TILLAGE AND COVER CROP EFFECTS ON COTTON GROWTH, YIELD AND SOIL ORGANIC MATTER

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Abstract

Soils in the Macon Ridge area of Louisiana are typically low in organic matter, have poor physical structure, and are highly erodible. This study was conducted to determine the effects of tillage and cover crops on cotton growth, yield, and soil organic matter. The study was conducted from 1987 through 1996 on a Gigger silt loam soil (fine-silty, mixed, thermic Typic Fragidaulf). Tillage systems were conventional-till (CT), ridge-till (RT), and no-till (NT). Winter cover crops were native vegetation, crimson clover, hairy vetch, and wheat. At 30 days after planting, cotton plants were taller and had more nodes in NT than in RT and CT systems. Plant growth rate in CT was reduced compared with NT and RT as shown by a smaller NAWF at July 5 and 18 and TIL at July 18. From 1991 through 1993, NT cotton yielded 829 lb lint per acre, while RT yielded 703 lb lint per acre and CT yielded 779 lb lint per acre. Cotton following crimson clover yielded less than cotton following wheat, vetch, or native vegetation. From 1994 through 1996, NT cotton yielded 979 lbs lint per acre, while RT yielded 844 lb lint per acre and CT yielded 921 lb lint per acre. Cotton following wheat yielded 981 lb lint per acre while cotton following vetch yielded 824 lb lint per acre and cotton following native vegetation yielded 938 lb lint per acre. After six years of conservation tillage, soil organic matter had more than doubled in all treatments from an initial value of 0.5% to 1.2% due to a reduction in tillage intensity. After 10 years, NT and wheat plots had the highest levels of soil organic matter. Adoption of NT practices and winter cover crops in the Macon Ridge area of Louisiana would increase yields of cotton while minimizing soil erosion.

Introduction

Cotton is grown extensively in the Macon Ridge Area of Louisiana. This region has undulating topography and loess soils that are classified as highly erodible (Martin et al., 1981). Soil erosion has already reduced the productivity of these soils and is a continuing threat to further reduce long-term productivity. Conservation tillage systems that maximize surface residue are among the most effective and economical practices for reducing soil erosion on erodible cropland (Hutchinson, 1993). In addition to crop residue, cover crop mulches are also effective for erosion control and to conserve soil water for crop use (Unger and Weise, 1979).

Objectives

The objectives of this study were to: (1) determine the growth and yield responses of cotton to conservation tillage practices and winter cover crops and (2) determine the effects of tillage and winter cover crops on soil organic matter.

Materials and Methods

A field study was conducted from 1987 through 1996 at the Macon Ridge Research Station in Winnsboro on a Gigger silt loam soil (fine-silty, mixed, thermic Typic Fragidaulf). Four cover crops - winter wheat, hairy vetch, crimson clover and native vegetation - were evaluated across three tillage systems - conventional-till (CT), ridge-till (RT), and no-till (NT). The experimental design was a factorial arrangement of tillage and cover crops in a randomized complete block with four replications. Plots were 8 rows (40-inch spacing) 50 feet in length. All treatments have been maintained in the same location since 1987. The test was not irrigated.

The crimson clover (15 lb/a), hairy vetch (25 lb/a), and wheat (90 lb/a) were broadcast seeded into the standing cotton stalks between mid-October and early-November each year. The cotton stalks were shredded with a rotary mower after the cover crops were seeded.

The CT treatments were disked twice in early-April and twice again in late April each year. Following the final disking, the CT plots were bedded with disk hippers. A reel and harrow bed conditioner was used for final seedbed preparation.

The NT and RT wheat and native vegetation treatments received a burndown application of glyphosphate (Roundup) at 1.0 lb ai/a in early-April and paraquat dichloride (Gramoxone Extra) at 0.5 lb ai/a in late-April. The NT and RT crimson clover and hairy vetch treatments received burndown applications of paraquat dichloride (Gramoxone Extra) at 0.5 lb ai/a in early-April and again in late-April.

