Effect of Crop Rotation/Tillage Systems on Cotton Yield in the Tennessee Valley Area of Alabama, 1980-2001

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ABSTRACT

A replicated cotton (*Gossypium hirsutum* L.) rotation experiment has been conducted for 22 years on a Decatur silt loam (fine, kaolinitic, thermic, Rhodic Paleudults) in the Tennessee Valley of northern Alabama. The highly productive soil with little disease and nematode problems resulted in cotton yield increases from rotations of generally less than 10% during the first 15 years of the study. A switch to no-tillage in all rotations except continuous cotton in 1995 greatly improved cotton yield response to rotations. From 1995 to 2001 cotton yield increases to rotation have averaged between 5% and 18%. In this study, yield increases due to rotations seem linked to increases in soil organic matter and consequent improvements in soil quality. From 1979 to 1994 using conventional tillage, the only rotation that produced a greater than 10% yield increase was cotton rotated with wheat (*Triticum aestivum* L.) and double-cropped soybean [*Glycine max* (L.) Merr.]. This rotation was also the only rotation that significantly increased organic matter levels under conventional tillage. From 1995 to 2001 all rotations were no-tilled and the greater yield increases to rotations can also be associated with higher soil organic matter levels. Wheat as a grain rotation or cover crop often produced the greatest yield increases to the following cotton crop. Under conventional tillage the wheat residue provided increased organic matter residue. With no-tillage the wheat cover crop reduced surface soil compaction. No-tillage and rotations that increased residue production were linked to increased cotton yields on this soil.

KEYWORDS

Double-cropping, soil organic matter, soil compaction, wheat, soybean

INTRODUCTION

In 1979, a cotton rotation experiment was established at the Tennessee Valley Substation in northern Alabama. At that time continuous cotton production was one practice being investigated for declining cotton yields across the US Cotton Belt. This long-term test has provided valuable information about the benefits of crop rotation to cotton producers in Alabama and across the United States. Many changes have been made to the test during the last 22 years as farming practices have changed. The research results have provided needed information as farmers switched to conservation tillage and searched for alternative crops.

MATERIALS AND METHODS

An area with a history of continuous cotton production was selected as the test site on the Tennessee Valley Substation in northern Alabama. Plot size was 26.7 feet (8, 40 inch rows x 50 feet). Yields were determined by mechanically harvesting the middle four rows. Treatments were replicated four times in a randomized complete block design. Initial treatments established in 1979 included:

1) continuous cotton,
2) continuous soybean,
3) two year rotation, cotton-soybean,
4) two year rotation, cotton-corn,
5) two year rotation, cotton-wheat/soybean,
6) three years alfalfa (*Medicago sativa* L.) followed by cotton, and
7) skip row (2 x 1) cotton.

In 1988 the alfalfa and skip row treatments were eliminated. A cotton-wheat rotation was established as well as two continuous no-tillage areas. The two no-tillage treatments consisted of planting into old cotton stubble or into a wheat cover crop.

In 1994 all plots except continuous cotton were changed to no-tillage. Row spacing was changed from 40 inches to 30 inches. Three treatments added in 1994 were:

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1) cotton ridge-tilled into old cotton stubble,

2) cotton ridge-tilled with a wheat cover crop, and

3) fall tillage (disk-chisel) with a wheat cover crop.

With all the changes four treatments have remained continuous since 1980. They include:

1) continuous cotton,

2) cotton/soybean,

3) cotton/corn, and

4) cotton/wheat-soybean.

The two continuous no-tillage plots have also been maintained since 1988.

RESULTS AND DISCUSSION

Results from the first eight years of the experiment indicated only small cotton yield increases due to rotations (Burmester *et al.*, 1988). Yield increases due to rotations were generally about 2% to 7%. The smaller than expected yield increases with rotations may have been due to limited disease and nematode pressure at the test location. Soil organic matter samples taken from the rotation plots in 1987 also revealed very little organic matter increase due to rotations (Table 1). All plots used conventional fall chiseling with spring leveling that limited organic matter building.

