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COTTON YIELD AND FIBER QUALITY FOR IRRIGATED TILLAGE SYSTEMS OF THE TENNESSEE VALLEY

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Abstract

Irrigation can positively influence cotton (*Gossypium hirsutum* L.) yield and fiber quality during periods of short-term drought. A cover crop in conjunction with conservation tillage can also benefit cotton yield and fiber quality by conserving soil moisture and potentially increasing plant available water. A split-plot experiment in a randomized complete block design was utilized to examine how interactions between irrigation levels and tillage systems affect cotton yield and fiber quality in the Tennessee Valley on a Decatur silt loam (fine, kaolinitic, thermic Rhodic Paleudults) from 2001-2003. Main plots were tillage systems and subplots were irrigation levels. The no-tillage system increased yields 13% in 2003 (normal rainfall year), while irrigation levels increased yields 46% and 32%, respectively in 2002 and 2003 over non-irrigated yields. Micronaire and staple were not affected by tillage system or irrigation level in 2001; however, micronaire and staple were influenced by tillage system and irrigation level in 2002. Only irrigation level influenced fiber quality in 2003. A no-tillage system, utilizing a cover crop combined with irrigation, can improve cotton yields in the Tennessee Valley.

Introduction

Water can be a major limiting factor for cotton producers during the growing season due to sporadic summer rainfall patterns. Irrigation has been utilized to supplement rainfall to maximize cotton yields and net returns over non-irrigated cotton (Bronson et al., 2001; Pringle and Martin, 2003).

One practice that growers may adopt to help conserve soil moisture is conservation tillage. Cover crop management is an important aspect of conservation tillage (Brown et al., 1985). Cover crop residues combined with crop residues on the soil surface improve 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, and will increase soil water content, and in turn increase plant available water (PAW). This increase in PAW may decrease the amount of water required during the growing season, or reduce the number of irrigations required during the year. Subsequent reductions in water requirements help preserve water resources while increasing net returns for growers.

Another aspect of conservation tillage is non-inversion deep tillage to alleviate soil compaction. One such implement utilized for this purpose is a bent-leg subsoiler or paratill. The elimination of compacted layers with non-inversion tillage enables roots to explore a larger soil volume to obtain nutrients and moisture, while cover crop residue remains undisturbed on the soil surface (Schwab et al., 2002).

Integrating irrigation and conservation tillage that utilizes non-inversion deep tillage and a cover crop has not been examined in the Tennessee Valley. Therefore, our objective was to compare cotton yields and subsequent fiber quality across irrigation levels in conventional and conservation tillage systems.

Materials and Methods

An experimental site was established on a Decatur silt loam (fine, kaolinitic, thermic Rhodic Paleudults) at the Tennessee Valley Research and Extension Center in Belle Mina, AL from 2001-2003. Treatments were established in a split-plot arrangement in a randomized complete block design with three replications. Main plots were four tillage systems and subplots were four irrigation levels. Tillage systems consisted of factorial combinations of conventional tillage (fall chisel/disk, spring disk/level) with and without fall paratilling and no-tillage (no surface tillage) with a rye (*Secale cereale* L.) cover crop with and without fall paratilling. Irrigation levels were 0, 2, 4, and 6 gpm (gallons per minute) corresponding to no irrigation, 1" of water every 9.4 days, 1" of water every 4.7 days, and 1" every 2.35 days. Treatments remained in the same location each year. Plot dimensions were 8 rows wide (40-inch rows, 36.6 ft.) and 39 ft. long separated by 26 ft. alleys.

