DIFFERENCES OF SOIL WATER USE, LINT AND BIOMASS YIELD IN NO-TILL AND CONVENTIONALLY TILLED COTTON IN THE SOUTHERN PIEDMONT.

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Abstract. The southeast, despite its abundant rainfall, suffers short-term summer droughts with detrimental effect on crop yield. No-till production systems provide added insurance against such conditions by improving infiltration, and conserving moisture in drought-prone soils. In three years of experiment near Watkinsville, GA, no-till cotton treatments maintained higher soil moisture content, more vegetative growth and higher lint yield than conventional tillage treatments. A combination of no-till and poultry litter treatments did even better compared to conventional tillage and conventional fertilizer treatments.

INTRODUCTION

Much of the agriculture in the southeast is based on clean-tilled crops grown on sloping land. These crops are grown on soils that are relatively infertile, highly erodible, low in organic matter, and easily compacted by rainfall and machine traffic (Carreker et al., 1977). The soils respond well, however, to good management practices, including adequate levels of nutrients, and cropping systems that restore organic matter and soil structure, increase available water and reduce machine traffic. One such system, which has steadily gained acceptance by farmers, is no-till. The system is credited with maintaining or increasing yield, reducing overall production costs, arresting or reversing soil degradation processes and reducing nutrient and pesticide losses by reducing runoff volume (increased infiltration) and soil loss (CTIC, 1992; Domitruk and Crabtree, 1997). While considerable experience is accumulating with regard to no-till production of cotton on the alluvial and loess soil of Arkansas, Louisiana, Mississippi, and Tennessee (eg. Keisling et al., 1992; Kennedy and Hutchinson, 1993), much less is known about the performance and water quality effects of no-till cotton on the dominant agricultural soils of the Piedmont and Coastal Plain where there has been a rapid expansion of cotton production.

Georgia is experiencing a growing poultry agribusiness, currently worth $10 billion (Rodekohr and Rahn, 1997). If this growth is to be sustainable, additional outlets for efficient poultry litter utilization must be identified. The recent and projected growth in cotton acreage provides one such outlet whereby poultry litter can be utilized as an alternative nutrient source. Little is known about the tillage-poultry litter interactions as manifested on soil water availability, yield and water quality effects on Piedmont soils.

The objective of the component of the research discussed here was to compare soil water use and quantify the effect on biomass and yield production potential of no-till and conventionally tilled cotton in Southern Piedmont Comparison of the effect of nutrient source of poultry litter and chemical fertilizer on the same parameters is included as a secondary objective

METHODS

The experiment was conducted in 1996, 1997 and 1998 at the USDA-ARS J. Phil Campbell, Senior, Natural Resource Conservation Center, Watkinsville GA. The site consisted of 12 instrumented tile-drained plots each 10 m by 30 m, located on nearly level (0-2%) slope Cecil sandy loam (Clayey, Kaolinitic thermic Typic Kanhapludults). The experimental design was a completely randomized block with a factorial combination of tillage and fertility source. Each treatment combination was replicated three times. The conventional tillage (CT) consisted of chisel plowing and disking while no-till (NT) consisted of coulter planter use only. The nutrient sources were poultry litter (PL) and inorganic fertilizer (CF).

Stonville 474 variety cotton was planted on May 30 (1996), and May 14 (1997) in 34 inch rows at a rate of 3 to 4 plants per foot and harvested on November 1 (1996) and 4 (1997). In 1998 cotton was planted on May 14 in 30 inch rows and harvested on November 12. Effective insect, weed and grass control was achieved with a combination of pesticides and, on conventional tillage plots, cultivation. Pesticides and fertilizers were applied before planting, and, in conventional till plots, incorporated into soil by light disking immediately afterwards. There was no soil incorporation of pesticides and fertilizer in no-till plots. Rye was used as cover crop each winter.

