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EVALUATION OF WEED CONTROL AND COTTON GROWTH AND YIELD IN CONVENTIONAL AND REDUCED TILLAGE COTTON PRODUCTION

Kwame O. Adu-Tutu, William B. McCloskey, Stephen H. Husman, Michael J. Ottman, Patrick A. Clay, Edward C. Martin, and Trent Teegerstrom
University of Arizona
Tucson, AZ

Abstract

Field experiments were established at the University of Arizona Marana and Maricopa Agricultural Centers as part of a cotton/small grain crop rotation conservation tillage project. In the 2002 cotton season, no-till planting of cotton into a dead barley cover or barley stubble, and elimination of cultivation for weed control greatly reduced the number of cultural operations required to grow a cotton crop. Adequate cotton weed control was achieved in reduced tillage systems using only postemergence herbicides, and a computerized weed-sensing, automatic spot spray technology reduced the amount of spray volume and herbicide used to control weeds. The reduction in herbicide spray volumes was more pronounced in cotton that had been planted into a thick layer of barley cover crop residues than in cotton that had been planted after a barley grain crop. Cotton yields in conservation tillage systems were similar to, or slightly lower than, yields in conventional tillage systems, and early cotton planting into barley cover crop residues tended to outyield cotton planted late following a barley grain crop. Solum barley was successfully planted on existing beds after shredding cotton stalks without tillage using a John Deere 1560 no-till grain drill, reducing costs associated with complying with pink bollworm control regulations.

Introduction

Cotton farmers in Arizona use disking and many other forms of mechanical soil disturbance each year (Bryson and Keeley, 1992) in conjunction with using pre-emergence herbicides and to prepare fields for cotton planting. Farmers consider cultivation or tillage to be necessary for aerating the soil and promoting plant growth, breaking the surface crust, breaking or penetrating hardpans and especially for controlling weeds between rows and maintaining furrows for efficient irrigation. Kaddah (1977) found that reduced-tillage cotton had higher yield and greater profits than conventional cotton, indicating that not all of the many tillage practices conducted in conventional systems are necessary for cotton production. Clay *et al.* (2000) and Husman *et al.* (2000) found that reduced-tillage practices could save money in ultra-narrow row cotton production. The presence of crop residue over time may increase soil organic matter content, improve soil tilth, and increase the moisture holding capacity, cation exchange capacity and overall productivity of the soil (Boquet *et al.*, 1997; Daniel *et al.*, 1999; Smart and Bradford, 1999).

Pre-emergence herbicides are applied in anticipation of weed populations, the density of which cannot be easily determined beforehand. This practice wastes chemical and increases the pesticide load on the environment. Postemergence herbicides are generally applied either broadcast or in bands to entire fields regardless of whether or not weeds are present, and they may not control all species of weeds effectively in many situations. Postemergence herbicides can be efficiently applied using chlorophyll/plant sensing automatic spot sprayers (Hanks and Beck, 1998). Hanks and Beck (1998) found that the amount of Roundup spray applied in soybeans was reduced 63-85% by using the weed-sensing automatic spot spray technology. Since herbicide is sprayed only where weeds exist, higher rates of herbicides and more potent herbicide tank mixtures can be used without tremendously increasing weed control costs.

The experimental objectives were to evaluate the planting of cotton into cover crop residues or into small grain crop stubble without tillage, to evaluate a weed-sensing automatic spot sprayer and to test postemergence herbicide weed control programs in reduced tillage cotton, and to compare reduced tillage and conventional tillage cotton production systems.

Materials and Methods

An experiment was initiated at the University of Arizona Marana Agricultural Center in the fall of 2001 in a field with clay soil. The treatments were: (1) conventional tillage plots that were fallow in the winter followed by conventional tillage and cotton planting in April (early planting); (2) conventional tillage plots that were fallow in the winter followed by conventional tillage and cotton planting in May at the same time as treatment 3 (late planting); (3) minimum tillage or no-till planting of a barley cover crop followed by a no-till early cotton planting (there were three subplots: one brittle stem barley subplot and two Solum barley subplots); and (4) minimum tillage or no-till planting of a Solum barley grain crop followed by a no-till late cotton planting. In the fall of 2002, only a Solum barley cover crop was planted. In fall of 2002, the experiment was duplicated at the University of Arizona Maricopa Agricultural Center.