From 1988 through 1994 cotton yield responses to rotations were still small except for one treatment (Table 2).

Table 1. Soil organic matter (%) from 0-2.5 inch depth in long-term rotation/tillage experiment at the Tennessee Valley Substation, Belle Mina, Alabama, 1980-2001.

Rotation/Tillage System	1987	1994	2001
Continuous Cotton†	1.34	1.48	1.41
Cotton/Soybean‡	1.38	1.58	1.65
Cotton/Corn‡	1.35	1.50	1.70
Cotton/Wheat-Soybean‡	1.46	1.85	1.98
Cotton – No till stubble§	¶	1.75	2.23
Cotton – No till wheat§	¶	1.68	2.26
LSD (0.05)	0.27	0.19	0.18

† continuous conventional tillage cotton since 1979.

‡ rotations established in 1979, converted from conventional to no-tillage in 1994.

§ no-tillage into wheat cover crop or previous cotton stubble established in 1988.

¶ treatment not established until 1988.

A rotation with wheat and double-crop soybean increased cotton yields 13% compared to continuous cotton during this period. All other rotation increased yield by 9% or less. The yield increase with the wheat and double-soybean can be traced to an increase in soil organic matter levels (Table

Table 2. Seed cotton yield response to long-term crop rotation/tillage systems at the Tennessee Valley Substation, Belle Mina, Alabama, 1988-1994.

Rotation/Tillage System	1988	1989	1990	1991	1992	1993	1994	Avg.	(%) #
	---------- lbs acre^{-1} ----------								
Continuous Cotton†	1400	2780	1700	1090	2990	1900	2660	2070	100
Cotton/Soybean‡	1270	2620	1760	1020	3340	2030	3190	2180	105
Cotton/Corn‡	1280	3040	1910	1110	3260	2200	2800	2230	108
Cotton/Wheat-Soybean‡	1310	2860	1940	1240	3290	2160	3490	2330	113
Cotton- No till stubble§	1140	2430	1510	920	3160	1760	3250	2020	98
Cotton- No till wheat§	1380	2490	1920	970	3150	1790	3410	2160	104
Cotton/Wheat¶	1500	2800	1940	1040	3270	2350	2930	2260	109
LSD (0.05)	234	456	258	112	239	329	762	-	-

† continuous conventional tillage cotton since 1979.

‡ rotations established in 1979, converted from conventional to no-tillage in 1994.

§ no-tillage into wheat cover crop or previous cotton stubble established in 1988.

¶ established in 1988.

mean yield increase compared to continuous conventional tillage cotton.

Table 3. Seed cotton yield response to long-term crop rotation/tillage systems at the Tennessee Valley Substation, Belle Mina, Alabama, 1995 – 2001.

Rotation/Tillage System	1995	1996	1997	1998	1999	2000	2001	Avg.	(%) [#]
	---------- lbs acre^{-1} ----------								
Continuous Cotton[†]	1500	3170	1490	1830	1890	1770	2400	2007	100
Cotton/Soybean[‡]	1550	3030	2210	2120	2100	1730	2300	2149	107
Cotton/Corn[‡]	1680	3040	2270	2110	2020	1930	2450	2214	110
Cotton/Wheat-Soybean[‡]	1560	3420	2230	2240	2200	2000	2320	2281	114
Cotton-No till stubble[§]	1580	3430	2120	2260	1820	1800	2550	2223	111
Cotton-No till wheat[§]	1580	3550	2310	2400	1890	1795	2810	2334	116
Ridge-till wheat[¶]	1590	3070	2100	2020	1800	1920	2640	2163	108
Ridge-till stubble[¶]	1570	3130	1990	2050	1780	1800	2410	2104	105
Fall chisel-wheat[¶]	1650	3480	1990	2340	2280	1950	2820	2359	118
LSD $_{(0.05)}$	178	303	287	263	260	305	265	-	-

[†] continuous conventional tillage cotton since 1979.

[‡] rotations established in 1979, converted from conventional to no-tillage in 1994.

[§] no-tillage into wheat cover crop or previous cotton stubble established in 1988.