No seedbed preparation was used in the NT plots; however, ripple coulters were mounted ahead of each planter unit for planting the NT treatments. In the RT plots, a Buffalo® row cleaner was used to clear the residue and approximately one inch of soil from the top of the beds prior to planting. Cotton was planted in all plots in early May with in-furrow treatments of aldicarb (Temik) at 0.5 lb ai/a and pentachloronitrobenzene + 5-Ethoxy-3-(trichloromethyl)-1,2,4 thiadiazole (Terrachlor Super X) at 1.0 + 0.25 lb ai/a.

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Preemerge weed control in all plots consisted of a broadcast application of pendimethalin (Prowl) at 1.0 lb ai/a plus fluometuron (Cotoran) at 1.2 lb ai/a. All CT and RT treatments were cultivated twice and received banded post-emergence applications of fluometuron (Cotoran) plus MSMA (0.6 + 1.0 lb ai/a) and prometryn (Caparol) plus MSMA (0.31 + 1.0 lb ai/a). No-till plots were similarly cultivated from 1987 through 1994, but were not cultivated in 1995 and 1996. Ridging wings were attached to the cultivator to rebuild the beds in the RT plots at the last cultivation. Post-emergence weed control in the NT plots consisted of a post-directed application of fluometuron (Cotoran) plus MSMA (0.6 + 1.0 lb ai/a) followed by broadcast application of prometryn (Caparol) plus MSMA (0.62 + 2.0 lb ai/a) applied beneath the cotton plants. All plots received a layby application of cyanazine (Bladex) at 1.1 lb ai/a plus MSMA (1.65 lb ai/a).

In late May each year, all plots received 75 lbs N as 32% UAN solution either as a dribble band approximately 10 inches from the drill, or as a knifed application approximately 3 inches deep and 10 inches from the drill. The test was checked twice weekly for insects and appropriate insecticide applications made whenever any pest insect populations reached threshold numbers. The entire test was defoliated in late-August or early-September each year, usually with thidiazuron (Dropp) at 0.05 lb ai/a plus tribuphos (Def) at 0.6 lb ai/a.

A spindle picker was used to harvest the four center rows of each plot. Boll samples were hand picked from border rows and laboratory-ginned to provide a lint percentage. The lint percent was used to calculate the lint yield by multiplying machine-picked seedcotton yields by the laboratory-derived lint percentages. Ten plants per plot were measured for plant height and number of mainstem nodes. From 1994 through 1996, plant measurements were expanded to include nodes above white flower (NAWF), and terminal internode length (TIL) at several dates during the cotton growing season. Soil samples were collected from each plot after harvest and analyzed for nutrients and organic matter content by the Louisiana State University Agronomy Department Soils Laboratory.

All data were analyzed using the ANOVA or GLM procedures of SAS (SAS Institute, 1989). The protected LSD (P=0.05) test was used for mean separation.

Results and Discussion

Plant Growth

Plant height and number of mainstem nodes were significantly affected by tillage but not by cover crops or tillage x cover crop interaction, when averaged across years (Tables 1and 2). At 30 days after planting (DAP), cotton plants were taller and had more nodes in NT than in RT and CT systems. At early-and mid-bloom dates, NAWF was significantly affected by tillage and cover, but not by tillage x cover crop interactions. Plant growth rate in CT was reduced compared with NT and RT as shown by the smaller NAWF at July 5 and 18 and TIL at July 18.

Yield

In the initial year of the study (1987), yields in NT were significantly higher than in RT treatments but were not different from CT (Table 3). Cotton following hairy vetch or wheat cover crops yielded significantly higher than when following crimson clover or native vegetation.

From 1988 through 1990, lint yield was not affected by tillage system, cover crop, or interactions. From 1991 through 1993, tillage had an effect on lint yield with NT yielding higher than CT or RT. Cover crops also affected lint yield as yields of cotton following crimson clover were consistently lower than for cotton following vetch or native cover.

