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COTTON YIELDS IN CONVENTIONAL AND CONSERVATION TILLAGE SYSTEMS UNDER DIFFERENT IRRIGATION LEVELS

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Abstract

Cotton (*Gossypium hirsutum* L.) producers in southwest Georgia that irrigate from surface water sources were required to participate in drought auctions during 2001 and 2002. In the fall of 2001, a study was initiated to determine optimal application amounts of irrigation for conventional and conservation tillage systems to maximize yields and conserve water. Cotton stand counts and lint yields were measured in three tillage systems (conventional, narrow strip tillage, and wide strip tillage) within four irrigation levels, on a Greenville fine sandy loam (fine, kaolinitic, thermic Rhodic Kandiudults) near Dawson, GA. First year results indicated cotton stand counts were highest for conventional tillage. Narrow strip tillage produced higher stand counts than wide strip tillage. However, lint yields were higher in both conservation tillage systems compared to conventional tillage within all irrigation levels. Narrow strip tillage was superior to wide strip tillage for two irrigation levels (33% and 100%). Continuing this research should encompass multiple weather environments, to verify if differences between conventional and conservation tillage systems exist under limiting water environments.

Introduction

The Georgia Legislature passed the Flint River Drought Protection Act (FRDPA) in March 2000 to ensure that streamflows of the Flint River are maintained throughout an 18 county area in southwest Georgia known as the Flint River Basin. This law provided a $10 million fund (based on estimated elimination of irrigation from 100,000 acres) for reimbursing farmers located in the basin to cease irrigating from surface water of the Flint River, if the Environmental Protection Division (EPD) declared a "drought" for that year. In the event of a declared drought, EPD holds auctions to request bids on a per acre basis from farmers that irrigate from surface water of the Flint River. To date, these auctions have been conducted in 2001 and 2002 to maintain streamflows in the Flint River for stakeholders (rural and urban) within the basin.

Receipts from cotton and cottonseed agricultural sales were ranked second only to the poultry industry in Georgia, while Georgia cotton production was ranked third in the U.S., based on the 1997 Census of Agriculture (NASS, 1997a). The 1997 Census of Agriculture also indicated that approximately 351,000 acres of cotton were harvested in the Flint River Basin and that 29% of those acres were irrigated (NASS, 1997b). These statistics illustrate the importance of cotton to the state's economy, as well as the potential negative impact the elimination of irrigation within the Flint River Basin could have on cotton productivity in the region. Producers that utilize agronomic practices to conserve soil moisture can help alleviate concerns of rural and urban stakeholders by reducing irrigation needs and possibly prevent negative impacts associated with potential water restrictions imposed by regulatory agencies.

One practice that growers may adopt to help conserve soil moisture is conservation tillage. A critical component of conservation tillage is cover crop management (Brown et al., 1985). Residues on the soil surface have improved water management for cotton by reducing soil water evaporation and increasing infiltration of irrigation and rainfall (Lascano et al., 1994). Increased infiltration corresponds to a reduction in runoff, which may increase soil water contents, and potentially increase plant available water (PAW). An increase in PAW can increase water use efficiency of an irrigation or rainfall event. Increased efficiency may lower the amount of water required for the growing season, or reduce the number of irrigations required during the year. Reductions in water requirements help preserve the water resource while lowering production costs for growers.

The objective of this research was to compare optimal irrigation amounts for conventional and conservation tillage systems to maximize lint yields and conserve water.

Materials and Methods

An experimental site was established on a Greenville fine sandy loam at the Hooks Hanner Environmental Resource Center, near Dawson, GA in the fall of 2001. A factorial arrangement of three tillage systems (conventional, narrow strip tillage and wide strip tillage) and three replications were randomly assigned within four blocks. Each block corresponded to four irrigation levels established with a lateral irrigation system (dryland, 33%, 66%, and 100% of full irrigation). Irrigation timing was based on evapotranspiration measurements. Plot dimensions were 6 rows wide (18 ft.) and 120 ft. long.

The experimental site was fallow the previous 5 yr with occasional diskings or mowings to control weed growth. An exception occurred in 1998 when soybean (*Glycine max* (L.) Merr.) was planted, but no yields were obtained due to dry weather. Initial site preparation consisted of mowing and multiple diskings to bury existing weed residue. Prior to lime and fertilizer application, deep subsoiling (~ 20-in.) was performed over the entire experimental area. Lime was applied at 2.5 t acre^{-1} and P_2O_5 was applied at 40 lbs acre^{-1}. The site was deep subsoiled again at a 45° angle to the first subsoiling operation to help incorporate lime and fertilizer and disrupt any remaining compacted zones. An additional disk and field cultivator operation was performed over the area prior to cover crop establishment.

Wheat (*Triticum aestivum* L.) was drilled across the entire experimental area at 1.4 bu acre^{-1} on 21 December 2001. In late February, 2,4-D was applied to control emerged broadleaf weeds. Glyphosate was used to terminate the cover crop on 8 April 2002, prior to cotton planting. Wheat biomass samples (0.7 ft.^{2}) were collected at the time of termination from three locations within each block. Average wheat biomass across the experimental area was 5565 lb ac^{-1}. After tillage operations, pre-emergence herbicides were applied across the experimental area. Prior to planting, an application of glyphosate and gramoxone was applied to control emerged johnsongrass (*Sorghum halepense* L.) and small broadleaves in conservation tillage plots after cover crop termination.