[¶] established in 1994, cotton planted no-tillage in wheat cover crop or cotton stubble.

[#] mean yield increase compared to continuous conventional tillage cotton.

1). Soil samples taken in 1994 found continuous cotton with organic matter levels of 1.48% compared to 1.85% with the wheat/double-cropped soybean. Even with fall and spring tillage this rotation was building organic matter. Rotations with soybean and corn increased organic matter only slightly to 1.58% and 1.50%, respectively. The two no-tillage treatments also increased soil organic matter levels compared to conventional cotton (Table 1). Cotton yield, however, was actually slightly lower (98%) when cotton was no tilled into old stubble compared to conventional tillage. When cotton was no tilled into a wheat cover crop, average yields during this period were 4% greater than for conventional tillage continuous cotton. Yield decreases with no-tillage seemed greatest in the drought seasons of 1988, 1990, 1991 and 1993. Much of this difference may have resulted from surface soil compaction on these no-tillage sites as reported by Burmester *et al.*, 1995. Burmester reported that these soil types often develop surface soil compaction with no-tillage, limiting cotton root growth and water uptake. Growing a wheat cover crop reduced this surface compaction which corresponds with yield trends seen in this rotation test. The wheat cover crops were terminated three to four weeks prior to planting in early-April and resulting surface residue quickly dissipated by mid-summer.

Cotton yield response to rotations increased greatly during the period 1995 to 2001 (Table 3). Yield increases due to rotations averaged between 7% and 18% during this period. This increased cotton yield response to rotations compared to the earlier periods may be due in part to the switch to no-tillage in 1995. Research has shown that tillage can negate the benefits of crop rotation (Bruce *et al.*, 1990; Reeves, 1997). Soil samples taken in 2001 revealed a more rapid building of soil organic matter with rotations compared to conventional continuous cotton (Table 1). This was particularly evident in the two plots that have been in no-tillage since 1988 and the wheat and double-cropped soybean rotation. The largest increases in yields seem to be with rotations that include wheat as a cover crop (Table 3) or for grain, and coordinating research showed dramatic improvements in soil quality with these systems (Motta, 2002). The wheat/soybean double cropping, no tillage with wheat cover, ridge-till with wheat cover and fall chiseling with wheat cover increase cotton yields 14%, 16%, 8% and 18%, respectively, compared to conventional tillage continuous cotton. The yield increases resulting from the combination of fall tillage with a wheat cover crop are corroborated by similar findings using non-inversion deep tillage and a rye (*Secale cereale* L.) cover crop for this soil (Raper *et al.*, 2000; Schwab *et al.*, 2002). Cotton no-tilled

into old stubble or ridge-tilled into old cotton stubble averaged 3% to 5% lower yields during this period compared to corresponding treatments using a wheat cover crop. This could be due to wheat reducing soil compaction as mentioned earlier or other unknown factors. Nematodes are still not a problem in this test area as indicated by sampling in 2001. During 1995 to 2001 soybean and corn rotations increased cotton yields 7% and 10%, respectively, compared to continuous cotton.

CONCLUSIONS

This experimental area was a highly productive and well-drained soil with little disease problems and no detectable levels of nematodes to affect cotton yields. Because of this, and/or due to conventional tillage negating rotation effects, cotton yield response to various rotations was generally lower than expected during the first 15 years of this study. Only the rotation of wheat and double-cropped soybean produced a cotton yield increase greater than 10% during this period compared to continuous cotton. This treatment was also the only rotation that significantly increased soil organic matter when conventional tillage was used in all rotations.

Cotton yield response to rotations were generally much higher during 1995 to 2001 when all rotations except continuous cotton were converted to no-tillage. Highest yielding rotations during this period contained wheat as a cover crop or grown for grain. Previous research on these soils found that small grains might reduce surface soil compaction under a no-tillage system. This may explain part of the increase in cotton yield when wheat was used in the rotations. Increases in soil organic matter levels and consequent improved soil quality (Motta, 2002) with the rotations under no-tillage was also a factor in the higher yield increases seen after 1994.

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