From 1994 through 1996, NT cotton yielded significantly higher than cotton planted with other tillage systems. Cotton following the wheat cover crop yielded significantly higher than cotton following vetch or native cover crops (Table 4). The tillage by cover crop interaction for lint yield was not significant throughout the study.

Soil Organic Matter

The initial soil organic matter levels for the test area averaged less than 0.5%. Within four years, organic matter had almost doubled in each treatment because of the reduction in tillage intensity for all treatments (Tables 5 and 6). From 1988 through 1996, NT cotton plots increased soil organic matter more rapidly than CT or RT (Table 5). After 10 years, NT and wheat plots had the highest levels of soil organic matter.

Conclusions

Cotton plant height, number of mainstem nodes and NAWF were higher in NT than in CT. Lint yield of cotton was increased by NT treatments and/or by using wheat as a winter cover crop. Soil organic matter content was increased primarily by reduction in tillage intensity and secondarily by growing a wheat cover crop. Adoption of NT practices and winter cover crops in the Macon Ridge Area of Louisiana would increase yields of cotton while minimizing soil erosion.

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Table 1. Effects of tillage systems and cover crops on cotton plant growth on a Gigger silt loam soil; Macon Ridge Research Station, Winnsboro, LA, 1994-96.

	Plant Height 30 DAP	Nodes 30 DAP	NAWF		Terminal Internode Length	
	1994-96	1994-96	7/5/96	7/18/96	7/5/96	7/1896
	-inches-	-number-	-----number-----		-----inches------	
Tillage means across cover crops						
Conventional-Till	11	7.6	6.6	3.3	2.6	1.5
Ridge-Till	9	7.0	7.2	4.6	2.4	1.8
No-Till	12	8.5	7.6	4.3	2.7	1.7
Cover crop means across tillage systems						
No Cover Crop	10	7.4	7.3	4.2	2.6	1.7
Crimson Clover	11	7.7	6.9	3.9	2.6	1.6
Hairy Vetch	11	7.9	7.2	4.1	2.5	1.7
Wheat	11	7.7	7.1	4.1	2.6	1.7
LSD (0.05) Tillage System	1	0.3	0.3	0.3	0.1	0.1
LSD (0.05) Cover Crops	NS	NS	0.3	0.4	0.1	0.1
C.V. (%)	9	5	6	9	4	5

Table 2. Effects of tillage systems and cover crops on cotton plant growth on a Gigger silt loam soil; Macon Ridge Research Station, Winnsboro, LA, 1994-96.

	Plant Height 30 DAP	Nodes 30 DAP	NAWF		Terminal Internode Length	
Cover Crop	1994-96	1994-96	7/5/96	7/18/96	7/5/96	7/18/96
	inches-	number-	-----number-----		---inches--	
Conventional-Till						
No Cover Crop	11	7.5	6.6	3.4	2.7	1.5
Crimson Clover	11	7.9	6.4	2.9	2.5	1.4
Hairy Vetch	11	7.7	6.6	3.3	2.6	1.4
Wheat	10	7.2	6.6	3.5	2.6	1.6
Ridge-Till						
No Cover Crop	9	6.7	7.6	4.6	2.5	1.8
Crimson Clover	9	7.1	6.8	4.5	2.5	1.6
Hairy Vetch	9	7.0	7.3	4.8	2.3	1.8
Wheat	9	7.0	7.2	4.5	2.6	1.8
No-Till						
No Cover Crop	11	7.9	7.6	4.5	2.7	1.7
Crimson Clover	12	8.2	7.4	4.2	2.7	1.7
Hairy Vetch	13	8.9	7.8	4.3	2.6	1.7
Wheat	14	8.8	7.6	4.3	2.7	1.8
LSD (0.05) Tillage System x Cover Crop	NS	NS	NS	NS	0.2	0.2
C.V. (%)	9	5	6	9	4	5

Table 3. Effects of tillage systems and cover crops on cotton lint yield on a Gigger silt loam soil, Macon Ridge Research Station, Winnsboro, LA, 1987-96.

