# CONSERVATION TILLAGE TO MANAGE WATER AND SUPPLEMENTAL IRRIGATION IN GEORGIA

C.C. Truman[1] and D.L. Rowland[2]

AUTHORS: [1]Soil Scientist, USDA-ARS, Southeast Watershed Research Lab, POB 946, 2375 Rainwater Rd., Tifton, GA 31793; 229-386-7174; ctswrl@tifton.usda.gov; [2]Plant Physiologist, USDA-ARS, National Peanut Research Lab, POB 509, 1011 Forrester Dr., Dawson, GA 39842; 229-995-7430; drowland@nprl.usda.gov.

REFERENCE: *Proceedings of the 2005 Georgia Water Resources Conference*, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute Ecology. The University of Georgia, Athens, GA.

**Abstract.** Crop production in Georgia tends to be water limited due to climatic and soil conditions; and because of the demands for water, producers face increasingly stringent water management regulations. Georgia producers are dependent on supplemental irrigation to maintain competitive yields. Most soils in Georgia are relatively sandy, tend to be drought-prone, are susceptible to compaction and erosion, thus present water management challenges. Adverse climatic and soil conditions and potential policies restricting irrigation water use reveal a major dilemma facing Georgia producers; finding ways to maximize crop yields, maintaining responsible water-use efficiency, and limit soil and water quality concerns. In Georgia, conservation tillage systems have significant potential as a water management tool for agricultural producers. Conservation tillage systems, coupled with residue management and paratilling, increase infiltration and soil and plant available water, thus conserve soil and water resources by reducing runoff, soil loss and irrigation demand. In Georgia, conservation tillage systems improve producer profit margins, reduce environmental risks, and conserve water resources.

## BACKGROUND

The agricultural industry in Georgia accounts for ~20% of Georgia's $350 billion output and ~15% of the state's employment. In Georgia, a diverse range of crops are produced, including cotton, peanuts, corn, soybeans, vegetables, forages, grains, and tobacco. Crop production tends to be water limited due to climatic and soil conditions. Georgia receives ~50 inches of poorly distributed rainfall annually. Soils in Georgia have traditionally been intensively cropped under conventional tillage systems. These highly-weathered, low organic carbon soils have relatively sandy surfaces, tend to be drought-prone, are susceptible to compaction and erosion, and present water management challenges. Georgia and the rest of the Southeast can probably benefit more from conservation tillage than any other region of the U.S. (Reicosky et al., 1977) because conservation tillage has significant potential as a water management tool for agricultural producers.

Conservation tillage coupled with residue management and paratilling are associated with reduced runoff and erosion, enhanced infiltration, and increased soil water holding capacity (Truman et al., 2003; 2005). These benefits are generally attributed to the build up of residue and organic matter at the soil surface with time as a result of conservation tillage adoption, thus improving soil properties governing infiltration and soil water storage (Reeves, 1997; Truman et al., 2003; 2005). Furthermore, mechanical compaction and intrinsic consolidation, through increased soil density, have traditionally contributed to low conservation tillage adoption rates because of decreased infiltration and a more adverse rooting environment, especially 1-3 years after conservation tillage adoption. (NeSmith et al., 1987; Radcliffe et al., 1988; Truman et al., 2003). In Georgia, consolidation readily compacts weakly-structured surface soils and some form of deep tillage is needed to disrupt compacted zones. Paratilling, a non-inversion, deep tillage technique, is often used to break up compacted zones, thus increasing and/or restoring infiltration (Truman et al., 2003; 2005). The *objective* of this paper is to demonstrate how conservation tillage systems influence water management and supplemental irrigation demands in Georgia.

## METHODS

Data presented in this paper come from two sites with contrasting soil types. The Tifton loamy sand was located at the Gibbs Farm Research center near Tifton, GA. The loamy sand soil was managed under conventional- (CT) and strip-till (ST) systems. The surface residue on ST plots was not distributed. With ST, only the 15-20 cm area that the crop is planted into is tilled with the remaining area remaining untilled. Row centers were 76 cm apart and stripped rows averaged 20 cm wide, thus the residue was distributed over a 55-60 cm wide area (row middles). Each tillage was established in 1998 on field plots 30-m wide by 70-m long, and was replicated three times. Tillage treatments included conventional tillage without paratilling and without cover (CT-P-C) and strip tillage without paratilling and with cover (ST-P+C). Rainfall simulation plots (three 6-m$^2$) were established on a 30-m wide by 145-m long plot that was divided (evenly) length-wise between CT-P-C and ST-P+C. This plot was identical to the six 30-m by 70-m tillage plots, and was specifically established to conduct rainfall simulations for comparisons between simulator plot results and results from each 0.2 ha plot.

