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Johnsongrass and Palmer Amaranth Control in Conventional-Till and No-Till Systems with Roundup Ready Cotton

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INTRODUCTION

Cotton producers in the Mississippi Delta have been slow to adopt no-till production practices. Among the many reasons for this slow adoption are an apparently very low soil erosion rate on the flat Delta topography, the demonstrated positive yield response obtained with subsoiling the best sandy and silt loam cotton soils, the positive response from deep placement of potash, and the historical necessity for planting on an elevated bed for proper surface drainage and soil temperature. Due to fiscal restraints for replacing equipment and lack of adequate labor, there are recent trends toward the use of less tillage. Also, weed control procedures and products that allow growers greater latitude with weed management decisions have become more available. The inclusion of corn into a rotation system under "freedom-to-farm" legislation assists in maintaining/increasing soil "tilth," which also has a positive bearing on cotton yield and management.

The objective of this research was to evaluate cotton weed management systems with conventional and no-tillage systems in a large natural population of rhizome johnsongrass [*Sorghum halepense* (L.) Pers.] and Palmer amaranth (*Amaranthus palmeri* S. Wats).

MATERIALS AND METHODS

The experiment was conducted on a site naturally infested with a large population of johnsongrass and Palmer amaranth (pigweed). The experiment was not irrigated. The soil type was silt loam (Mollic hapludalfs) with a pH of 6.4 and 1.1% organic matter. A split-plot experimental design was used with six replications. Main plot treatments (Table 1) were (A) conventional-till and (B) no-till, each 16 rows wide and 40 feet long with 40 inches between rows. Conventional treatments were cultivated three times each year. A 12-inch undisturbed band centered on the row was not cultivated. No-till was initially hipped (Nov. 14, 1996) to establish a row profile for drainage and reduced in height with a bed conditioner to level for planting. Subplot treatments (Table 2) were four weed control systems: (1) application of preplant soil incorporated (PPI) and/or preemergence (PRE) herbicides followed with postemergence directed (PODIR) applications of Cotoran + MSMA and Cy-Pro + MSMA followed with a lay-by application of Direx + surfactant; (2) PRE herbicides at 50% labeled rate followed with one or two over-the-top (OT) applications of Roundup Ultra to one- to four-node cotton followed with one or two PODIR Roundup Ultra applications; (3) Roundup Ultra only as in Treatment 2; and (4) an untreated check. Subplots were repeated on the same areas each year and were four rows wide and 40 feet long. Applications of herbicides (except PPI) made to conventional-till plots were directed to the drill area on a 20-inch band, while all applications to no-till plots were made broadcast. Roundup Ultra and Fusilade DX were applied in 10 gallons per acre broadcast volume, while other herbicides were applied in 20 gallons per acre. Broadcast PPI applications of Treflan were made only to conventional-till plots. Soil incorporation was performed with disking in 1997 and with a bed conditioner in 1998-2000. Beds were re-hipped soon after the

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PPI application each year. Transgenic Roundup Ready® varieties were planted each year: PM 1244RR, May 5, 1997; PM 1220BG/RR, April 27, 1998; and DP 5415RR, May 3, 1999, and May 1, 2000 (conventional-till replanted May 15).

Cotton stand was determined by counting plants in a preselected harvest row and converting to plants per acre (Table 3). Seed cotton yield was determined by mechanically picking the two center rows of each subplot, weighing the cotton, and converting the plot weight to pounds per acre (Table 4). Visual ratings (0 = no control and 100 = complete control) were made for rhizome johnsongrass and Palmer amaranth control each year in late May or early June and again in early or mid-July (Tables 5-8). Weed plants present but in numbers too low to be rated were pitted morningglory, ivyleaf morningglory, spotted spurge, prickly sida, and crabgrass.

Winter weeds in no-till were controlled with "burn-down" applications of Gramoxone Extra, Roundup Ultra, or Select (Treatment 1, 1999). A "burn-down" treatment was applied to conventional-till with Roundup Ultra in 1997 and with Gramoxone Extra to Treatment 4 in 2000 to both conventional- and no-till.