Conventional tillage consisted of moldboard plowing in early March followed by multiple diskings, one field cultivator operation, and a bedding operation prior to planting. Narrow strip tillage consisted of a coulter ahead of a subsoil shank followed by two parallel press wheels that firm the disturbed area in one pass. An area approximately 12 in. wide was tilled over the row. Wide strip tillage consisted of one pass with an implement consisting of a coulter ahead of a subsoil shank, followed by two sets of fluted coulters ahead of a rolling basket and a drag chain assembly. An area approximately 18 in. wide was tilled over the row.

Deltapine DP 555 BG/RR was planted at approximately 4.5 seeds ft^{-1} in 36-in rows on 14 May 2002. Cotton stand counts were measured one month later by counting the number of plants emerged within 10 ft. of row and averaging the values from three locations within each plot. Cotton was harvested on 1 November 2002 by trimming the two center rows of each plot to 100 ft., then harvesting with a mechanical spindle picker equipped with a bag attachment system. Lint yields were determined by weighing lint and seed collected from each plot and assuming a 35% ginning outturn.

Cotton stand counts were analyzed by analysis of variance using a general linear model procedure provided by Statistical Analysis System (SAS Institute, 2001). Data were analyzed among tillage systems, regardless of irrigation level, because no irrigation was applied prior to stand count measurements. Lint yields were analyzed among tillage systems, within irrigation levels, by analysis of variance using a general linear model procedure provided by Statistical Analysis System (SAS Institute, 2001). Orthogonal contrasts were used to further distinguish between tillage systems. Treatment differences were considered significant if $P > F$ was equal to or less than 0.10.

Results and Discussion

Rainfall was near 30 yr monthly means for the region during April and May and exceeded 30 yr monthly means the remainder of the growing season, except in August (Fig. 1). Above normal rainfall eliminated the need for irrigation until the latter part of the growing season. Amounts of irrigation applied in the 100% irrigation treatment corresponded to 4.6 and 1.3 in. for August and September, respectively.

Cotton stand counts measured one month after planting are shown in Fig. 2. No irrigation was applied prior to stand count measurements, which quadrupled replication among tillage systems. The increase in replication increased precision to detect differences in stand counts between tillage systems. Stand counts measured in the conventional system (4.0 plants ft^{-1}) were higher than stand counts measured in both conservation tillage systems (3.2 plants ft^{-1} for narrow strip and 2.9 plants ft^{-1} for wide strip). Stand counts measured in narrow strip tillage were higher than counts measured in wide strip tillage.

The increase in stand counts measured in conventionally grown cotton did not provide increased cotton yields. Tillage systems were analyzed within irrigation levels, with conventionally grown cotton yielding lowest across all water levels (Table 1). Narrow strip tillage, which disturbs the least amount of residue on the soil surface, yielded highest in two of the four irrigation levels (33% and 100%). Lint yields for narrow strip tillage were numerically superior to wide strip tillage in the 66% irrigation level and significantly lower than wide strip tillage in the dryland area (Table 1).

Lint yields were not statistically analyzed across irrigation levels, because irrigation levels were not replicated. However, two relationships are evident from the yields observed across irrigation levels. First, the 33% irrigation level added an additional 1.9 in. of water compared to rainfall received in the dryland plots. As a result, lint yields measured in the 33% irrigation level were over 100% greater for the conventional and narrow tillage system and over 50% greater for the wide strip tillage system when compared to lint yields measured in the dryland area within the corresponding tillage system (Table 1). Second, the highest lint yields of each tillage system were attained within the 66% irrigation level. We hypothesized that the above average rainfall and the aggressive growth habit of DPL 555 increased rank cotton growth in the 100% irrigation level, which depressed lint yields.

Conclusions

First year results indicated cotton stand counts were highest in the conventional tillage system compared to both conservation tillage systems. Stand counts within conservation tillage systems were higher in narrow strip tillage compared to wide strip tillage. Both conservation tillage systems produced higher lint yields, within each water level, compared to conventional tillage cotton. In the future, potential benefits of conservation tillage should become more pronounced as surface residue is increased. Adoption of conservation tillage systems within the Flint River Basin has the potential to lower irrigation requirements, while preserving surface water flows.

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References

Brown, S.M., T. Whitwell, J.T. Touchton, and C.H. Burmester. 1985. Conservation tillage systems for cotton production. Soil Sci. Soc. Am. J. 49:1256-1260.

Lascano, R.J., R.L. Baumhardt, S.K. Hicks, and J.L. Heilman. 1994. Soil and plant water evaporation from strip tilled cotton: Measurement and simulation. Agron. J. 86:987-994.

National Agricultural Statistics Service. 1997a. Census of Agriculture. Market value of agricultural sales for Georgia. Available online at http://www.nass.usda.gov/census/census97/rankings/gasales.htm (verified 16 September 2003). NASS, Washington, DC.