The Greenville sandy clay loam was located at the Hooks Hanner Environmental Resource Center (HHERC) near Dawson, GA. The sandy clay loam soil was managed under conventional- (CT) and strip-till (ST) systems. Again, surface residue on ST plots was distributed only over the 55-60 cm wide row middles. Each tillage was established in 2003 on field plots 6-m wide by 100-m long, and was replicated three times. Tillage treatments included conventional tillage without paratilling and without cover (CT-P-C) and strip tillage without paratilling and with cover (ST-P+C). Conventional till consisted of fall disking and bedding (top 25 cm) followed by spring disking and repeated bedding (top 25 cm). Rainfall simulation plots (three 6-m$^2$) were established on each treatment. At both sites, a peanut-cotton rotation was used.

Also, simulated rainfall was applied at a target intensity of 50 mm/h (2 in/h) for 1 hour. Runoff water was measured continuously at 5-min intervals during each simulation, and was determined gravimetrically. Infiltration was calculated by difference (rainfall - runoff). Water use was measured continuously with stem flow collars.

## RESULTS

In the first year after conservation tillage (ST) adoption at both sites, we consistently found no difference in how rainfall or irrigation is partitioned into infiltration or runoff (Fig. 1,2). In subsequent years however, differences in rainfall partitioning have been observed between the two tillage systems. Compared to conventional tillage (after year 1), ST increased infiltration and decreased runoff by as much as 30%.The increase in infiltration has yielded a consistent increase in soil water content throughout the root zone of ST systems in 2004 (Fig. 3), compared to CT systems. However, increased soil water content within the root zone does not automatically equate to increased plant available water (PAW). To obtained PAW estimates, we used infiltration data (Fig. 1) and assumed that all infiltration was available to the growing crop(s) and assumed a daily evapotranspiration value of 6 mm/d. After year 1, ST increased PAW estimates by as much as 50%, compared to CT systems (Fig. 4). However, the question remains: Can these increased plant available water estimates be quantified?

**Fig. 1. Infiltration (% of rainfall) from CT and ST systems for Tifton loamy sand (LS) and Greenville sandy clay loam (SCL).**

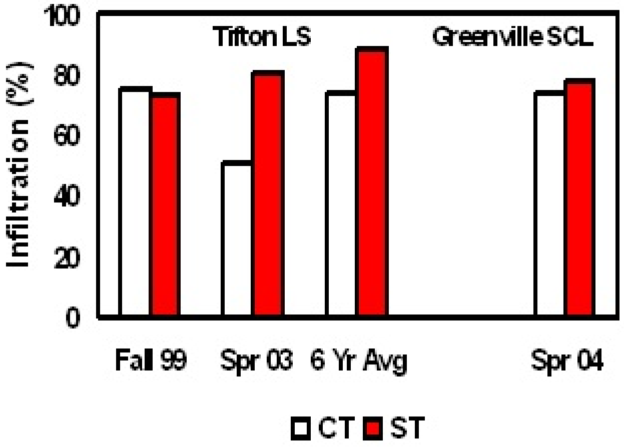
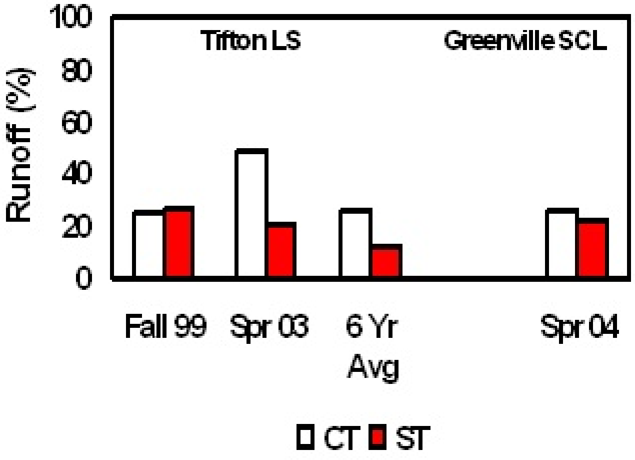


**Fig. 2. Runoff (% of rainfall) from CT and ST systems for Tifton loamy sand (LS) and Greenville sandy clay loam (SCL).**



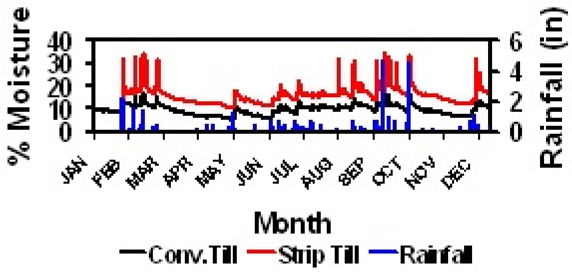


**Fig. 3. Soil water content at the 12 inch depth (monthly, 2004) from CT and ST systems for Tifton loamy sand (LS).**

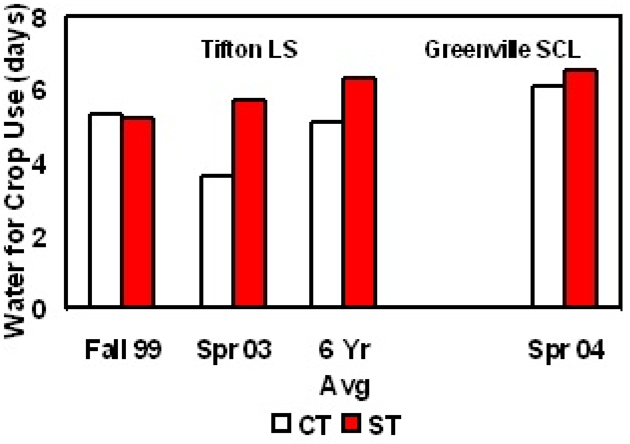


**Fig. 4. Plant available water estimates from CT and ST systems for Tifton loamy sand (LS) and Greenville sandy clay loam (SCL).**

