The *Journal of Cotton Science 9:10–14 (2005)*
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AGRONOMY AND SOILS

Evaluation of Strip Tillage on Weed Control, Plant Morphology, and Yield of Glyphosate-Resistant Cotton

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ABSTRACT

In 2001 and 2002, a field study was conducted in Quincy, FL, with glyphosate-resistant cotton (*Gossypium hirsutum* L.) to evaluate the influence tillage on weed control, plant development, and yield. Two tillage systems, conventional and strip-till, were evaluated. The plots were broadcast sprayed with glyphosate (Roundup Ultra; Monsanto, St. Louis, MO) at 427 g a.i. ha^{-1} when cotton plants were at the 3- to 5-node stage and direct-sprayed at the same rate at the 8- to 10- and the 12- to 15-node stages. Averaged across years, tillage system did not influence cotton yields (957 and 964 kg ha^{-1} for conventional and strip tillage, respectively). For most traits, responses were not affected by tillage or by the tillage by year interaction. Greater weed control was obtained for conventional than strip-tilled cotton (1.3 and 4.1% of the soil surface covered with weeds, respectively) at 30 days after treatment (DAT), but weed control at 10 and 60 DAT was similar between treatments. Plant stand at 14 days after planting (DAP) was greater in conventional tillage in 2002. Plants were taller in conventional tillage at 90 DAP in 2002, but number of main stem nodes were greater in strip tillage at 90 and 120 DAP in 2002. Strip tillage increased the total number of bolls per plant, and the number of bolls on the second and third position of the fruiting branch in 2002. These results indicate that growing cotton in strip-tillage is comparable to conventional tillage.

Research is needed to compare weed management and cotton development and yield of glyphosate-resistant cotton grown in conventional and strip tillage systems. Conservation tillage has increased in the southeastern USA, mainly due to time and labor savings (Johnson et al., 2001), and has become an integral component of sustainable farming (Lal et al., 1990). According to Paxton et al. (1993), concern about soil erosion, water quality, and decreasing soil productivity has stimulated interest in alternative cotton production systems designed to minimize these problems. Strip tillage, a conservation tillage system used in the southeastern U.S., uses a seed-bed preparation implement with in-row subsoil shanks, multiple coulters, and ground driven crumblers that cultivate a band approximately 30 cm wide (Johnson et al., 2001). Crops can be sown with planter units mounted on the tillage implement or as a separate operation. Based on a 10-year research project in Tennessee, cotton yields averaged 1019 kg ha^{-1} from reduced tillage and 1001 kg ha^{-1} from conventional tillage (Bradley, 1993). In Texas, yields of cotton were 41% higher for reduced tillage than for conventional tillage (Harmon et al., 1989). Triplett (1985) reported that poor weed control is a limiting factor in the adoption of conservation tillage. Tillage system can affect the density and spectrum of weed population, and broadleaf species become dominant in conventional tillage (Clements et al., 1996). Broome et al. (2000) noted that selection of herbicides and timing of application are important factors in controlling perennial species in a reduced tillage system. Weeds can cause significant economic losses (Swanton et al., 1993), so the success of conservation tillage depends on the development of agronomically and economically viable weed management systems (Derksen et al., 1996).

Glyphosate-resistant cotton became available for research testing by university scientists in 1995 (Hayes et al., 1996), and was introduced to farmers in 1997 with little cultivar trial evaluation (May et al., 2000). In glyphosate-resistant cotton, glyphosate can be applied broadcast up to the four-leaf stage and followed by post-directed application (Kerby and Voth, 1998). This weed control practice was intended to replace soil-applied or post-directed herbicides used in standard weed control systems (Askew and Wilcut, 1999). Weed management systems that included a

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post-directed or postemergence herbicide application provided greater weed control than systems with only preemergence herbicides (Vencill et al., 1994). The objective of this study was to evaluate weed control and yield of glyphosate-resistant cotton grown under strip and conventional tillage systems with glyphosate herbicide applications.

MATERIALS AND METHODS

Field trials with cotton cultivar Suregrow 501BRR (Delta Pine and Land, Co.; Scott, MS) were conducted in 2001 and 2002 on a Dothan sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) at the University of Florida, North Florida Research and Education Center in Quincy, FL. The experimental area was winter fallowed and sprayed with glyphosate (Roundup Ultra; Monsanto, St. Louis, MO) at 427 g a.i. ha^{-1} 2 wk before planting. Prior to planting, the experimental area was fertilized with 25, 22, and 62 kg ha^{-1} of N, P, and K, respectively. The treatments were two tillage systems (conventional and strip-till).