Table 1. Tillage operations, preplant herbicide use, and dates of application in conventional-till and no-till main plot treatments, 1997-2000

Treatments	1997	1998	1999	2000
(A) Conventional-Till[1]				
Subsoil – 45° to rows in 1996 between rows in 1997-99	11/14/96	10/17/97	10/9/98	9/21/99
Hip	11/14/96	11/2/97	11/30/98	10/25/99
Re-Hip	3/12, 4/15	4/15	4/14	3/8
Disk	3/12	—	—	—
Bed conditioner	4/15, 4/16	3/16, 3/24, 4/15	2/25, 4/11	3/7, 4/26
Cultivation (12-inch band on row undisturbed)	5/22, 6/16, 7/9	5/8, 5/28, 6/15	5/14, 5/24 (Trt.1), 6/7	5/24, 6/12, 6/28
Burn-down before planting				
Roundup 0.5 lb ai/A	4/21	—	—	—
Gramoxone 0.5 lb ai/A	—	—	—	5/1 (Trt. 4)
(B) No-Till[2]				
Subsoil – 45° to rows/Hip	11/14/96	—	—	—
Bed Conditioner	4/16	—	—	—
Burn-down before planting				
Roundup 1.0 lb ai/A	3/11	3/2, 4/22	2/26	—
Roundup 0.5 lb ai/A	4/21	—	4/23 (Trts. 2-4)	—
Select 0.094 lb ai/A	—	—	4/23 (Trt. 1)	—
Gramoxone 0.5 lb ai/A	—	—	—	5/1 (Trt. 4)

[1]In-season herbicides applied to 20-inch band on row.
[2]Herbicides applied broadcast.

Table 2. Subplot treatments – herbicide, application rates, and dates of application, 1997-2000.

Treatments (lb ai/A)	1997	1998	1999	2000
(1) Treflan 0.75 PPI (Conventional-Till)	3/12	3/16	2/25	3/6
Prowl 1.0 PRE (No-Till)	5/5	4/27	5/3	5/1
Cotoran 1.25 + Staple 0.047 PRE	5/5	4/27	5/3	5/1
Cotoran 1.0 + MSMA 1.5 PODIR	—	5/28	5/24	—
Cy-Pro 0.6 + MSMA 1.5 PODIR	6/18	6/15	—	6/14
Cy-Pro 0.8 + NIS 0.5% PODIR	7/8	—	—	6/27
Staple 0.063 OT	—	—	6/17	5/31
Fusilade 0.125 OT	5/19	5/18, 6/4	5/21, 6/21	5/16, 5/30
Direx or Riverside diuron 1.0 Lay-by	7/15	6/30	7/14	7/6
(2) Cotoran 0.63 + Staple 0.023 PRE	5/5	4/27	5/3	5/1
Roundup 1.0 OT	5/19, 6/6	5/18	5/21	5/12, 5/30
Roundup 1.0 PODIR	6/18, 7/8	6/8	6/17	6/20
(3) Roundup 1.0 OT	5/19, 6/6	5/18	5/21	5/12, 5/30
Roundup 1.0 PODIR	6/18, 7/8	6/24	6/17	6/20
(4) None	—	—	—	—

RESULTS

Cotton Stand

The cotton stand was marginal for optimum yield in 1997-1999 and in no-till in 2000 (Table 3). The significant interaction of tillageXweed treatment was significant in 1999. The no-till treatment without Roundup was the only treatment with herbicides that reduced the number of cotton plants per acre. This was the result of competition due to very poor Palmer amaranth control. The untreated controls produced lower stands each year with no plants counted from these plots on June 21, 2000.