Marana

Initial field preparation at Marana in 2001 consisted of ripping (twice), disking (twice), disking (twice) after spreading fertilizer, listing beds and cultipacking. Barley was planted in both minimum tillage treatments (3 and 4) at 72 lb/A seeding rate in December 2001 and killed in March 2002 using glyphosate at 1.12 lb ae/A (Roundup UltraMax at 40 oz/A). The barley grain crop was harvested immediately prior to planting the late cotton. Beds in the conventional tillage treatments were re-disked and relisted, before cotton was planted. Cotton cultivar DB 422 BR was planted early on 17 April 2002 and late on 3 May 2002. A standard John Deere 7100 MaxEmerge 4-row planter was used to plant the conventional tillage cotton. A Yetter Farm Equipment 2976 residue manager/coulter assembly unit was bolted to each planter unit for planting cotton in the reduced tillage treatments.

Weed control in the conventional tillage treatments was obtained using pre-plant incorporated herbicides [pendimethalin at 0.72 lb ai/A (Prowl 3.3 at 28 oz/A) and prometryn at 0.88 lb ai/A (Prometryne at 28 oz/A)], four cultivation operations, and hand weeding. A topical, broadcast application of glyphosate (Roundup UltraMax) at 0.75 lb ae/A (26 oz/A) + ammonium sulfate (AMS) at 2% w/w was made in the reduced tillage/barley cover crop-early cotton treatment on 8 May, 2002; the application was repeated on 29 May, 2002 in the two no-till treatments. On 27 June 2002, glyphosate at 0.75 lb ae/A (Roundup UltraMax at 26 oz/A) + AMS at 2% w/w was applied post-directed to the cotton seed line and glyphosate at 1.5 lb ae/A (Roundup UltraMax at 52 oz/A) + AMS at 2% w/w was applied under RedBall 410 conservation tillage spray hoods equipped with three 95 degree even flat fan nozzles. Two of the hoods were modified by installing three WeedSeeker weed-sensing, intermittent spray units (NTech Industries, Inc.) in each hood to automatically detect and spot treat weeds in the furrows. This allowed comparison of the WeedSeeker spray units in two hoods and continuous spray nozzles in other hoods in terms of spray volume applied and weed control of predominant weeds. All spray hoods had 80 degree flat fan nozzles on single swivels mounted at the rear of the hoods to post-direct spray at the base of the cotton plants in the seed line. On 15 July 2002, a layby application of glyphosate at 0.75 lb ae/A (Roundup UltraMax at 26 oz/A) + prometryn at 1.6 lb ai/A (Prometryne at 50.9 oz/A) + AMS at 1% w/w was made in all treatments using Redball 410 layby hoods.

In Fall 2002 after the cotton stalks had been shredded to about 6 to 10 in from the ground, Solum barley was planted on the old beds without tillage in all no-till treatments at a seeding rate of 51 lb/A using a 10-ft wide John Deere 1560 no-till grain drill. Cotton stalks in the conventional tillage plots were root-pulled. The conventional tillage plots were deep ripped and disked and new beds were listed and roto-mulched before planting cotton in the spring. In spring 2003, cotton cultivar DeltaPine 449 BR was dry-planted in the winter fallow, conventional tillage early plant cotton and the Solum barley cover crop, no-till, early plant cotton treatments with or without the Yetter residue manager/coulter assembly attachments described above.. Late cotton cultivar DeltaPine 458 BR was planted in the winter fallow, conventional tillage late plant cotton and the Solum barley grain crop, no-till late plant cotton treatments.

A pre-plant application of pendimethalin at 1.44 lb ai/A (Prowl 3.3 EC at 56 oz/A) + prometryn at 1.76 lb ai/A (Prometryne at 56 oz/A), a postemergence glyphosate-based application, handweeding in some plots and two cultivation operations were used for weed control in the conventional tillage treatments in 2003. Glyphosate at 0.75 lb ae/A (Roundup UltraMax at 26 oz/A) + AMS at 1% w/w was post-directed to the base of the cotton plants and glyphosate at 1.5 lb ae/A (Roundup UltraMax at 52 oz/A) + carfentrazone-ethyl at 0.008 lb ai/A (Aim at 0.5 oz/A) + AMS at 2% w/w was applied under hoods with or without weed-sensing units, respectively in the early plant no-till cotton treatment. On 10 June 2003, a topical-broadcast application of glyphosate at 1.12 lb ae/A (Roundup UltraMax at 40 oz/A) + AMS at 2% w/w was made in the late plant cotton. On 3 July 2003, glyphosate at 0.75 lb ai/A (Touchdown at 32 oz/A) + carfentrazone-ethyl at 0.016 lb ai/A (Aim at 1 oz/A) + AMS at 2% w/w was applied under hoods while simultaneously applying glyphosate at 0.75 lb ai/A (Touchdown at 32 oz/A) + prometryn at 0.5 lb ai/A (Prometryne at 15.9 oz/A) + AMS at 2% w/w to the base of the cotton plants in the early plant, no-till treatment. A similar application was made in the late plant no-till treatment on 6 July 2003. A layby application of glyphosate at 0.5 lb ai/A (Touchdown 32 oz/A) + carfentrazone-ethyl at 0.016 lb ai/A (Aim at 1 oz/A) + prometryn 1.2 lb ai/A (Prometryne at 38.2/A) + AMS at 1% w/w + Herbimax @ 1% v/v was made in all treatments, both early and late plant cotton, using a RedBall 420 layby sprayer.