In the conventional tillage system, plots were disked, sub-soiled, and s-tine-harrowed. The strip-till treatment consisted of using a Brown Ro-till implement (Brown Manufacturing Co.; Ozark, AL) designed to rip the rows approximately 38 cm deep and create a 18-cm wide seedbed. Cotton was planted using a Monosem air planter (A.T.I. Inc./Monosem; Lenexa, KS) at 11 seeds m^{-1} row on 11 May and 12 April in 2001 and 2002, respectively. Each plot (7.3 by 9.9 m) consisted of 8 rows on 91-cm row spacing. The conventional and strip tillage sections were broadcast sprayed with glyphosate at 427 g a.i. ha^{-1} when cotton was at the 3- to 5- node stage and direct sprayed at the same rate at 8- to 10- and 12- to 15-node stages. Cotton was side-dressed with 67 kg N ha^{-1} at 27 DAP. When 60 to 70% of cotton bolls were opened, the plants were defoliated with a mixture of thidiazuron (Dropp SC, Bayer CropScience LP; Research Triangle Park, NC) at 0.4 kg a.i. ha^{-1} and ethephon plus cyclanilide (Finish 6 PRO, Bayer CropScience LP; Research Triangle Park, NC) at 1.3 kg a.i. ha^{-1} and 162 g a.i. ha^{-1}, respectively. Adjuvant (Agri-dex, Helena Chemical Co.; Memphis, TN) at 1.2 L ha^{-1} was added to the mixture. Cotton was picked with an International 782 spindle picker (International Harvester Co.; Chicago, IL) on 15 and 18 November in 2001 and 2002, respectively.

Weed cover, which consisted of annual weeds, was assessed visually on 10, 20, and 60 days after the last glyphosate treatment (DAT). The rating scale was 0 to 100 with 0 having no cover and 100 having complete weed cover. Plant stand, plant height, boll number, and yield data were collected from the two adjacent middle rows of each plot. Plant stand was determined by counting the number of plants that emerged 2 wk after planting. Number of bolls per plant was obtained from 10 plants per plot at 120 DAP. Cotton bolls were recorded from the first to fifth lateral fruiting position on sympodial (fruiting) branches. Lint yield was calculated based on lint percentage in ginned cotton sample (908 g) from each plot.

Weather data was collected from a weather station located at the North Florida Research and Education Center, Quincy, FL (84˚ 33’ W, 30˚ 36’ N). The monthly average air temperatures and and total rainfall and 20-year (1981 to 2000) averages during the growing season are summarized in Table 1. Air temperature and precipitation was different between years compared with the 20-year average data. Com-

Table 1. Air temperature and rainfall for 2001 and 2002 growing seasons and 20-year averages at Quincy, FL

Month	Average monthly air temperature (°C)			Rainfall (mm)		
	2001	2002	20 year avg.	2001	2002	20 year avg.
March	14.3	15.6	15.6	252	58	167
April	19.9	22.0	18.5	30	35	106
May	22.7	23.6	22.8	28	77	122
June	26.0	26.2	25.8	310	109	154
July	25.8	27.2	27.1	133	140	167
August	25.8	26.9	26.7	142	61	149
September	24.1	25.9	25.0	194	223	101
October	18.3	21.6	20.4	68	132	94
November	18.0	12.7	15.9	4	59	103

pared with the 20-year averages, air temperatures were 1.3 to 2.1°C lower in March, July, October, and November of 2001. In 2002, air temperatures were 1.2 to 3.5°C higher in April and October but 3.2°C lower in November compared to the 20-year averages. Rainfall was generally lower during the study compared to the 20-year average, except for higher precipitation in March, June, and September of 2001 (252, 310, and 194 mm, respectively), and September and October of 2002 (223 and 132 mm).

The experimental design was a randomized complete block arrangement of treatments with four replications. Years and tillage treatments were considered fixed effects. Blocks and interactions including blocks were assumed to be random effects. The PROC MIXED procedure of SAS (SAS Institute; Cary, NC) with the LSMEANS PDIFF option was used to compare tillage systems at $P \leq 0.05$.

RESULTS AND DISCUSSION

The year by tillage interaction was significant for cotton stand (Table 2). Plant stands were greater for conventional than strip tillage in 2002, but was not different between tillage treatments in 2001 (Table 2). Johnson et al. (2001) reported greater cotton stands in conventional than reduced tillage in some years but less in other years. Weed control averaged across years (primarily annuals) was better in conventional tillage than in strip tillage at 30 DAT but was not affected by tillage at 10 and 60 DAT (Table 2). Hooker et al. (1997) found that weeds were effectively managed with herbicide inputs in conservation tillage systems. A single application of glyphosate was not adequate to control weeds, but weed control was nearly complete when followed by a post-directed spray (Hayes et al., 1996). Johnson et al. (2001) noted that no consistent trend in tillage effects was observed at midseason weed control.