Seed Cotton Yield

No cotton was harvested from the untreated control treatments in any year. All years except 2000 resulted in a tillageXweed control interaction for seed cotton yield. In 1997 and 1998, the weed control treatment of Roundup alone had lower yield but only with conventional tillage. This was the result of poor weed control when Roundup was applied only to the row. With no-till in 1998 and 1999, seed cotton yield was less with the treatment that did not include Roundup. In 2000, no-till yield was greater than conventional-till when averaged over subplots. Roundup treatments yielded greater than the treatment without Roundup when averaged over main plots.

In Table 9, seed cotton yield results are presented for herbicide treatments only because the control treatments did not produce any seed cotton. When only these treatments are considered, the tillageXweed control interaction for seed cotton yield was significant in all years and for the 1997-2000 average. No response difference occurred in 1997 with or without control treatments included. In 1998, the no-till subplot treatment of Roundup only was intermediate in yield and was not different from treatments of PRE + Roundup or PRE + PODIR without Roundup. In 1999, yield with the subplot treatment without Roundup was lower than treatments with Roundup with no-till but not with conventional-till. The treatment without Roundup was not different with either conventional-till or no-till.

In 2000 with no-till, yield with the no-Roundup treatment was lower than either treatment that included Roundup. The 4-year average seed cotton yield with the conventional-till Roundup-only treatment was lower than other treatments, while with no-till, the no-Roundup treatment was lower than other treatments. The Roundup-only treatment yield with conventional-till was lower than with no-till.

Table 3. Influence of conventional-till and no-till production systems and weed control practices on cotton stand with Roundup Ready® cotton, 1997-2000.

Treatments	Plants per acre			
	1997	1998	1999	2000
	x1,000	*x1,000*	*x1,000*	*x1,000*
Main plot[1]				
(A) Conventional-Till	26 a	27 a	27	30 a
(B) No-Till	27 a	27 a	24	20 b
Subplot[1]				
(1) PPI + PRE + 2 PODIR + 1-3 OT + Lay-by	29 a	33 a	25	31 a
(2) PRE + 1-2 OT + 1-2 PODIR	26 ab	30 a	28	33 a
(3) 1-2 OT + 1-2 PODIR	29 a	29 a	27	34 a
(4) None	23 b	17 b	22	0 b
Main Plot X Subplot[2]				
AX1	26	34	28 a A	38
AX2	27	30	29 a A	40
AX3	29	28	28 a A	41
AX4	22	17	22 b A	0
BX1	31	31	21 b B	24
BX2	26	30	27 a A	27
BX3	30	29	26 a A	28
BX4	23	18	22 b A	0

[1]Within each column of main plot or subplot means, different letters indicate a significant difference (P=.05).
[2]Within each column, different lowercase letters indicate a significant difference (P=.05) between subplot means with the same main plot (for example, compare means 1-4 in A and means 1-4 in B). Uppercase letters indicate a significant difference (P=.05) between main plot means with the same subplot (for example, compare means AX1, BX1; AX2, BX2; etc.).

Table 4. Influence of conventional-till and no-till production systems and weed control practices on seed cotton yield with Roundup Ready® cotton, 1997-2000.

Treatments	Seed cotton yield			
	1997	1998	1999	2000
	lb/A	*lb/A*	*lb/A*	*lb/A*
Main plot[1]				
(A) Conventional-Till	2,103	1,390	1,354	1,009 b
(B) No-Till	2,293	1,686	1,398	1,355 a
Subplot[1]				
(1) PPI + PRE + 2 PODIR + 1-3 OT + Lay-by	3,214	1,924	1,580	1,171 b
(2) PRE + 1-2 OT + 1-2 PODIR	3,020	2,488	1,962	1,788 a
(3) 1-2 OT + 1-2 PODIR	2,558	1,741	1,963	1,770 a
(4) None	0	0	0	0 c
Main plot X Subplot[2]				
AX1	3,290 a A	1,951 a A	1,883 a A	1,061
AX2	2,972 a A	2,329 a A	1,769 a A	1,485
AX3	2,148 b B	1,281 b B	1,763 a A	1,491
AX4	0 c A	0 c A	0 b A	0
BX1	3,139 a A	1,897 b A	1,276 b B	1,282
BX2	3,067 a A	2,646 a A	2,154 a A	2,091
BX3	2,967 a A	2,201 a A	2,163 a A	2,048
BX4	0 b A	0 c A	0 c A	0

[1]Within each column of main plot or subplot means, different letters indicate a significant difference (P=.05).
[2]Within each column, different lowercase letters indicate a significant difference (P=.05) between subplot means with the same main plot (for example, compare means 1-4 in A and means 1-4 in B). Uppercase letters indicate a significant difference (P=.05) between main plot means with the same subplot (for example, compare means AX1, BX1; AX2, BX2; etc.).

