# Tillage and Cover Crops Affect Cotton Growth and Yield and Soil Organic Matter

*D. J. Boquet, R. L. Hutchinson, W. J. Thomas, and R.E.A. Brown

ABSTRACT

The loess soils in the mid-Southern USA are easily eroded, drought prone, and have low organic matter and poor physical structure Without irrigation, crop yields are low. Conservation tillage and winter cover crops can reduce erosion and increase soil organic matter, thereby improving the soil's physical structure. This study was conducted to determine the effects of tillage intensity and cover crops on cotton *(Gossypium hirsutum)* growth, yield, and soil organic matter. A field experiment was conducted from 1987 through 1996 on Gigger silt loam (fine-silty, mixed, thermic Typic Fragidaulf) with three tillage systems and four winter cover crops. Tillage systems were conventional-till (CT), ridge-till (RT), and no-till (NT), Winter cover crops were native vegetation, crimson clover *(Trifolium incarnatum)*, hairy vetch *(Vicia villosa)*, and wheat *Triticum aestivum)*. At 30 d after planting, cotton plants in NT were 9 to 33% taller with 12 to 21% more nodes than in CT and RT systems. Plant growth rate in CT was reduced compared with NT and RT as shown by 15% smaller nodes after white flower (NAWF) and 30% shorter terminal internode length (TIL) in July. From 1991through 1993, NT cotton yielded 829 lb lint/a. which was 18% higher than RT and 6% higher than CT. Cotton following crimson clover consistently yielded 10 to 20% less than cotton following vetch or wheat. From 1994 through 1996, NT cotton yielded 979 Ibs lint per acre, which was 16% higher than RT and 6% higber than CT. Per acre lint yield following wheat was 981 lb; following vetch; 924 lb and following native vegetation, 938 lb. After 6-yr of conservation tillage, soil organic matter had more than doubled in all treatments from an initial value of 0.5%. due to a reduction in tillage intensity. After 10-yr, 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.

D.J. Boquet, R.L. Hutchinson, W.J. Thomas, and R.E.A. Brown. Louisiana State University Agricultural Center, Winnsboro, and St. Joseph, LA. Manuscript received 3 March 1997. *Corresponding author.

## INTRODUCTION

Cotton *(Gossypium hirsutum* L.) 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 threatens 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). 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 19% at the Macon Ridge Research Station in Winnsboro on a Gigger silt loam soil (fine-silty, mixed, thermic Typic Fragiudalf). The site chosen for the experiment was on a field with a 1.6% slope that had experienced considerable erosion. Four cover crops (winter wheat *(Triticum aestivum* L.), hairy vetch *(Vicia villosa* L.), crimson clover *(Trifolium incarnatum* L.), and native vegetation) were evaluatd across three tillage systems of 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 eight rows (40-in. spacing), 50 ft in length. All treatments have been miantained 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. Fall tillage was not used in this study, although this was a common practice for many years on this field and on farms in the area at the time this study was initiated.

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 bumdown 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 modified 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.

Preemerge weed control in all plots consisted of a broadcast application of pendimethalin (Prowl) at 1.0 lb ai/a plus fluometruon (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). Ridging wings were attached to the cultivator to rebuild the beds in the RT plots at the last cultivation. From 1987 through 1993, postemergence weed control in NT plots was the same as for CT and RT. From 1994 through 1996, the NT plots were not cultivated but received 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 yr, all plots received 70 lb N/a as 32% UAN solution either as a dnbble band approximately 10 in. from the drill, or as a knifed application approximately 3 in. deep and 10 in. from the drill. An additional 30 lb N/a was sidedress applied to wheat and native vegetative plots in June. 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) (the average internode length above the NAWF) 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 1 and 2). At 30 d 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 5 July and 18 July and TIL at 18 July.

### 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 (Tables 3 and 4). 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. Cotton following wheat was higher yielding than when following other cover crops. During the 1991 through 1993 and 1994 through 1996 periods, tillage had an effect on lint yield with NT yielding higher than CT or RT. Cover crops also affected lint yield during this period, as yields of cotton following crimson clover were consistently lower than for cotton following vetch or native cover. During the 1991-1993 period, cotton following wheat and hairy vetch yielded similarly, but during the next three years, cotton following wheat was higher-yielding than cotton following any other cover crop.