Plant height was not influenced by tillage at 60 DAP, but the year by tillage interaction was significant for plant height at 90 DAP (Table 2). At 90 DAP, plants were taller from conventional tillage than from strip tillage in 2002, but plant height was not influenced by tillage in 2001 (Table 2). When averaged across both years, taller plants were observed in conventional than in strip tillage at 120 DAP (Table 2). Lascano et al. (1994) reported

Table 2. Effect of conventional (conv.) and strip tillage and the year × treatment interaction on plant stand, weed cover, plant height, main stem node number, bolls per plant, and lint yield

Variable	Stage [y]	2001		2002		Average		Yr × trmt [z]
		Conv.	Strip	Conv.	Strip	Conv.	Strip	
Stand	14 DAP	9.9 a	10.6a	7.9 a	4.1 b	8.6 a	7.4 a	*
Weed cover	10 DAT	1.0 a	3.3 a	1.8 a	1.5 a	1.4 a	2.4 a	NS
(%)	30 DAT	1.3 a	3.0 a	1.3 a	5.3 a	1.3 b	4.1 a	NS
	60 DAT	1.3 a	3.0 a	12.5 a	21.3 a	6.9 a	12.1 a	NS
Plant height	60 DAP	0.80 a	0.74 a	0.75 a	0.62 a	0.78 a	0.68 a	NS
(cm)	90 DAP	1.08 a	1.10 a	0.92 a	0.88 b	1.00 a	0.99 a	*
	120 DAP	1.16 a	1.11 a	0.91 a	0.90 a	1.03 a	1.01 b	NS
Main stem nodes	60 DAP	10.4 a	9.8 a	13.8 a	13.6 a	12.1 a	11.7 a	NS
(no. plant^{-1})	90 DAP	15.7 a	16.0 a	17.7 a	19.2 a	16.7 b	17.6 a	NS
	120 DAP	17.7 a	16.5 a	16.6 b	18.9 a	17.2 a	17.7 a	**
Boll	First Pos.	6.5 a	6.4 a	7.2 a	7.9 a	6.9 a	7.2 a	NS
(no plant^{-1})	Second Pos	3.6 a	2.9 a	5.1 b	6.9 a	4.4 a	4.9 a	*
	Third Pos.	1.1 a	1.2 a	2.1 b	4.2 a	1.6 b	2.8 a	*
	Total	11.2 a	10.9 a	15.1 b	21.1 a	13.1 b	16.0 a	*
Lint yield		1082 a	1211 a	832 a	717 a	957 a	964 a	NS
(kg ha^{-1})								

[y] DAP = days after planting; DAT = days after last glyphosate application.

[z] NS, * , ** = not significant, significant at $P \leq 0.05$, and significant at $P \leq 0.01$, respectively, according to analysis of variance.

taller plants in strip-tilled cotton than in conventionally-tilled cotton.

When averaged across years, tillage did not influence number of plant nodes at 60 DAP, but at 90 DAP number of nodes was greater in strip-tilled than conventional cotton. An interaction of year by tillage was noted for number of plant node at 120 DAP (Table 2). More plant nodes were observed from strip than from conventional tillage in 2002, but tillage did not influence the number of nodes in 2001. The results for the number of plant nodes at 90 DAP (averaged over years) and 120 DAP in 2002 agree with Triplett et al. (1996), who reported more nodes on cotton grown in reduced than conventional tillage.

Boll number on the first position was not influenced by tillage, but a year by tillage interaction was observed for boll number on the second and third position, and total boll number per plant (Table 2). In 2002, boll number on the second and third position, and total boll number per plant were greater on strip-tilled than on conventionally grown cotton.

Tillage did not influence lint yields of cotton (Table 2). Similar yields despite increased total boll numbers per plant agrees with the results reported by others (Hicks et al., 1989; Triplett et al., 1996; Johnson et al., 2001; Stevens et al., 1992; Paxton et al., 1993). The greater number of bolls per plant without an accompanying yield increase probably reflects a reduced plant stand in the strip tillage treatment in 2002.

SUMMARY

Plant stand and plant height in conventional tillage were either equal to or greater than in strip tillage. In contrast, main stem node numbers and boll numbers in strip tillage were either greater than or equal to that found in conventional tillage. Conventional tillage had greater weed control at 30 DAT, but this did not translate into a lint yield difference. These results indicate that growing cotton in a strip-till system resulted in similar plant morphology as conventional tillage, and indicated that both systems provide viable options for cotton production in the southeast USA.

ACKNOWLEDGEMENT

This research was supported by the Florida Agricultural Experiment Station and approved for publication as Journal Series No. R-09921.

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