COTTON YIELD AND GROWTH RESPONSES TO TILLAGE AND COVER CROPS ON SHARKEY CLAY

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INTRODUCTION

A large portion of the crop land in the humid mid-South is made up of soils with a high clay content. Because of their unique physical characteristics, low organic matter content, and slow internal and surface drainage, these clayey soils require specific management techniques to produce profitable cotton yields. The most important of these is tillage practices.

Tillage of clay soils in the mid-South can have either beneficial or detrimental effects. Tillage can be important for weed control and is necessary to build raised beds that improve surface drainage. Rapid surface drainage is needed for good growth of a winter cover crop. Raised beds also provide a better aerated and warmer seedbed that allows earlier planting and enhances early-season cotton development. If needed tillage procedures are completed in the fall, such practices have no apparent ill effects on cotton production. Tillage in the spring, however, often delays planting because, after the wet winter months, clay soils are slow to dry, and large clods are formed by normal tillage procedures of disking and bedding up. Several inches of rain and additional tillage are needed to restore soil moisture and structure before planting. Thus, the degree of effectiveness in providing beneficial results as opposed to detrimental results is largely reliant upon timing of the tillage procedures so that the need for extensive tillage in the spring is circumvented.

The continuing development of reduced tillage systems that include the use of preemergent and postemergent herbicides in lieu of preplant soil incorporated herbicides has greatly reduced the need for potentially harmful spring tillage (Crawford, 1992; Hutchinson et al., 1991; Reynolds, 1990). These effective and economical herbicides applied before and after planting has made possible new management techniques for clay soils, such as the formation of beds in the fall or late winter, which are then planted with limited or no tillage in the spring (Crawford, 1992; Boquet and Coco, 1991; Reynolds, 1990; Elmore and Heatherly, 1988). These reduced tillage systems have greatly enhanced the opportunities for producing cotton successfully on clay soils in the mid-South. Morrison et al. (1990) developed and evaluated no-till systems, such as raised permanent wide-beds and controlled-traffic patterns, that resulted in crop yields similar to, or better than, those for conventional tillage on the Vertisols of the central Texas Blackland Prairie.

One of the major problems with extensively row cropped clay soils in the mid-South is the low content of organic matter in the soil. Use of year-round cropping systems, such as hairy vetch followed by grain sorghum or wheat-soybean double-cropping, have been used to reverse the organic matter depletion that results from continuous row cropping of clay soil (Boquet and Hutchinson, 1992). There is, however, little information in the literature about the influence of a winter cover crop on the soil organic matter of clay land used for cotton production.

In addition to having positive effects on soil organic matter, winter legume cover crops can accumulate large quantities of N (Boquet and Dabney, 1991; Oyer and Touchton, 1988; Rickerl and Touchton, 1986). On silt loam soils, a legume cover crop can replace one-half to two-thirds of the total inorganic fertilizer N needs of a cotton crop (Hadden, 1953; Breitenbeck, et al., 1989, Touchton and Reeves, 1988). However, the fertilizer N requirement on clay soil is 30 to 40% greater than on silt loam (Maples et al., 1992). Further, there is no information on the potential N loss by denitrification or other mechanisms in clay soil managed with different cover crop species and seedbed preparation systems. It is, thus, unclear what influence legume-fixed N will have on cotton production on clay, and therefore, to what extent the use of fertilizer N can be reduced.

The objectives of this study were to: 1) compare two reduced tillage systems (no-till and ridge-till) with conventional spring tillage procedures for yield and growth of cotton and 2) determine the influence of a winter cover crop on cotton yield, soil organic matter content, and fertilizer N requirements of cotton.

