High-Residue Conservation System for Corn and Cotton in Georgia

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ABSTRACT

Two limiting factors to economical crop yields in Georgia are short-term drought and root-restricting hard pans. Deep tillage eliminates the effects of the hard pan and improves water infiltration, increasing the volume of soil water accessible by crop roots. The objectives of this study were to develop a practical high-residue conservation tillage system that reduces risk of short-term drought and improves soil quality for corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.). A strip-split plot design was used to test the following treatment combinations at the Coastal Plains Experiment Station, Tifton and the Southwest Branch Experiment Station in Plains on a Tifton sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) and Greenville sandy clay loam (fine, kaolinitic, thermic Rhodic Kandiudults), respectively, during 1999-2001: 1) surface tillage (disk and field cultivate vs. no-till), 2) deep tillage (in-row subsoil, zonal paratill, and no-till), and 3) cover crops (black oat [*Avena strigosa* Schreb.) , wheat (*Triticum aestivum* L.) and natural winter weed infestations. Corn was grown in 1999 and 2000. Cotton was planted in 2001. Grain yield differences were obtained only at the Tifton location. Corn grain yields were significantly higher (P = 0.10) in the deep tillage plots compared to no deep tillage in both years and with surface tillage of residue in 2000. There was a strong trend for corn following a black oat cover crop to have the highest yields both years at Tifton, especially with in-row subsoiling. Cotton yields in 2001 were significantly higher with deep tillage (either in-row subsoiling or paratilling) at both locations (P = 0.10) There was a strong trend at both locations for higher cotton yields when the residue was incorporated. There was also an interaction of surface tillage and cover crops in cotton at Tifton. Cotton yields were highest with surface tillage with no cover but lowest in the no-till without a cover crop. These data suggest that without deep tillage, surface tillage regardless of cover is needed for best yields in both corn and cotton on Tifton soils. This effect may be due to improved water infiltration and mineralization of residue. However, this was not observed in corn at Plains.

KEYWORDS

Soil compaction, hardpans, in-row subsoiling, *Avena strigosa* Schreb, *Triticum aestivum* L.,

INTRODUCTION

Short term drought stress and root-restricting hard pans are the two most yield limiting factors in crop production in Georgia. Soils are highly weathered and eroded, inherently infertile and low in organic matter that results in poor soil structure, limited rainfall infiltration and water storage. Conservation tillage has been shown to increase soil organic matter and improve water infiltration and storage (Reeves, 1997). Unfortunately, only 25% of Georgia's corn and cotton are grown with conservation tillage. A majority of this acreage does not have sufficient residue or cover mulch to effectively increase moisture conservation and organic matter. Production practices are needed that improve both moisture conservation and reduce limitations on root growth in order to sustain corn and cotton production in Georgia; where available water resources fast are becoming more limited. The objectives of this research were to: 1) develop a practical high-residue conservation tillage system that reduces risk of short term drought and improves soil quality and 2) demonstrate the practicality and benefits of the system as compared to conventional practices.

MATERIALS AND METHODS

The study was conducted in 1999, 2000 and 2001 at the Coastal Plains Experiment Station, Tifton and the South-

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west Branch Experiment Station in Plains on a Tifton sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) and Greenville sandy clay loam (fine, kaolinitic, thermic Rhodic Kandiudults), respectively. Four replications of a strip-split plot design were used to test the following treatment combinations: 1.) surface tillage (disk and field cultivate vs. no-till), 2.) deep tillage (in-row subsoil, zonal paratill, and no-till), and 3.) cover crops black oat, wheat and natural winter weed infestation). Individual plots were 45 feet long and 12 feet wide. Cover crops were planted on Dec. 3, 1998, Oct. 13, 1999, and Oct.17, 2000 in seven-inch rows. Cover crops were fertilized with 40 lbs N acre^{-1} after planting. Winter cover was chemically killed with glyphosate two weeks prior to planting corn and cotton with a four row no-till planter equipped with residue managers. Pioneer® brand hybrid 3163 was planted in 30 inch rows on March 18, 1999 and March 23, 2000 at 28,000 plants per acre and 30, 000 plants per acre, respectively. Corn was fertilized according to soil test recommendations by the University of Georgia Cooperative Extension Service. Nitrogen for corn was applied in a split application: 40 lbs acre^{-1} at planting and 100 lbs acre^{-1} at 3 and 6 leaf stage. Irrigation was applied as needed or available. Corn plots were harvested approximately August 18, 1999 and August 23, 2000.

The cotton variety, DeltaPine 655 B/RR was planted on May 11, 2001 following fertilization of P and K according to soil test recommendations. Nitrogen was applied in a split application: 42 lbs acre^{-1} at planting and 70 lbs acre^{-1} in mid-June. At-plant insecticides were used each year for both corn and cotton. The growth regulator, mepiquat chloride was applied to cotton at the rate of 8 oz acre^{-1} at both locations. Cotton was harvested mechanically on October 22-24, 2001.

Data were subjected to analysis of variance. Means were separated using Fishers protected LSD (P = 0.10 *a priori*).

RESULTS AND DISCUSSION

The late planting date for the cover crop in 1998 limited biomass/residue production but was greatly improved with earlier plantings in 1999 and 2000. Mean residue increased as expected in year two and three of the test at both locations (Table 1) due to previous corn residue and a more timely planting date for the cover crop. Residue was much higher at Tifton than Plains due to better moisture conditions and soil type. Winter weed population was much greater in the second and third year due to the early corn harvest of 1999 and 2000, which allowed more time for weed emergence and growth. In 2000, black oat and wheat were equal in biomass/residue accumulation except under no-till production (Table 2). Black oat produced significantly more biomass than wheat or winter weeds in no-till production in 2000. In Brazil, where black oat are commonly used in no-till production, studies have indicated black oat tolerates denser soil conditions than other small grains (Calegari *et al.*, 1993; Derpsch *et al.*, 1985).