With stem flow collars, we determined actual plant water use curves (Fig. 5). A 1 inch rain or irrigation generated a 3-5 day lag time in water use curves for peanuts and cotton, and we identified those times during the crop growing season where the highest water use occurs (85-120 days after planting for peanuts and 80-110 days after planting for cotton). ST decreased the amount of water used by peanuts (5 in.) and cotton (10 in.) during the growing season; 19% less for peanuts (2004) and 42% less for cotton (2003). If we assume that a weekly irrigation is needed for peanut or cotton production during the 60-125 day period after planting (~9 weeks), and given PAW estimates and measured crop water use, we can reduce 9 irrigations by 20-50% or ~2 to 4 irrigations with ST. Conservation tillage (ST) reduced irrigation demand and costs and conserved water, thus improves a producer's profit margin and sustainability.

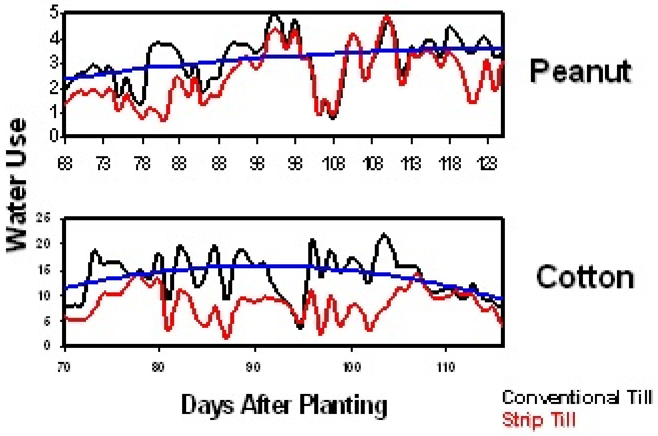


**Fig. 5. Seasonal water use curves from CT and ST systems cropped to cotton and peanuts for the Greenville sandy clay loam (SCL).**

## CONCLUSIONS AND RECOMMENDATIONS

We have shown how conservation tillage influences water management and irrigation demands in Georgia. The following concluding statements and recommendations can be made:

1. Compared to CT, ST reduced runoff and increased infiltration by at least 30%.
2. Compared to CT, ST increased the amount of water in the root zone (top 30 cm) of soil.
3. Compared to CT, ST increased plant available water estimates by as much as 50%.
4. Compared to CT, ST decreased the amount of water used over the entire growing season by 19% for peanuts and 42% for cotton.
5. Compared to CT, ST would have decreased the estimated number of irrigations by 2-4 (20-50%) in 2003.
6. Conservation tillage systems (ST), coupled with residue management and paratilling, increases infiltration and PAW, thus conserves water resources by reducing irrigation costs/demands, and improves a producer's profit margin and sustainability while protecting the environment.

## REFERENCES

NeSmith, D.S., D.E. Radcliffe, W.L. Hargrove, R.L. Clark, and E.W. Tollner. 1987. Soil compaction in double-cropped wheat and soybeans on an Ultisol. Soil Sci. Soc. Am. J. 51:183-186.

Radcliffe, D.E., E.W. Tollner, W.L. Hargrove, R.L. Clark, and M.H. Golabi. 1988. Effect of tillage practices on infiltration and soil strength of a Typic Hapludult soil after ten years. Soil Sci. Soc. Am. J. 52:798-804.

Reeves, W.D., 1997. The role of organic matter in maintaining soil quality in continuous cropping systems. Soil Tillage Res:43:131-167.

Reicosky, D.C., D.K. Cassel, R.L. Blevins, W.R. Gill, and G.C. Naderman. 1977. Conservation tillage in the Southeast. J. Soil & Water Conserv. 32:13-19.

Truman, C.C., D.W. Reeves, J.N. Shaw, A.C. Motta, C.H. Burmester, R.L. Raper, and E.B. Schwab. 2003. Tillage impacts on soil property, runoff, and soil loss variations from a Rhodic Paleudult under simulated rainfall. J. Soil & Water Conserv. 58:258-267.

Truman, C.C., J.N. Shaw, and D.W. Reeves. 2005. Tillage effects on rainfall partitioning and sediment yield from an Ultisol in central Alabama. J. Soil & Water Conserv. 60:89-98.