Phosphorus, K, and lime were applied prior to planting the fall cover crop based on Auburn University soil test recommendations. In the corresponding plots, rye was drilled at 90 lb acre^{-1} during the first 2 wk of October each yr. Fall paratill treatments were administered to appropriate plots at the time of cover crop planting. The rye cover crop in no-tillage plots was burned down with Roundup Ultramax® (26 oz/A) + Prowl® (1.2 qt/A) at least 2 wk before planting. Cover crop dry matter samples (2-0.25 m^2 squares per plot) were collected after chemical termination, but prior to planting.
PayMaster 1218 BG/RR was planted 20 April 2001 and Suregrow 215 B/R was planted on 24 April 2002 and 1 May 2003. Cotton was first harvested on 1 October 2001, 24 September 2002, and 8 October 2003 with a mechanical spindle picker equipped with a bag attachment system. All plots were harvested a second time, approximately 2 wk after the initial picking. Lint yields were determined by weighing lint and seed collected from each plot and subsamples were ginned in a 20-saw tabletop micro-gin to determine ginning turnout. An additional subsample of ginned cotton was sent to the USDA classing office (USDA, Pelham, AL 35124) for HVI (High-Volume Instrumentation) analysis of fiber properties (micronaire and staple) from each plot.

Cotton lint yields, micronaire, and staple were analyzed using the MIXED procedure provided by Statistical Analysis System (SAS Institute, 2001). Orthogonal contrast statements were used to further distinguish between tillage systems and irrigation levels. Treatment differences were considered significant if P > F was equal to or less than 0.10.

Results and Discussion

Rainfall totals during the growing season were significantly lower during the 2002 growing season (17.7 inches) compared to the 2001 (29.9 inches) and 2003 (31.5 inches) growing seasons.

Lint Yields

No interactions existed between tillage system and irrigation level for lint yields; therefore, only main effects are presented. Lint yields were affected by tillage treatments only in 2003 (Table 1). The no-tillage plots, regardless of fall paratillage, yielded higher than conventional tillage plots. Within the conventional and no-tillage systems, presence or absence of paratilling had no effect on yields. This data indicates that the cover crop positively influenced lint yields compared to fall paratilling in 2003. The lack of lint yield response in 2001 may be attributed to low cover crop biomass in no-tillage plots resulting from a late planting date and early termination date (data not shown). The lack of lint yield response in 2002 could be related to differences in maturity between the tillage systems.

Lint yields were influenced by irrigation levels in 2002 and 2003 (Table 1). Four gpm maximized lint yields in 2002, while only 2 gpm was required to maximize lint yields in 2003. The lack of supplemental rainfall during the 2002 growing season depressed lint yields across all irrigation levels compared to 2003. As a result, non-irrigated lint yields in 2003 were superior to 2002 lint yields measured over all irrigation levels.

Fiber Quality

Similar to lint yields, no interactions existed between tillage system and irrigation level for fiber properties. Tillage system influenced micronaire only in 2002 with higher micronaire values observed for conventional tillage than for no-tillage (Table 2). These differences are important because the micronaire values from the no-tillage plots are at or slightly below the range where growers receive a low micronaire deduction. The dry 2002 growing season probably influenced micronaire from the standpoint of soil moisture and its effect on plant maturity. If the soil moisture content was higher in the no-tillage plots, the increased moisture may have caused the plants to retain more bolls, which may not have matured at harvest, resulting in low micronaire cotton. As with lint yields, fall paratill had no effect on micronaire.

Irrigation level affected micronaire during the 2002 and 2003 growing seasons (Table 2). Micronaire was highest, but within an acceptable range, with no irrigation applied during the 2002 growing season. Micronaire decreased with all levels of irrigation and was in the discount range for low micronaire at the 4 and 6 gpm irrigation levels. Additional water supplied by irrigation may have delayed maturity, similar to no-till plots, resulting in low micronaire attributed to immature bolls. Two gpm maximized micronaire during the 2003 growing season with all levels of irrigation within the accepted range resulting in no deductions.

Tillage system influenced staple only during the dry 2002 growing season (Table 3). Staple increased in no-tillage plots compared to conventional plots, but fall paratill had no effect. These differences will not affect the grower's cotton price because the values are above minimum standards.