RESULTS

Lint yield

Treatment effects were consistent over the three years (Table 1). Lint yields from no-till plots were higher by 26.7, 27.5 and 35.8 percent for the three consecutive years over conventional tillage plots. The average for the three years was 30 percent. The crop season in 1998 was drier than normal and this was reflected in lower yields than in the other two years. But no-till had the highest effect in 1998 indicating better use of available soil water. Yields compared further among combination of treatments (details not shown) were as follows. The PL treatments in CT plots out yielded CF treatments by 19.5, 11.8 and 7.8 percent. The equivalent values for NT plots were 6.3, 34.0, 13.4 percent. Combination of PL-NT treatments out yielded CT-CF treatments by 43.2, 54.6, 50.2 percent for the three consecutive years.

Table 1. Lint Yield Summary 1996-1998

	Average lint yield kg/ha			
Treatment*	1996	1997	1998	Average
CT	959	952	837	916
NT	1215	1214	1137	1189
NT/CT	1.267	1.275	1.358	1.300

* CT – conventional tillage; NT – no-till

Table 2. Average Plant Height, Leaf Area and Biomass Dry Weight for 1998 for CT and NT

	Plant Height	Leaf Area	Average dry weight in g*			
Treat.	cm	sq.m	P	L	S	B
CT	58.3	0.862	6.9	59.7	123.8	307.0
NT	74.8	1.045	8.1	72.5	197.9	469.7
NT/CT	1.283	1.213	1.174	1.214	1.599	1.530

* P-petiole; L-leaf; S-stem; B-boll

Biomass

Dry plant part weights were determined on six randomly selected plants per plot from the 1998 crop. Plants were sampled a few days before harvest, separated into different plant parts, dried in an oven and weighed. Results including plant height and leaf area are given in Table 2. NT treatments again proved superior to CT treatments. The largest differences were for stems (59.9 percent) and bolls (53 percent). Leaf mass and leaf area differed by 21.3 percent while plant height varied by 28.3 percent. Even larger differences were observed between combination of NT-PL treatments and CT-CF treatments, the former being superior (details not shown). Differences were 35.6, 46.7, 40.2, 97.7, 41.3 and 70.4 percent respectively for plant height, leaf area, and dry weights for leaf, stem, petiole and boll.

Soil water use

Soil moisture was measured between two and three times a week over the growing season in 1998 using the Moisture Point System of Environmental Sensors Inc. (ESI, Victoria, British Columbia, Canada). The system uses time domain reflectometry (TDR) principles to measure soil moisture on volume bases. Four plots were instrumented with two probes each and soil moisture readings were averaged. The plots were plot 1 (CT-PL), plot 6 (NT-CF), plot 7 (NT-PL) and plot 12 (CT-CF). We used probes that read average soil moisture in five segments (0-15 cm, 15-30 cm, 30-60 cm, 60-90 cm and 90-120 cm). The data were organized such that changes from the previous reading were cumulatively added to give temporal net soil moisture change. Cumulative net soil moisture change between June 8 and November 4, 1998 is shown in Figure 1. A typical net temporal soil moisture change

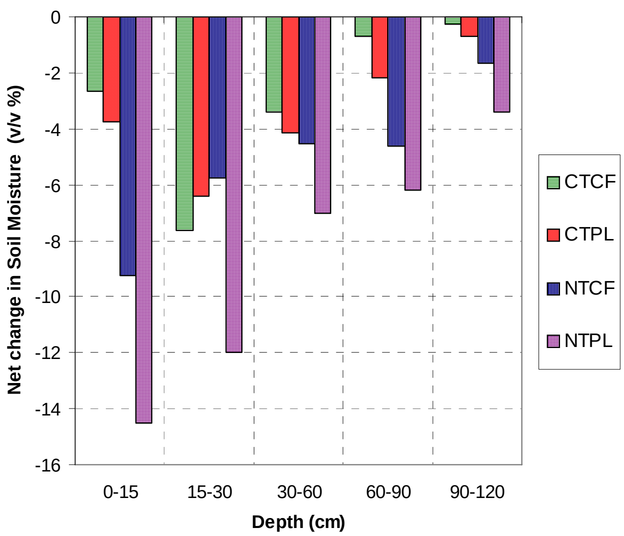

Figure 1. Cumulative net soil moisture change for 1998 for 4 plots of contrasting treatments.

is shown in Figure 2 for the 0-15 cm depth.