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. The advantage of the wheat cover crops is probably related to the protection provided seedling cotton from rapid temperature changes and to water conservation (Unger and Weise, 1979). The consistent reduction in yield of cotton following Crimson clover was possibly caused by allelopathic effects of the clover on cotton (Bradow, 1991) although this did not evidence itself in any of the measured plant growth parameters.

### Soil Organic Matter

The initial soil organic matter levels for the test area averaged less than 0.5%. Within four yr, organic matter had almost doubled in each treatment because of the reduction in tillage intensity for all treatments (Tables 5 and 6). This included the CT treatment, as tillage (especially fall tillage) in this treatment was reduced from that occurring prior to initiation of the study in 1987. From 1988 through 1996, NT cotton plots increased soil organic matter more rapidly than CT or RT (Table 5). The greatest benefit in conserving organic matter was with NT where no cover crop was planted. Planting winter cover crops increased soil organic matter but this effect was not as large as the tillage effect

## 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 winter 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. Tillage and cover crop effects on cotton plant growth on a Gigger silt loam - Winnsboro, LA.**

| | Plant Height 30 DAP[1] | Nodes 30 DAP | NAWF[2] | | Terminal Internode Length | |
|---|---|---|---|---|---|---|
| | 1994-96 | 1994-96 | 7/5/96 | 7/18/96 | 7/5/96 | 7/18/96 |
| | --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 | 7.1 | 7.1 | 4.1 | 2.6 | 1.7 |
| LSD (0.05) Tillage | 1 | 0.3 | 0.3 | 0.3 | 0.1 | 0.1 |
| LSD (0.05) Cov Crop | NS | NS | 0.3 | 0.4 | 0.1 | 0.1 |
| C.V. (%) | 9 | 5 | 6 | 9 | 4 | 5 |

[1]DAP = days after planting
[2]NAWP = nodes above white flower

**Table 2. Tillage and cover crop effects on cotton plant growth on a Gigger silt loam - Winnsboro, LA.**

| | Plant Height 30 DAP[1] | Nodes 30 DAP | NAWF[2] | | Terminal Internode Length | |
|---|---|---|---|---|---|---|
| | 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 x Cov | 1.4 | 0.6 | 0.6 | 0.5 | 0.2 | 0.2 |
| C.V. (%) | 9 | 5 | 6 | 9 | 4 | 5 |

[1]DAP = days after planting
[2]NAWF = nodes above white flower

**Table 3. Tillage and cover crop effects on cotton lint yield on a Gigger silt loam - Winnsboro, LA.**

| | Lint Yield | | | |
|---|---|---|---|---|
| | 1987 | 1988-90 | 1991-93 | 1994-96 |
| | ------------------- | lb/a | ------------------- | |
| | | Tillaee 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 | 39 | 45 | 37 | 35 |
| LSD (0.05) Cov Crop | 46 | 52 | 42 | 41 |
| C.V. (%) | | | | |

**Table 4. Tillage and cover crop effects on cotton lint yield on a Gigger silt loam - Winnsboro, LA.**

| | Lint Yield | | | |
|---|---|---|---|---|
| | 1987 | 1988-90 | 1991-93 | 1994-96 |
| | | | lb/a ------------------- | |
| | | 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 | 581 | 586 | 802 | 987 |
| Crimson Clover | 657 | 540 | 798 | 875 |
| Hairy Vetch | 719 | 601 | 877 | 997 |
| Wheat | 733 | 689 | 838 | 1056 |
| LSD (0.05) Till x Cov Crop | 78 | 82 | 61 | 59 |
| C.V. (%) | 8 | 16 | 6 | 5 |

**Table 5. Tillage and cover crop effects on organic matter content of a Gigger silt loam - Wmnsboro, LA.**

| | Lint Yield | | | |
|---|---|---|---|---|
| | | 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) Till x Cov Crop | NS | 0.14 | 0.11 | 0.25 |
| C.V. (%) | | | | |

**Table 6. Tillage and cover crop effects on organic matter content of a Gigger silt loam - Winnsboro, LA.**

| | 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 | 1.25 | 1.54 |
| LSD (0.05) Tillage | NS | 0.07 | NS | 0.11 |
| LSD (0.05) Cov Crop | NS | NS | 0.07 | NS |
| C.V. (%) | 16 | 11 | 7 | 12 |