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MATERIALS AND METHODS

These experiments were conducted on Sharkey clay at the Northeast Research Station near St. Joseph, Louisiana. The tillage plots were initially established in the fall of 1987. The tillage treatments were no-till, ridge-till, and conventional-till. The first cover crop of hairy vetch was planted in the fall of 1988. Each tillage plot consisted of 16 rows 120 ft in length. Row spacing was 40 inches. The tillage plots were divided into two 8-row cover crop subplots of: 1) hairy vetch or 2) no cover crop (native vegetation). The experiment was conducted with the two treatments of tillage and cover crop for 3 years, 1988 through 1990, under a uniform N rate of 110 lb/A. In 1991, the experiment was modified and N rate was added as a third variable. Two N rates were applied to subplots of the cover crop treatments - the normal rate for this soil type of 110 lb/A and, in addition, a reduced rate of 80 lb/A. The N was applied about 2 weeks after planting as a surface broadcast application of ammonium nitrate. The experiment was planted in a randomized complete block design with four blocks. Tillage regimes were on main plots, cover crops on sub plots, and N rates on sub-sub plots.

Spring ridge-till procedures were done with a Buffalo Ridge Runner equipped with residue clippers and sweeps. Conventional tillage consisted of two spring diskings, bedding with hipper, and smoothing with a reel and harrow row conditioner. All treatments received two cultivations with a Buffalo model 4630 All-Flex cultivator at about 4 and 6 weeks after planting in conjunction with post-directed herbicides. This equipment was also used in no-till and ridge-till treatments to rebuild beds in the fall of each year prior to stalk shredding. No fall procedures were done on the conventional-till plots except stalk shredding.

All of the no-till plots were treated with burndown applications of 0.47 lb/A Gramoxone [Paraquat dichloride (l,l'-dimethyl-4,4'-bypridinium dichloride)] in early April. Only one application was needed to kill the vegetation in the native cover plots. Hairy vetch plots were retreated 7 to 10 days later for complete kill of vegetation. All plots were planted with a John Deere 7300 planter as soon after April 15 as soil moisture and seedbed conditions were favorable for planting. No-till and ridge-till plots were planted on 21 April 1989, 24 April 1990, 15 May 1991, and 23 April 1992. The conventional-till plots were planted on 7 May 1989, l May 1990, 24 May 1991, and 23 April 1992. Thus, in 1 of 4 years, the conventional-till treatment was planted on the same date as the no-till and ridge-till treatments. In the other 3 years, seedbed preparation delayed planting of the conventional-till treatment. Deltapine 90 was planted from 1989 through 1991, and Deltapine 5415 was planted in 1992.

In addition to the burndown treatments, weeds were controlled with preemerge applications of fluometuron [l,l-dimethyl-3-(a,a,a-trifluoro-*m*-tolyl) urea] and metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-N-(2-methoxy-l-methyl-ethyl) acetamide] and postemerge applications of fluometuron and MSMA (monosodium acid methanearsonate). Fluazifop-P-butyl {Butyl(R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl] oxy]phenoxy]propanoate} was applied overtop in spot treatments for grass control.

Insects were controlled with an in-furrow application of aldicarb {aldicarb[2-methyl-2-(methy1thio)propionaldehyde *0*-(methylcarbamoyl) oxime]} and season-long applications of several labeled foliar-applied insecticides on an as-needed basis. Seedling diseases were controlled with an in-furrow application of Terraclor Super X {Pentachloronitrobenzene; 5-Ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole; Disulfoton: O,O-Diethyl S-[2-(ethylthio) ethyl] phosphorodithioate}.

Cotton was defoliated on an individual treatment basis when at least 60% of the bolls were open by applying Def 6 (S,S,S-Tributyl phosphorotrithioate) and ethephon (2-Chloroethyl) phosphonic acid. Two rows of each plot were mechanically harvested with a John Deere 9910 cotton picker adapted for small plot harvest to determine seedcotton yield/A.