Maricopa

Initial field preparation at Maricopa consisted of disking, landplaning, listing and roto-mulching in the fall of 2002. Solum barley cover and grain crops were planted at 100 and 25 lb/a seeding rate, respectively, using a John Deere 8200 4-row grain drill. The cover crop was killed with glyphosate at 1.5 lb ae/A. (Roundup UltraMax at 52 oz/A) + AMS at 2% w/w. Prior to planting cotton, the conventional tillage plots were disked again and the beds re-listed and shaped. Planting method and cotton cultivars were similar to those used at Marana.

In the conventional tillage plots, a pre-plant application of pendimethalin at 0.82 lb ai/A (Prowl 3.3 EC at 32 oz/A), postemergence glyphosate-based herbicide applications and three cultivations were done for weed control. Glyphosate at 0.75 lb ae/A (Roundup UltraMax at 26 oz/A) + AMS at 1% w/w was broadcast sprayed topically in the early plant cotton treatments on 23 May 2003. Glyphosate at 0.75 lb ai/A) (Touchdown at 32 oz/A) + prometryn at 0.5 lb ai/A (Caparol at 15.9 oz/A) + AMS at 1% w/w was sprayed post-directed to the seed line, and glyphosate at 0.75 lb ai/A (Touchdown at 32 oz/A) + carfentrazone-ethyl at 0.016 lb ai/A (Aim at 1 oz/A) + AMS at 1% w/w was sprayed under hoods with or without weed-sensing units as used in the Marana experiment in the early, no-till treatment on 11 June 2003. Glyphosate at 0.75 lb ai/A (Touchdown at 32 oz/A) + prometryn at 0.5 lb ai/A (Caparol at 15.9 oz/A) + AMS at 1% w/w was sprayed post-directed to the seed line in the conventional tillage plant cotton treatment on the same date. On 11 June 2003, a topical, broadcast application of glyphosate at 1.12 lb ae/A (Roundup UltraMax at 40 oz/A) + AMS at 1% w/w was made in the late plant cotton treatments. The post-directed application made in the early plant cotton treatments on 11 June 2003 was repeated in the late plant cotton treatments on 8 July 2003.

In the no-till, early plant treatment, glyphosate at 0.75 lb ai/A (Touchdown at 32 oz/A) + prometryn at 1.2 lb ai/A (Caparol 38.4 oz/A) + AMS at 2% w/w was applied as a continuous spray layby treatment to the base of the cotton plants and glyphosate at 0.75 lb ai/A (Touchdown at 32 oz/A) + carfentrazone-ethyl at 0.016 lb ai/A (Aim at 1 oz/A) + prometryn at 1.2 lb ai/A (Caparol at 38.2 oz/A) + AMS at 2% w/w was similarly applied under hoods on 25 July 2003. Glyphosate at 0.75 lb ai/A (Touchdown at 32 oz/A) + prometryn at 1.2 lb ai/A (Caparol at 38.2 oz/A) + AMS at 2% w/w was applied to base of the cotton plants in the conventional tillage early plant cotton treatments. The late plant cotton treatments, either no-till or conventional tillage, received the same layby herbicide treatment as the corresponding early treatment.

Results and Discussion

Generally, cotton planting method and the presence of barley crop residues or grain stubble did not affect cotton seedling emergence and establishment (Table 1). However, at Marana in 2002, emergence was significantly less in the conventional tillage, late-planted cotton treatment compared to the other treatments. This was caused by hot air and soil temperatures which dried out the pre-irrigated seedbed before germination and emergence were completed, despite planting the seed in moisture. This problem was solved in the 2003 season by dry-planting and then irrigating to germinate the cotton seed.

