigger silt loam soil; Macon Ridge Research Station, Winnsboro. LA, 1987-1992.

Tillage System	Cover Crop	1987	1988	1989	1990	1991	1992	1987-92 Mean
		Lint Yield						
		lb/A						
Conventional	Native vegetation	641	827	494	681	958	701	717
	Crimson Clover	643	881	508	641	948	630	708
	Hairy Vetch	698	891	426	652	1051	710	738
	Wheat	634	780	578	695	1002	734	737
Ridge-Till	Native vegetation	564	566	396	618	964	607	619
	Crimson Clover	581	613	426	621	865	442	591
	Hairy Vetch	684	751	455	665	1010	638	700
	Wheat	667	801	674	643	977	664	738
No-Till	Native vegetation	587	605	517	637	1022	678	674
	Crimson Clover	657	424	546	650	1033	654	661
	Hairy Vetch	719	544	569	690	1151	752	737
	Wheat	733	650	701	716	1079	645	754
Tillage means across cover crops								
Conventional		654	844	501	667	990	694	725
Ridge-Till		624	683	488	637	954	588	662
No-Till		674	556	583	673	1071	682	706
cover crop means across tillage systems								
	Native vegetation	597	666	469	645	981	662	670
	Crimson Clover	628	639	493	637	948	575	654
	Hairy Vetch	700	729	483	669	1071	700	725
	Wheat	678	744	651	684	1019	681	743
LSD (0.05) Tillage System x Cover Crops		NS	161	77	NS	NS	NS	41
LSD (0.05) Tillage Systems		39	80	38	NS	81	61	20
LSD (0.05) Cover Crops		46	NS	44	NS	NS	70	24
C.V%		8	16	10	8	11	13	10

NS = Nonsignificant at the 0.05 probability level.

Table 3. Effects of tillage systems and cover crops on earliness of cotton on a Gigger silt loam soil; Macon Ridge Research Station, Winnsboro, LA, 1987-1992.

Tillage System	Cover Crop	First Harvest 1987	1988	1989	1990	1991	1992	1987-92 Mean
		---	---	---	%	---	---	---
Conventional	Native vegetation	92	90	66	95	80	84	84
	Crimson Clover	92	93	71	95	a7	a7	87
	Hairy Vetch	92	92	67	95	a5	85	86
	Wheat	91	91	81	96	81	a4	a7
Ridge-Till	Native vegetation	76	80	59	94	a5	87	80
	Crimson Clover	70	78	62	94	86	aa	79
	Hairy Vetch	75	a2	68	94	a7	aa	a2
	Wheat	82	a2	80	94	81	86	a4
No-Till	Native vegetation	a4	80	78	93	a5	a7	a4
	Crimson Clover	92	77	79	94	a7	89	86
	Hairy Vetch	93	78	a2	96	90	aa	a7
	Wheat	92	76	a2	94	aa	a7	86
Tillaae means across cover crops								
Conventional		92	91	71	95	a3	a5	86
Ridge-Till		76	81	67	94	a5	a7	81
No-Till		90	78	80	94	aa	aa	86
Cover crop means across tillaae systems								
	Native vegetation	a4	a3	68	94	a3	86	a3
	Crimson Clover	85	a2	71	94	86	88	84
	Hairy Vetch	86	a4	72	95	a7	a7	a5
	Wheat	88	a3	81	95	a3	86	86
LSD (0.05) Tillage System x Cover Crops		NS	NS	8	NS	NS	NS	NS
LSD (0.05) Tillage Systems		5	3	4	0.8	3	1.8	1.4
LSD (0.05) Cover Crops		NS	NS	4	NS	3	NS	1.6
C.V%		8.1	4.5	7.4	1.2	4.8	2.8	5.9

NS = Nonsignificant at the 0.05 probability level.

fertilizer nutrients, and pesticides. It should be noted, however, that these systems are more management intensive than the production systems currently being used by most cotton producers. Furthermore, cost of production may be higher for some conservation systems compared with CT because of cover crop establishment cost and increased herbicide requirements. Current and future research aimed at developing more effective and economical weed control systems for cotton in conservation tillage systems should greatly enhance the acceptability and profitability of these systems,

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