RESULTS

Yield

In 1989, cotton in all but one of the tillage treatments produced similar yields of about 2500 lb seedcotton/A (Table 1). The conventional-till with native cover was an exception that yielded significantly less seedcotton than all other tillage-cover crop treatments. The hairy vetch cover crop, however, increased the yield of the conventional-till treatment by 600 lb seedcotton/A so that its yield was similar to the no-till and ridge-till treatments. It seems plausible that the 17-day delay in planting of the conventional-till would have had a negative influence on yield. It is not known why the cover crop, which had no effect on the yield of the no-till and ridge-till treatments, increased the yield of the conventional-till treatment by such a substantial amount.

In 1990, differences in yield among tillage treatments were not significant, and within the no-till and ridge-till treatments, cover crop did not significantly increase the yield of cotton. The conventional-till with native cover, which had yielded lowest in 1989, was again the lowest yielding treatment in 1990. Its yield was significantly lower than all treatments except ridge-till with native cover. As in 1989, the vetch cover crop significantly increased the yield of cotton in the conventional-till treatment only.

Nitrogen rate did not have a significant influence on yield in 1991 or 1992, and the tillage-by-N rate and cover crop-by-N rate yield interactions were not significant. This suggests that, to determine the contribution of legume N in reducing the N requirements for cotton, the N rates in this study should be lower than those used in this study in 1991 and 1992. In the following results and discussion, the effects of tillage and cover crop for 1991 and 1992 are reported averaged across N rates.

The average yield of cotton in the ridge-till treatment in 1991was significantly higher than both the no-till and conventional-till. This was the first year in which tillage had an effect on cotton yield. As in previous years, the vetch cover crop did not significantly influence the yield of cotton in no-till and ridge-till treatments. In contrast with previous years' results, the yield of cotton in the conventional-till treatment was not increased by the vetch cover crop.

In 1992, the tillage treatments had a significant effect on cotton yield. In treatments where no cover crop was planted, the yield of cotton in conventional-till was significantly higher than in either no-till or ridge-till. With a vetch cover crop, results were somewhat different, and both ridge-till and conventional-till produced higher yields than no-till. Under each of the three tillage regimes, a winter vetch cover crop significantly increased yields compared with the native winter vegetation.

Plant height

In each year, plant height was affected significantly by tillage and by cover crop. The differences among treatments were smallest in 1990 (only 1 inch) and largest in 1989.

In 1989, the tallest plants were produced in conventional-till even though the planting date was 16 days later than no-till and ridge-till (Table 2). The vetch cover crop had an additional stimulatory effect on growth of cotton in conventional-till. The improved growing conditions imparted by the cover crop were reflected in the large yield increase in the vetch cover crop treatment compared with native cover (Table 1).

In 1991, with native cover only, both no-till and ridge-till produced taller plants than conventional-till. The vetch cover crop increased plant height in the conventional-till treatment but did not affect plant height in the no-till and ridge-till treatments (Table 2). The taller plants in the conventional-till vetch plots did not result in higher yield production for this treatment (Table 1).

In 1992, the vetch cover crop significantly increased plant height in each tillage regime by 3 to 7 inches. The greater plant height of the vetch cover crop treatment was associated with increase in seedcotton yield. Plant height was also significantly affected by tillage, but these effects were only about one-half as large as those induced by the vetch cover crop.

Averaged across years, the effects of tillage on plant height were small (1 to 2 inches) but statistically significant. The average effect of cover crop on plant height was larger with conventional-till than with no-tiil or ridge-till.

DISCUSSION

Results among years were consistent in that tillage regimes had little influence on yields. No one tillage regime among the three consistently produced significantly higher yields than another. When differences did occur among tillage treatments, they may have been related to planting date. The yield reduction in conventional-till in 1989, for example, may have been due to the unavoidable delay in planting of that treatment, and the superior performance of cotton in conventional-till in 1992 was possible only because planting was not delayed by spring tillage in that year.

Both no-till and ridge-till had a significant advantage in earliness of planting cotton because, in three of four years, planting of the conventional-till treatment was delayed by seedbed preparation. Early planting has several advantages. First, the earlier planting date would be expected to result in earlier crop maturity and, thus, reduces the number and cost of insecticide applications at season end when insects are most numerous and difficult to control. Second, the resultant earlier harvest would often produce a

Table 1. Effect of tillage practices and winter cover crop on the yield of cotton grown on Sharkey clay.