Data in Tables 2 and 3 show that the weed-sensing, automatic spray technology reduced herbicide spray volumes by 47-90% at Marana in 2002 and 2003. At Maricopa, a 99% reduction was obtained in the early-planted no-till cotton which was planted into a thick layer of crop residue. In contrast, there was no substantial reduction (6.9%) in the late-planted, no-till cotton following a barley grain crop because of volunteer barley germination. Weed control generally did not differ between the two spray technologies; however, control of annual sowthistle (*Sonchus oleraceus* L.) at Marana and sprangletop (*Leptochloa uninerva* {Presl} Hitchc. & Chase) at Maricopa was not as good with the weed-sensing technology as with conventional continuous spray technology (Table 4). Timely herbicide application, higher boom pressure and larger spray volumes per acre that ensure better spray coverage may be necessary for effective control of these weeds. The postemergence herbicide program in the reduced tillage systems was as effective in controlling weeds as the combined pre-emergence herbicides, the numerous cultivations, postemergence herbicides and hand-weeding used in the conventional tillage systems (Tables 5 and 6).

At both Marana (2002) and Maricopa (2003), there was a trend for higher lint yields from the early-planted cotton compared to the late-planted cotton (Table 7). The early-planted, conventional tillage cotton tended to give the highest yields. At Maricopa, the early-planted, conventional tillage treatment (1141 lb/A) significantly out-yielded the early-planted, no-till treatment (956 lb/A); a similar trend was observed among the two late-planted treatments, though differences were not statistically significant. At Marana (2003), while there were no statistical differences in yields between the treatments, numerically the no-till treatments tended to have lower yields.

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Table 1. Cotton emergence and establishment in the various tillage and barley cover/grain crop treatments at the Marana and Maricopa Agricultural Centers. Stand counts were made in 10 1-m long subplots in each plot and the row spacing was approximately 40 inches.

		Plants/meter of row	
Location	**Grain/Tillage/Cotton System**	**2002**	**2003**
Marana	Winter fallow, conventional tillage, early cotton planting	11.6 a	12.2 a
	Solum barley cover, no-till, early cotton planting	11.6 a	14.5 a
	Brittle stem barley cover, no-till, early cotton planting	10.8 a	-
	Winter fallow, conventional tillage, late cotton planting	7.6 b	13.8 a
	Solum barley grain crop, no-till, late cotton planting	11.9 a	13.7 a
	LSD (P=0.05)	2.49	ns
	CV (%)	15.1	8.1
Maricopa	Winter fallow, conventional tillage early cotton planting	-	10.3 a
	Solum barley cover, no-till early cotton planting	-	9.6 a
	Winter fallow, conventional tillage late cotton planting	-	10.6 a
	Solum barley grain crop, no-till late cotton planting	-	10.3 a
	LSD (P=0.05)	-	ns
	CV (%)		6.19

*Values are means of 4 replications; means from the same location in the same column followed by the same letter are not different at the P=0.05 significance level according to the Student-Newman-Keuls significant difference test; LSD=least significant difference and CV=coefficient of variation.

Table 2. Herbicide spray volumes in gallons per acre (GPA) applied by NTech Industries WeedSeeker weed-sensing, automatic spot sprayer versus conventional continuous flat fan spray nozzles in gallons per acre (GPA) at the Marana Agricultural Station in 2002 and 2003.

	Sprayer	**Spray volume (GPA)**		
Tillage/grain/cotton treatment	**technology**	**7/27/02**	**6/02/03**	**7/03/03**
Minimum tillage, Solum barley	Continuous	20.38 a*	20.31 a	25.04 a
cover crop, early cotton planting	Weed sensing	4.33 b	10.67 b	11.83 b
Minimum tillage, brittle stem barley	Continuous	19.88 a	-	-
cover crop, early cotton planting	Weed Sensing	5.13 b	-	-
Minimum tillage, Solum grain crop,	Continuous	24.41 a	-	-
late cotton planting	Weed sensing	2.30 b	-	-
LSD (P=0.05)		3.95	5.83	2.00
CV (%)		20.59	16.73	4.82

*Values are means of 4 replications; means in a column followed by the same letter are not different at P=0.05 according to the Student-Newman-Keuls significant difference test; LSD=least significant difference and CV=coefficient of variation.

Table 3. Herbicide spray volumes in gallons per acre (GPA) applied by NTech Industries WeedSeeker weed-sensing, automatic spot sprayer versus conventional continuous flat fan spray nozzles at the Maricopa Agricultural Station, 2003.