Staple was also influenced by irrigation level in 2002 and 2003 (Table 3). In 2002, staple was below the established minimum value when no irrigation was applied, however irrigation resulted in staple values above the minimum with staple maximized at 4 gpm. All staple values were above the minimum with no deductions, regardless of irrigation level in 2003. Two gpm maximized staple values during this growing season.

Conclusions

Tillage and irrigation levels influenced lint yields, micronaire, and staple; however, no interactions were observed between tillage and irrigation. Lint yields from no-surface tillage plots were superior to yields from conventional plots during 2003. A lack of adequate cover crop biomass in 2001 and differences in boll maturity between tillage systems in 2002 may explain why no yield responses were observed during those years. Irrigation increased lint yields nearly 40% two out of three years. Fiber quality appeared to be influenced by different maturity levels between tillage systems. Although statistically significant differences were detected for micronaire and staple, these differences will not likely influence net returns. Conservation tillage with a cover crop and irrigation can increase cotton yields in the Tennessee Valley.

Disclaimer

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Table 1. Cotton lint yields measured in four tillage treatments and four irrigation levels during a 3 yr experiment conducted at the Tennessee Valley Research and Extension Center in Belle Mina, AL.

	Lint yields		
Treatment†	2001	2002	2003
	-------------------	$lb\ ac^{-1}$	-------------------
CT-P	1153	940	1329
CT + P	1199	931	1345
NT - P	1140	909	1513
NT + P	1199	880	1505
$LSD_{0.10}$	NS‡	NS	86
0 gallons $minute^{-1}$	1101	680	1150
2 gallons $minute^{-1}$	1257	933	1525
4 gallons $minute^{-1}$	1170	1025	1532
6 gallons $minute^{-1}$	1161	1022	1485
$LSD_{0.10}$	NS	81	113

† CT – P conventional tillage, no paratill; CT + P conventional tillage, paratill; NT – P no-tillage, no paratill; NT + P no-tillage, paratill.
‡ Not significant.

Table 2. Micronaire measured in four tillage treatments and four irrigation levels during a 3 yr experiment conducted at the Tennessee Valley Research and Extension Center in Belle Mina, AL.

	Micronaire		
Treatment†	2001	2002	2003
CT-P	4.59	3.85	3.92
CT + P	4.58	3.86	3.92
NT - P	4.45	3.43	3.95
NT + P	4.53	3.47	3.94
$LSD_{0.10}$	NS‡	0.19	NS
0 gallons $minute^{-1}$	4.47	4.47	3.50
2 gallons $minute^{-1}$	4.63	3.70	4.11
4 gallons $minute^{-1}$	4.51	3.11	4.00
6 gallons $minute^{-1}$	4.55	3.33	4.11
$LSD_{0.10}$	NS	0.19	0.14

† CT – P conventional tillage, no paratill; CT + P conventional tillage, paratill; NT – P no-tillage, no paratill; NT + P no-tillage, paratill.
‡ Not significant.

Table 3. Staple measured in four tillage treatments and four irrigation levels during a 3 yr experiment conducted at the Tennessee Valley Research and Extension Center in Belle Mina, AL.

	Staple		
Treatment†	2001	2002	2003
	---------------------------------	inches	---------------------------------
CT-P	1.076	1.058	1.094
CT + P	1.070	1.058	1.097
NT - P	1.072	1.080	1.096
NT + P	1.073	1.070	1.099
$LSD_{0.10}$	NS‡	0.01	NS
0 gallons $minute^{-1}$	1.073	1.033	1.083
2 gallons $minute^{-1}$	1.077	1.067	1.103
4 gallons $minute^{-1}$	1.072	1.087	1.103
6 gallons $minute^{-1}$	1.070	1.080	1.098
$LSD_{0.10}$	NS	0.01	0.009

† CT – P conventional tillage, no paratill; CT + P conventional tillage, paratill; NT – P no-tillage, no paratill; NT + P no-tillage, paratill.

‡ Not significant.