	Lint Yield			
	1987	1988-90	1991-93	1994-96
	----------lb/acre----------			
Tillage means across cover crops				
Conventional-Till	654	671	779	921
Ridge-Till	624	602	703	844
No-Till	674	604	829	979
Cover crop means across tillage systems				
No Cover Crop	597	593	767	938
Crimson Clover	628	590	711	815
Hairy Vetch	700	627	801	924
Wheat	678	693	802	981
LSD (0.05) Tillage Systems	39	NS	37	35
LSD (0.05) Cover Crop	46	NS	42	41
C.V. (%)	8	16	6	5

Table 4. Effects of tillage systems and cover crops on cotton lint yield on a Gigger silt loam soil, Macon Ridge Research Station, Winnsboro, LA, 1987-96.

	Lint Yield			
	1987	1988-90	1991-93	1994-96
	----------lb/acre----------			
Conventional-Till				

No Cover Crop	641	667	781	957
Crimson Clover	643	677	731	842
Hairy Vetch	698	656	794	927
Wheat	634	684	811	958
		Ridge-Till		
No Cover Crop	564	527	718	871
Crimson Clover	581	553	605	727
Hairy Vetch	684	624	732	849
Wheat	667	706	756	928
		No-Till		
No Cover Crop	587	586	802	987
Crimson Clover	657	540	798	875
Hairy Vetch	719	601	877	997
Wheat	733	689	838	1056
LSD (0.05)				
TillageSystems x Cover Crops	NS	NS	NS	NS
C.V. (%)	8	16	6	5

Table 5. Effects of tillage systems and cover crops on soil organic matter on a Gigger silt loam soil, Macon Ridge Research Station, Winnsboro, LA, 1987-96.

	Organic Matter			
		0-6" Depth		0-3" Depth
	1987	1988-91	1992-95	1992-96
	----------%----------			
	Conventional-Till			
No Cover Crop	0.47	0.83	1.14	1.22
Crimson Clover	0.44	0.78	1.21	1.36
Hairy Vetch	0.50	0.91	1.21	1.33
Wheat	0.46	0.86	1.30	1.42
	Ridge-Till			
No Cover Crop	0.48	0.80	1.08	1.34
Crimson Clover	0.53	0.90	1.18	1.49
Hairy Vetch	0.50	0.92	1.20	1.51
Wheat	0.57	0.98	1.27	1.58
	No-Till			
No Cover Crop	0.54	0.99	1.20	1.65
Crimson Clover	0.48	0.99	1.23	1.65
Hairy Vetch	0.46	0.97	1.27	1.67
Wheat	0.49	1.00	1.26	1.61
LSD (0.05)				
Tillage Systems x Cover Crops	NS	NS	NS	S
C.V. (%)	16	11	7	12

Table 6. Effects of tillage systems and cover crops on soil organic matter on a Gigger silt loam soil, Macon Ridge Research Station, Winnsboro, LA, 1987-96.

	Organic Matter			
		0-6" Depth		0-3" Depth
	1987	1988-91	1992-95	1992-96
	----------%----------			
	Tillage means across cover crops			
Conventional-Till	0.46	0.84	1.22	1.33
Ridge-Till	0.52	0.90	1.19	1.48
No-Till	0.49	0.98	1.24	1.65
	Cover crop means across tillage systems			
No Cover Crop	0.50	0.87	1.14	1.41
Crimson Clover	0.48	0.89	1.21	1.50
Hairy Vetch	0.49	0.93	1.23	1.50
Wheat	0.50	0.94	1.28	1.54
LSD (0.05)				
Tillage Systems	NS	0.07	NS	0.11
LSD (0.05)				
Cover Crop	NS	NS	0.07	NS
C.V. (%)	16	11	7	12