Table 1. Mean residue dry matter biomass (lbs acre^{-1}) as affected by cover crop.

	1999		2000		2001	
Cover Crop	Plains	Tifton	Plains	Tifton	Plains	Tifton
Black oats	1778	2586	2207	4225	6967	6469
Wheat	1837	2520	2514	3739	12,089	9966
None	155	329	2764	2789	717	1675
$LSD_{0.10}$	260	287	382	236		

Table 2. Mean corn grain yields and residue as affected by cover crops and deep tillage.

		Grain yield		
Tillage	Cover	1999	2000	Residue
		----- bu acre^{-1}---		lbs acre^{-1}
Subsoil	black oat	170	182	3925
Paraplow	black oat	160	169	4148
No-till	black oat	154	150	4558
Subsoil	wheat	165	174	4112
Paraplow	wheat	164	170	4103
No-till	wheat	137	123	2988
Subsoil	none	167	167	2676
Paraplow	none	162	163	2899
No-till	none	143	142	2569
$LSD_{0.10}$		NS	NS	401

Corn (1999 and 2000)

No differences in yield were obtained in either year at Plains. Mean yields at the Plains location were lower than at the Tifton location (128 bu acre^{-1} vs. 158 bu acre^{-1} in 1999; 108 bu acre^{-1} vs. 159 bu acre^{-1} in 2000, respectively).

At Tifton, corn grain yields were much higher following deep tillage than no deep tillage (Table 3) both years, although, there was no difference between either deep tillage treatment (zonal paratilling or subsoiling in-the-row). Corn following surface tillage of residue yielded significantly greater than corn planted without incorporation of the residue (187 bu acre^{-1} vs. 169 bu acre^{-1}, respectively). While plant population was slightly lower in the no surface tillage treatments as compared to the surface tillage treatment (28,200 vs. 29,480 plants per acre), it was only significantly reduced in the no surface tillage, no-till treatment plots (25,780 plants per acre). The higher grain yields may be due to better water infiltration from a less compacted surface area and greater mineralization of the incorporated residue. At Tifton, corn behind the subsoil and black oat treatment tended to be higher in yield than any other combination treatment (Table 2) in both 1999 and 2000 (P = 0.13 and P = 0.17). This trend for higher crop yields with black oat has been noted in other studies (Calegari, *et al.*, 1993; Derpsch, *et al.*, 1985, Bauer and Reeves, 1999).

Cotton (2001)

Lint yields were significantly higher following deep tillage than no-deep tillage (averaged over surface tillage treatments) at both locations (Table 4) . As with corn, there was no difference between either deep tillage treatment. There was a trend at Tifton and Plains for higher lint yields following surface incorporation of the residue prior to planting (P = 0.19 and P = 0.11, respectively). At Tifton, cotton yields were affected by a surface tillage X cover crop interaction (Table 5). Yields with surface tillage and no cover were greater than those in the no-till, no cover plots. Reasons why are inconclusive, plant populations were lower in the no-till plots (data not shown). The surface of the no- till, no cover plots was much denser and may have reduced water infiltration and also had less N mineralization.

Table 3. Mean grain yield (bu acre^{-1}) as affected by tillage, Tifton.

Treatment	1999	2000
Subsoil	167	175
Paratill	162	167
No deep tillage	145	137
$LSD_{0.10}$	14	14

Table 4. Effects of tillage on cotton lint yield, 2001.

Treatment	Tifton	Plains
	------ lbs lint acre^{-1} ------	
Paratill	1562	1207
Subsoil	1557	1254
Notill	1468	1135
$LSD_{0.10}$	56.7	85.0

Table 5. Cotton yields and cover crop residue as affected by surface tillage and cover crops at Tifton.

Surface tillage	Cover crop	Lint yield	Residue yield
		---- lbs acre^{-1} ----	
Conventional	black oat	1552	6551
No-till	black oat	1510	6431
Conventional	wheat	1488	10362
No-till	wheat	1542	9570
Conventional	none	1621	908
No-till	none	1460	2442
$LSD_{0.10}$		81	

CONCLUSIONS

Corn yields were increased 14% in 1999 and to 25% in 2000 by deep tillage at Tifton. There was a trend for corn following a black oat cover crop to have the highest yields both years at Tifton, especially with in-row subsoiling. This trend was not observed in cotton in the one year it was grown. Also, there was a strong trend for the lowest corn yields to be obtained with no-surface tillage, no-deep tillage, and a wheat cover crop. The poorest cotton yields were also in the no surface tillage and no-deep tillage plots. No differences in corn yields were obtained with any combination treatment at the Plains location which was unexpected. Moisture conditions were poorer at the Plains location during both years due to limited irrigation capabilities, however, crop response to tillage and cover was not evident. Most likely greater amounts of residue are needed to maximize moisture conservation for subsequent crop production. The trend towards higher grain yields with black oat suggest that more studies are needed to understand this relationship and develop use of this cover crop into a practical conservation tillage system. Cover crops did not affect cotton yields at either location, the one year tested. Given that both locations were irrigated, the incidence of short term drought stress observed in strict no-till plots may not have been significant enough to demonstrate any benefits from the cover crop residue. There was a trend across both crops for higher yields in plots where the surface was disked prior to planting. This may have aided in water infiltration and aeration during the early season.

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