Johnsongrass Control

Main plot ratings appear low for johnsongrass and Palmer amaranth control (Tables 5-8). Bear in mind that the control plot ratings are included, which considerably reduce these values. Without the control plot ratings, the 4-year average johnsongrass control values for the conventional-till main plot were 90% for May/June and 87% for July; for no-till, 95% for May/June and 93% for July. Without the control plot ratings, the 4-year average Palmer amaranth control values for the conventional-till main plot were 96% for May/June and 89% for July; for no-till, 92% for May/June and 90% for July.

In May 1997, June 1999, and June 2000, early johnsongrass control with Roundup was excellent, except with the Roundup-alone treatment in 1997 (Table 5). In 1998, johnsongrass control was lower with all herbicide treatments in conventional-till. The no-Roundup treatment was also lower in control than treatments including Roundup, but it was still excellent. In July 1997 and 1999, johnsongrass control was very similar in that both treatments including Roundup resulted in increased control with no-till (Table 6). Within both tillage systems, the Roundup-alone treatment gave less control than the combination treatment of PRE followed by Roundup. The no-Roundup treatment in 1997 was not different from Roundup, except that it was lower with no-till. In 1999, all treatments gave good to excellent johnsongrass control, except for the Roundup-alone treatment with conventional-till. In 1998 and 2000, the PRE + Roundup gave higher control than the treatment without Roundup, but it was not different from the Roundup-only treatment.

Palmer Amaranth Control

In May 1997, control with Roundup only was less in conventional-till than in no-till, and it was less than PRE followed by Roundup in both tillage systems (Table 7). In 1998, the treatment without Roundup gave less control than Roundup treatments. In June 1999, the treatment without Roundup gave less control in no-till while also giving less control than other herbicide treatments in both conventional-till and no-till systems. In June 2000, subplot treatment ratings were similar to May 1998 ratings. In 2000, control with conventional-till treatments was better than no-till. In July 1997 and 1998, the Roundup-only treatment gave less Palmer amaranth control in conventional-till than in no-till (Table 8). In no-till in 1997-1999, the treatment without Roundup gave less control than other herbicide treatments, except in 1997 with the Roundup-only treatment. The PRE followed by Roundup treatment gave good to excellent Palmer amaranth control in both conventional-till and no-till in 1997-1999. In 2000, treatments including Roundup gave greater control than the treatment without Roundup, regardless of tillage system.

Table 5. Visual rhizome johnsongrass control in May/June with selected herbicides in conventional-till and no-till production systems and with Roundup Ready® cotton, 1997-2000.

Treatments	Rhizome johnsongrass			
	5/27/97	5/27/98	6/4/99	6/6/00
	%	%	%	%
Main plot[1]				
(A) Conventional-Till	66 b	60	74 a	73 a
(B) No-Till	70 a	73	75 a	67 a
Subplot[1]				
(1) PPI + PRE + 2 PODIR + 1-3 OT + Lay-by	94 a	80	99 a	86 a
(2) PRE + 1-2 OT + 1-2 PODIR	93 a	97	100 a	98 a
(3) 1-2 OT + 1-2 PODIR	77 b	90	99 a	97 a
(4) None	8 c	0	0 b	0 b
Main plot X Subplot[2]				
AX1	95	62 b B	99	98
AX2	88	94 a B	99	97
AX3	63	86 a B	99	96
AX4	16	0 c A	0	0
BX1	92	98 ab A	98	74
BX2	99	100 a A	100	98
BX3	91	95 b A	100	96
BX4	0	0 c A	0	0

[1]Within each column of main plot or subplot means, different letters indicate a significant difference (P=.05).
[2]Within each column, different lowercase letters indicate a significant difference (P=.05) between subplot means with the same main plot (for example, compare means 1-4 in A and means 1-4 in B). Uppercase letters indicate a significant difference (P=.05) between main plot means with the same subplot (for example, compare means AX1, BX1; AX2, BX2; etc.).

