COTTON YIELD RESPONSE TO TILLAGE-POULTRY LITTER INTERACTIONS IN THE SOUTHERN PIEDMONT

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Abstract. Cotton (*Gossipium hirsutum* L.) is a major crop in Georgia and is mostly grown under conventional-tillage with conventional inorganic fertilizers, such as ammonium nitrate. But reduced tillage is drawing increased attention nationwide as a viable production option. A growing poultry industry in Georgia is generating increased quantities of poultry litter, some of which can be used as an alternative organic fertilizer in crop production. This research was conducted to observe the performance and yield response of cotton planted with no-tillage and fertilized with poultry litter. Research was conducted for three years under a factorial arrangement of tillage (no-tillage vs conventional-tillage) and fertilizer (ammonium nitrate vs poultry litter) on a Cecil soil of Southern Piedmont near Watkinsville, GA. Lint yield from the no-tillage treatment exceeded that of conventional-tillage by about 30% (P=0.009) over three years. Yield from no-tillage, poultry litter-fertilized cotton exceeded that of conventional-tillage, ammonium nitrate-fertilized cotton by almost 50 percent (P=0.005). Cotton production in the Southern Piedmont could be improved by using no-tillage and poultry litter as fertilizer compared to conventional-tillage and ammonium nitrate as fertilizer.

INTRODUCTION

Reduced tillage as a production option is drawing increased attention nation wide. It promises to save producers money in the short term and provide long-term benefits for their land and the environment. Reduced tillage 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). However, much of the row-crop agriculture, including cotton, in the Southeast is based on conventional tillage. Georgia is a major cotton producing state in the Southeast. Area planted to cotton increased from about 315 000 acres in 1987 to about 1 425 000 acres in 1997 (Rodekohr and Rahn, 1997).

Experience is accumulating with regard to no-till production of cotton on the alluvial and loess soil of Arkansas, Louisiana, Mississippi, and Tennessee (Keisling et al., 1992; Kennedy and Hutchinson,1993). Much less is known about the performance of no-till cotton on the dominant agricultural soils of the Piedmont. Georgia is also experiencing a growing poultry agribusiness, currently worth $10 billion annually (Rodekohr and Rahn, 1997). The recent and projected growth in cotton acreage provides an outlet for efficient use of poultry litter as an alternative organic fertilizer. Little is known about the tillage-poultry litter interactions on soil water availability and cotton yield effects on Piedmont soils.

OBJECTIVE

Evaluate the performance and yield response of cotton under a factorial arrangement of tillage (no-tillage vs conventional-tillage) and fertilizer (poultry litter vs. ammonium nitrate).

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 30 ft by 100 ft, 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 arrangement of tillage and fertilizer. Each treatment combination was replicated three times. The conventional-tillage consisted of chisel plowing and disking while no-tillage consisted of coulter planter use only. Fertilizers were poultry litter applied at a rate of 2 tons/acre (30% moisture basis; equivalent to about 54 lb/acre available N), and ammonium nitrate applied as conventional fertilizer at a rate of 54 lb/acre (60 kg/ha) available N. Potassium was applied based on soil test results. Phosphorous was not applied as soil test results established no need. Rye (*Secale cereale* L.) was used as cover crop each winter. Tillage treatment had been imposed on the 12 plots since April 1992 but this study was started in 1996.

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 November 4, 1997, respectively. 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 cultivation on conventional-tillage plots. Cotton pesticides were: Aldicarb (Temik), insecticide for control of thrips and nematodes at 4 lb/acre, Fluometuron (Cotoran), a broadleaf herbicide, at 2 pt/acre, and Pendimethalin (Prowl), a herbicide for control of annual grass and broadleaf weeds, at 1.5 pt/acre. Pesticides and fertilizers were applied before planting, and, in conventional-tillage plots, incorporated into soil by light disking immediately afterwards. There was no soil incorporation of pesticides and fertilizer in no-tillage plots. PIX was applied as a growth regulator at 8 oz/acre soon after bloom and 10 days later. Harvade and Prep at rates of 8 oz/acre and 1 pt/acre were used as defoliant and boll opener respectively.