Tillage regime	Cover crop†	Seedcotton yield 1989	1990	1991	1992	Average
		---------- lb/A ----------				
No-till	Native	**2,525**	**3,280**	**4,050**	**3,800**	**3415**
	Vetch	**2,580**	**3,420**	**3,850**	**4,330**	**3545**
Ridge-till	Native	**2,535**	**3,155**	**4,130**	**3,790**	**3400**
	Vetch	**2,560**	**3,285**	**4,220**	**4,560**	**3660**
Conventional-till	Native	**1,950**	**3,075**	**4,070**	**4,000**	**3275**
	Vetch	**2,565**	**3,460**	**4,050**	**4,680**	**3690**
LSD (0.05) =		**250**	**200**	**208**	**195**	**120**

†Native, native vegetation; Vetch, hairy vetch

Table 2. Effect of tillage practices and winter legume cover crop on plant height of cotton grown on Sharkey clay.

Tillage regime	Cover crop†	Plant height 1989	1990	1991	1992	Average
		---------- inches ----------				
No-till	Native	**37**	**55**	**42**	**33**	**43**
	Vetch	**35**	**55**	**42**	**36**	**44**
Ridge-till	Native	**38**	**54**	**43**	**34**	**44**
	Vetch	**36**	**55**	**44**	**37**	**45**
Conventional-till	Native	**41**	**54**	**40**	**32**	**42**
	Vetch	**46**	**55**	**44**	**39**	**46**
LSD (0.05) =		**4**	**1**	**2**	**1**	**1**

†Native, native vegetation; Vetch, hairy vetch.

superior grade of cotton fiber than is obtained from late harvest dates. Third, early destruction of crop residue eliminates food sources for boll weevils entering diapause, thereby reducing the need for insecticides the following spring. Finally, early harvest on Sharkey clay is important to avoid possible damage to the fields due to late harvest on wet ground that would require extensive tillage procedures to correct, further delaying spring tillage operations.

The no-till treatment reduced the tillage costs of seedbed preparation by about $15/A. Herbicide costs, however, increased because of the need to control weeds and to burn down the vetch cover crop, which required two applications of Gramoxone. The ridge-till treatment also reduced tillage costs compared with conventional-till and required less herbicide than no-till because weeds or cover crop residue were mechanically removed from the top of the seedbed rather than needing extensive burndown applications. Thus, the type of minimum tillage represented by ridge-till may be preferable to no-till because of its low cost and reduced need for herbicides.

Replacing the native winter vegetation with a planted cover crop of hairy vetch increased cotton yields an average of 330 lb/A during the 4 years of the experiment. We do not know the reasons for the response to the vetch cover crop as it does not seem to be related to N availability. However, as indicated by the increases in plant height and yield, a vetch cover crop can act synergistically with tillage to improve crop growing conditions. The increase in gross returns from the vetch cover crop would be variable, depending upon prices for cotton. At an average return of $.65/lb of lint, the increase in gross income/A from vetch would be about $75.

Planting vetch increases the cost of production by about $35/A for seeding the vetch and for additional burndown herbicides. The vetch, however, should reduce fertilizer N costs by about $7/A. (Our data on this point is thus far inconclusive since the N rate did not affect yield and the cover crop-by-N rate interaction was not significant.) Thus, a winter vetch cover crop can increase net/A returns by as much as $30 to $40.

CONCLUSIONS

A combination of limited- or no-till either with or without a winter legume cover crop can produce beneficial results for cotton grown on Sharkey clay, including earlier planting and reduced cost of production. This significantly reduces the risks associated with cotton production on Sharkey clay. A winter legume cover crop has several beneficial effects for cotton production. It substantially increases yield, improves crop growth rate, reduces the amount of fertilizer N needed for cotton, and increases soil organic matter.

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