Tillage/grain/cotton treatment	Sprayer technology	Spray volume (GPA) 6/11/03	7/08/03
Minimum tillage, Solum barley	Continuous	27.02 a*	-
cover crop, early cotton planting	Weed sensing	0.29 b	-
Minimum tillage, Solum grain crop,	Continuous	-	27.29 a
late cotton planting	Weed sensing	-	25.41 a
LSD (P=0.05)		7.32	ns
CV (%)		23.84	4.91

*Values are means of 4 replications; means in a column followed by the same letter are not different at P=0.05 according to the Student-Newman-Keuls significant difference test; LSD=least significant difference, OSL=observed significance level, and CV=coefficient of variation.

Table 4. Percent weed control from weed-sensing automatic spray technology versus continuous spray at Marana (evaluated on 17 July 2003) and Maricopa (evaluated on 21 July 2003).

	Sprangletop	Morningglory	Volunteer barley	Russian thistle	Sowthistle
Marana continuous spray	94.38 a	97.63 a	95.00 a	90.00 a	93.75 a
Marana weed-sensing unit	89.38 a	94.63 a	93.13 a	88.75 a	87.88 b
LSD (P=0.05)	Ns	ns	Ns	ns	3.16
CV (%)	5.51	4.92	4.18	11.23	3.07

	Volunteer barley	Skeletonweed	Common purslane	Sprangletop	Horse purslane
Maricopa continuous spray	97.00 a	98.13 a	89.75 a	91.00 a	95.38 a
Maricopa weed-sensing unit	96.00 a	97.50 a	84.75 a	86.00 b	94.13 a
LSD (P=0.05)	ns	ns	ns	4.13	ns
CV (%)	2.50	2.73	6.51	4.12	4.38

*Values are means of 4 replications; means in a column at the same location followed by the same letter are not different atP=0.05 according to the Student-Newman-Keuls significant difference test; LSD=least significant difference, OSL=observed significance level, and CV=coefficient of variation.

Table 5. Percent weed control at the Marana Agricultural Center in 2003.

Grain/tillage/cotton system	Ivyleaf morningglory 6/19/03	9/03/03	Annual sowthistle 6/19/03	9/03/03
Solum barley cover crop, minimum tillage, early cotton planting	67.5 b	88.2 a	57.2 c	100.0 a
Solum barley grain crop, minimum tillage, late cotton planting	97.0 a	92.8 a	87.5 b	100.0 a
Winter fallow, conventional tillage, early cotton planting	95.0 a	76.2 a	100.0 a	100.0 a
Winter fallow, conventional tillage, late cotton planting	100.0 a	71.2 a	100.0 a	100.0 a
LSD (P=0.05)	9.8	Ns	6.3	ns
CV (%)	6.8	12.5	4.6	0

*Values are means of 4 replications; means in a column followed by the same letter are not different at P=0.05 according to the Student-Newman-Keuls significant difference test; LSD=least significant difference and CV=coefficient of variation.

Table 6. Percent weed control at the Maricopa Agricultural Center in 2003.

Grain/tillage/cotton system	6/09/03 Common purslane	8/26/03 Volunteer barley	Common purslane	Volunteer barley
Winter fallow, conventional tillage, early cotton planting	100.00 a*	73.8 b	100.00 a	100.00 a
Solum barley cover crop, no-till, early cotton planting	96.5 b	98.8 a	100.00 a	99.50 a
Winter fallow, conventional tillage, late cotton planting	-	-	96.25 a	98.75 a
Solum barley cover crop, no-till, late cotton planting	-	-	99.75 a	98.25 a
LSD (P=0.05)	2.76	ns	ns	ns
CV (%)	1.25	1.78	2.47	2.02

*Values are means of 4 replications; means in a column followed by the same letter are not different at P=0.05 according to the Student-Newman-Keuls significant difference test; LSD=least significant difference and CV=coefficient of variation.

Table 7. Cotton yields measured in the various cotton-barley/tillage systems at the Marana Agricultural Center in 2002 and 2003.

	Lint (lb/A)		
	Marana		Maricopa
Grain/Tillage/Cotton System	2002	2003	2003
Winter fallow, conventional tillage, early cotton planting	1140 a*	1129 a*	1141 a
Barley cover crop, no-till, early cotton planting	1089 ab	946 a	956 b
Winter fallow, conventional tillage, late cotton planting	827 c	1080 a	856 bc
Solum barley grain crop, no-till, cotton planting	927 bc	968 a	759 c
LSD (0.05)	163	ns	163
CV (%)	10.2	12.2	9.2

*Values are means of 4 replications; means in a column followed by the same letter are not different at P=0.05 according to the Student-Newman-Keuls significant difference test; LSD=least significant difference and CV=coefficient of variation.