National Agricultural Statistics Service. 1997b. Census of Agriculture. 1997 Census of Agriculture: Georgia State and County Data. Available online at http://usda.mannlib.cornell.edu/reports/census/ac97aga.pdf (verified 17 September 2003). NASS, Washington, DC.

SAS Institute. 2001. The SAS system for Windows. Release 8.02. SAS Inst., Cary, NC.

Table. 1. Cotton lint yields measured in 2002 for three tillage systems within irrigation levels.

	Irrigation level			
Tillage system	**Dryland**	**33 %**	**66 %**	**100 %**
	--------------lb lint acre^{-1}--------------			
Conventional	193	421	798	770
Narrow strip tillage	296	655	1000	862
Wide strip tillage	358	566	934	782
	Analysis of variance (Pr > F)			
Conv. vs strip tillage	0.0012	0.0014	0.0172	0.0448
Narrow vs wide tillage	0.0297	0.0317	0.2561	0.0180

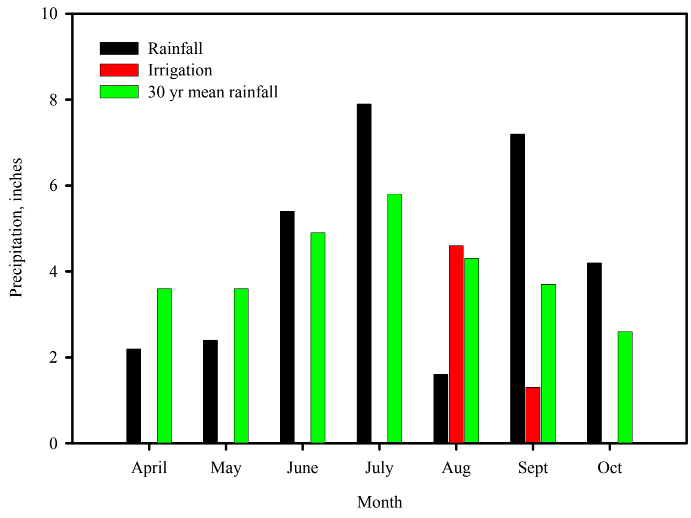

Figure 1. Rainfall received, irrigation applied, and 30 yr. monthly mean rainfall amounts for Dawson, GA

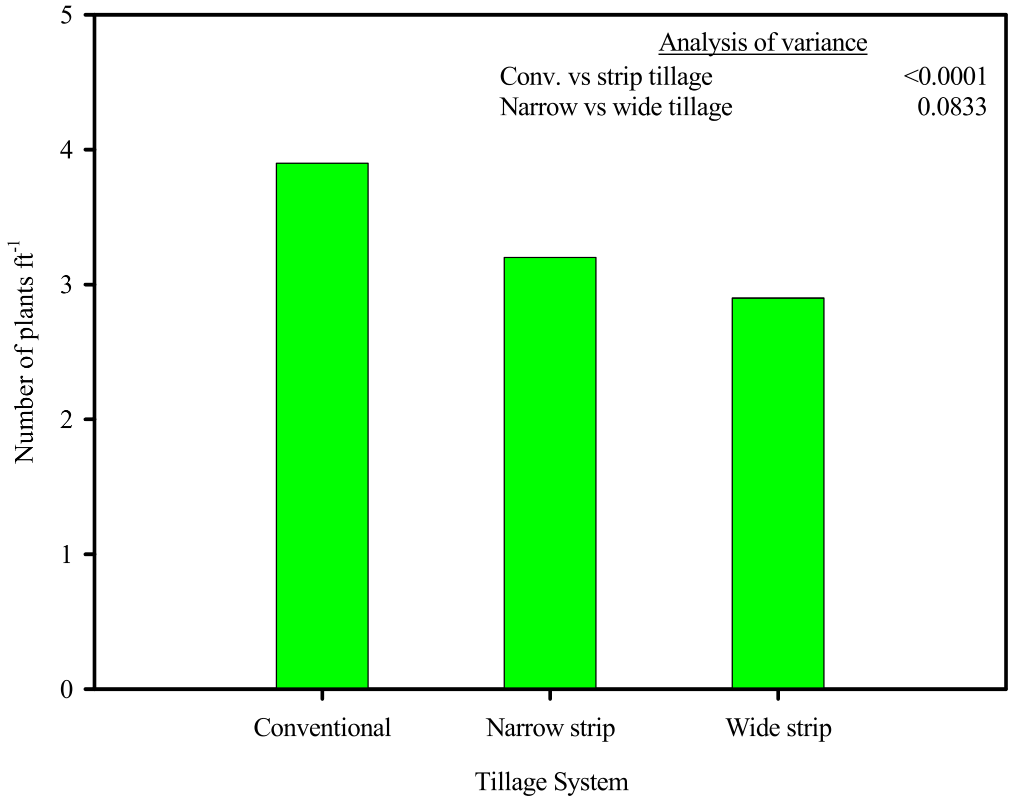

Figure 2. Cotton plant stands measured four wk after planting, within each tillage system.