Average soil moisture was measured in five segments (0-6 in., 6-12 in., 12-24 in., 24-36 in. and 36-48 in.) between two and three times a week over the growing season in 1998. A TDR-based Moisture Point System of Environmental Sensors Inc. (ESI, Victoria, British Columbia, Canada) was used for the measurement. Four plots (conventional-tillage-ammonium-nitrate, conventional-tillage-poultry-litter, no-tillage-ammonium-nitrate, and no-tillage-poultry-litter) were instrumented with two probes each and soil moisture readings were averaged. Data were organized such that changes from the previous reading were cumulatively added to give temporal net soil moisture change. Dry plant part weights for leaf, petiole, stem and bolls were determined on six randomly selected plants per plot just before harvest from the 1998 crop. Plants were sampled , separated into different plant parts, dried in an oven and weighed. Pant height and leaf area were also measured.

Yield data were analyzed as random complete block with a factorial arrangement of treatments, and repeated measures design using the MIXED procedure of SAS (Littell et al., 1996). A check on homogeneity of variances associated with treatments indicated that the no-tillage-poultry-litter treatment had a larger variance than the other treatment combinations. As a results, treatments were separated into two variance groupings and were included in the statistical analysis by using the grouping option on the repeated statement.

RESULTS

Lint yield

Treatment effects were consistent over the three years (figure 1). Lint yields from no-tillage plots compared to conventional-tillage plots were higher by 26.7, 27.5 and 35.8 percent (average 30 percent; P=0.009) for the three consecutive years, respectively. Yields from no-tillage-poultry-litter plots were higher by 43.2, 54.6, and 50.2 percent (average 49 percent; P=0.005) for the three consecutive years, respectively, compared to conventional-tillage-ammonium-nitrate plots. Yields were different between fertilizer treatments (P=0.078). Yields were not different among years (P=0.384). No interaction existed between combinations of fertilizer and tillage (P > 0.57).

Soil water use

Cumulative net soil moisture change between June 8 and November 4, 1998 is shown in figure 2.
Net soil moisture change was negative in all profiles indicating net soil water use. No-tillage plots had almost twice the total change of conventional-tillage plots in the 0-24 inch depth. About 68% of the change for no-tillage plots and 83% of the change for conventional-tillage plots occurred in the 0-24 inch depth.

About 22% of the change for no-tillage plots and 13% of the change for conventional-tillage plots occurred in the 24-36 inch depth. The greatest change for the no-tillage plots was in the 0-6 inch depth while for the conventional-tillage plots it was in the 6-12 inch depth. No-tillage-poultry-litter plots showed about 2.4 times more change than conventional-tillage-ammonium-nitrate plots in the 0-24 inch depth. The 1998 crop season was drier than normal and this was reflected in lower yields than in the other two years. No-tillage had the highest effect in 1998 indicating better use of available soil water.

Biomass

Differences in treatment effects were apparent not only in lint yield but in overall vigor of growth during the crop season. In general, cotton in no-tillage plots was taller and had more biomass by first bloom than cotton in conventional-tillage plots. The contrast was greater between no-tillage-poultry-litter and the other treatments. Results of the 1998 sampling are given in table 1. This table shows that plant height, leaf area index and average dry weights of petiole, leaf, stem and bolls were between 17 and 59 percent higher in no-tillage plots than in conventional-tillage plots (line 5). Differences were higher (39 to 97 percent) between no-tillage-poultry-litter and conventional-tillage-ammonium-nitrate treatments (line 6). The largest differences were for stems and bolls.

SUMMARY AND CONCLUSIONS

Yield of no-tillage cotton exceeded that of conventional-tillage cotton by approximately 30 percent over a three year period (P=009). Yields were almost 50 percent (P=0.005) greater from no-tillage-poultry-litter cotton treatment than from conventional-tillage-ammonium-nitrate treatment. The no-tillage treatment produced 50 percent more above ground biomass than the conventional-tillage treatment in 1998. And the no-tillage-poultry-litter treatment produced 72 percent more above ground biomass than the conventional-tillage-ammonium-nitrate treatment. Soil water use in the 0-24 inch depth was almost double for no-tillage compared to conventional-tillage cotton and about 2.4 times more in no-tillage-poultry-litter compared to conventional-tillage-ammonium-nitrate treated cotton.