Net soil moisture change was negative in all profiles indicating net soil water use. The two NT plots had the highest changes in all depths except for plot 6 (NTCF) in the 15-30 cm depth. The greatest change for the NT plots was in the 0-15 cm depth while for the CT plots it was in the 15-30 cm depth. The changes decreased with depth except for the 15-30 cm depth of CT plots. Changes for CT plots were less than 2 (v/v %) in the 60-90 cm depth and less than 1 (v/v %) in the 90-120 cm depth. The equivalent changes for the NT plots were 5.4 and 2.5 (v/v %) respectively. In the 0-15 cm depth the average change for NT plots was 3.71 times that of the CT plots. In the subsequent depths, it was 1.26, 1.53, 3.72 and 5.32 times respectively. NT plots had almost twice the total change of CT plots in the 0-60 cm depth. About 68% of the change for NT plots and 83% of the change for CT plots occurred in the 0-60 cm depth. About 22% of the change for NT plots and 13% of the change for CT plots occurred in the 60-90 cm depth.

Observed drainage differences between CT and NT plots showed that, except under very wet conditions, there was between 2 and 3 times more drainage from NT plots than CT plots implying more infiltration in NT plots (Endale et al, 1998). These results coupled with those of biomass and yield indicate superior available water use for NT plots over CT plots. Water use was even more in the NT-PL plots compared to CT-CF plots.

SUMMARY and CONCLUSIONS

A no-till cotton production system out-yielded a conventional tillage system by approximately 30% over a three year period. Differences were even larger (almost 50%) between a combination of no-till and poultry litter treatment, and that of conventional tillage–conventional fertilizer. Above ground biomass measured in 1998 was also more (50%) under the NT than the CT system. No-till plots showed between 2 and 3 times more drainage than CT plots under normal climatic conditions indicating more infiltration under NT plots. Soil water use was almost double in the 0-60 cm depth for NT plots over CT plots.

The Piedmont with its abundant precipitation and surface water resources and a relatively long growing season has favorable conditions for good plant production. However, it often suffers short-term droughts with detrimental effect on crop yield. Cotton is a major crop in Georgia but most is grown under conventional tillage and conventional fertilizer systems. Our research indicates that no-till systems are better users of available soil water and can provide additional insurance against crop failure during drought prone periods. More efficient soil water use also leads to better yields in normal years. A combination of no-till and poultry litter management system appears an even more efficient user of soil water and can provide even better insurance against crop failure and still higher yield. Statistical significance of the results for the whole research period will be carried out after the final crop season in 1999.

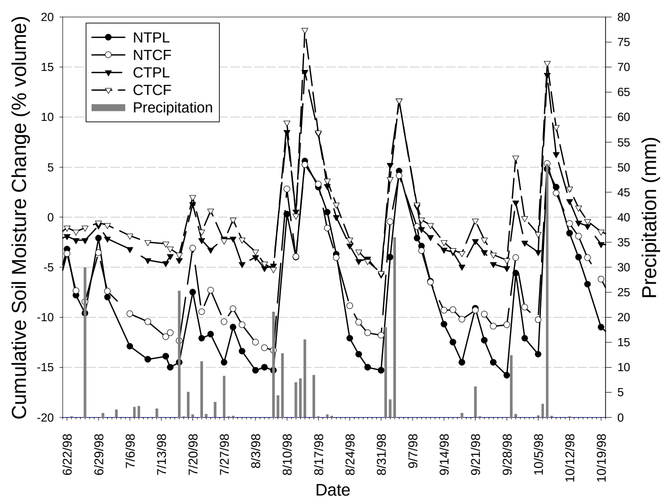

Figure 2. A typical cumulative soil moisture change in the 0-15 cm depth in 1998 for 4 plots under contrasting treatments.

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