The Southern Piedmont often suffers short-term droughts with detrimental effects on crop yield, despite abundant precipitation. Our research indicates that no-tillage enhances use of available soil water and can provide additional insurance against crop failure during drought-prone periods compared to conventional-tillage. More efficient soil water use also leads to greater yields in normal years. A combination of no-tillage with poultry litter fertilizer appears to enhance available soil water use even more than a conventional-tillage and ammonium nitrate combination and can provide even more insurance against crop failure and promote higher yields. Although most cotton in Georgia is grown under conventional-tillage using conventional fertilizers, such ammonium nitrate, production could be improved by adopting no-tillage and using poultry litter as fertilizer.

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Table 1. Average Plant Height, Leaf Area, and Biomass Dry Weight for 1998 for Six Randomly Selected Plants from Each of Conventional-tillage (Ct), No-tillage (Nt), Conventional-tillage-ammonium-nitrate (Ctan) and No-tillage-poultry-litter (Ntpl) Treatment Plots.

Treatment Plots	Plant Height inches	Leaf Area sq ft	Average dry weight in lb*			
			P	L	S	B
CT	22.9	9.27	0.015	0.132	0.273	0.677
NT	29.5	11.24	0.018	0.160	0.436	1.036
CTAN	22.5	7.94	0.014	0.121	0.236	0.625
NTPL	30.4	11.65	0.020	0.169	0.466	1.064
NT/CT	1.288	1.213	1.174	1.214	1.599	1.530
NTPL/CTAN	1.351	1.467	1.428	1.397	1.975	1.702

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

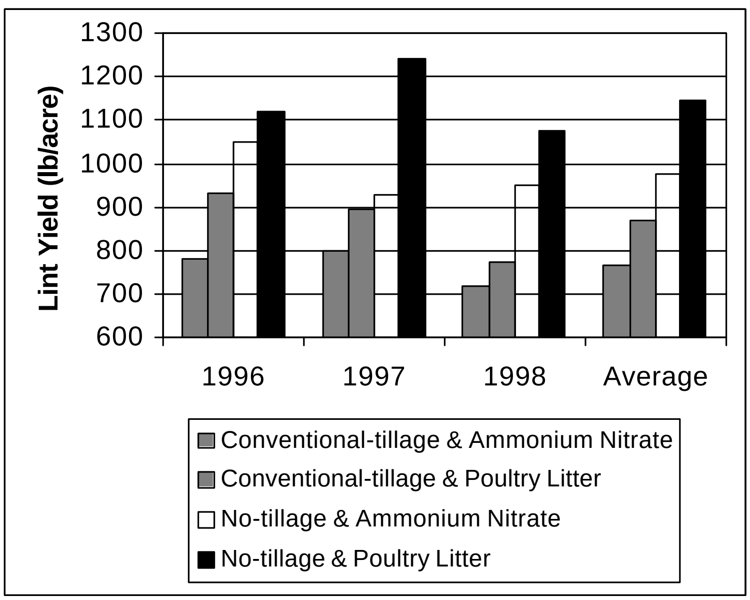

Fig. 1 Lint yield in lb/acre across treatments for 1996 to 1998

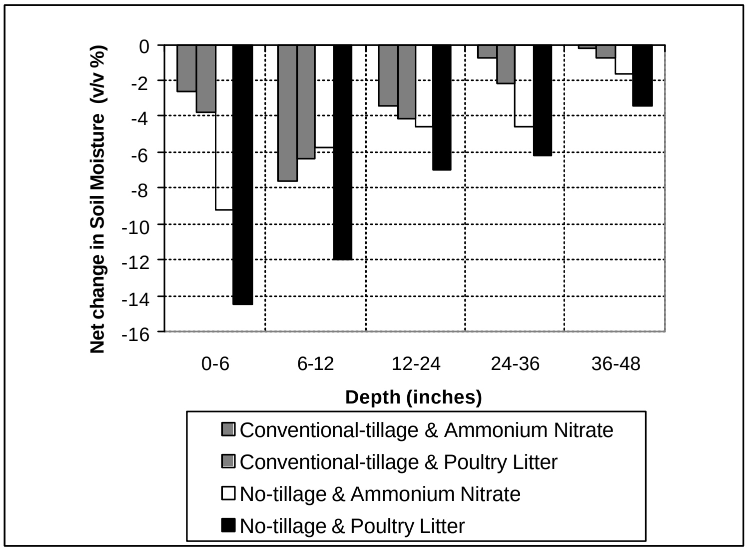

Fig. 2. Cumulative net soil moisture change between June 8 and November 4, 1998 for 4 plots of contrasting treatment.