Table 6. Visual rhizome johnsongrass control in July with selected herbicides in conventional-till and no-till production systems and with Roundup Ready® cotton, 1997-2000.

Treatments	Rhizome johnsongrass			
	7/3/97	7/16/98	7/1/99	7/19/00
	%	%	%	%
Main plot[1]				
(A) Conventional-Till	66	59 b	65	71 a
(B) No-Till	72	69 a	70	68 a
Subplot[1]				
(1) PPI + PRE + 2 PODIR + 1-3 OT + Lay-by	92	80 b	97	89 b
(2) PRE + 1-2 OT + 1-2 PODIR	95	92 a	91	97 a
(3) 1-2 OT + 1-2 PODIR	88	84 ab	84	94 ab
(4) None	0	0 c	0	0 c
Main plot X Subplot[2]				
AX1	91 a A	74	97 a A	94
AX2	90 a B	90	86 b B	97
AX3	82 b B	73	78 c B	94
AX4	0 c A	0	0 d A	0
BX1	92 b A	86	96 a A	83
BX2	100 a A	94	96 a A	97
BX3	94 b A	95	90 b A	93
BX4	0 c A	0	0 c A	0

[1]Within each column of main plot or subplot means, different letters indicate a significant difference (P=.05).
[2]Within each column, different lowercase letters indicate a significant difference (P=.05) between subplot means with the same main plot (for example, compare means 1-4 in A and means 1-4 in B). Uppercase letters indicate a significant difference (P=.05) between main plot means with the same subplot (for example, compare means AX1, BX1; AX2, BX2; etc.).

Table 7. Visual palmer amaranth control in May/June with selected herbicides in conventional-till and no-till production systems and with Roundup Ready® cotton, 1997-2000.

Treatment	Palmer amaranth			
	5/27/97	5/27/98	6/4/99	6/6/00
	%	%	%	%
Main plot[1]				
(A) Conventional-Till	72	72 a	72	71 a
(B) No-Till	73	71 a	64	67 b
Subplot[1]				
(1) PPI + PRE + 2 PODIR + 1-3 OT + Lay-by	99	87 b	73	77 b
(2) PRE + 1-2 OT + 1-2 PODIR	100	100 a	100	100 a
(3) 1-2 OT + 1-2 PODIR	92	99 a	100	100 a
(4) None	0	0 c	0	0 c
Main plot X Subplot[2]				
AX1	100 a A	89	89 b A	85
AX2	99 a A	100	100 a A	100
AX3	88 b B	99	100 a A	100
AX4	0 c A	0	0 c A	0
BX1	99 ab A	84	56 b B	69
BX2	100 a A	100	100 a A	100
BX3	95 b A	98	100 a A	100
BX4	0 c A	0	0 c A	0

[1]Within each column of main plot or subplot means, different letters indicate a significant difference (P=.05).
[2]Within each column, different lowercase letters indicate a significant difference (P=.05) between subplot means with the same main plot (for example, compare means 1-4 in A and means 1-4 in B). Uppercase letters indicate a significant difference (P=.05) between main plot means with the same subplot (for example, compare means AX1, BX1; AX2, BX2; etc.).

Table 8. Visual palmer amaranth control in July with selected herbicides in conventional-till and no-till production systems and with Roundup Ready® cotton, 1997-2000.

Treatments	Palmer amaranth			
	7/3/97	7/16/98	7/1/99	7/19/00
	%	%	%	%
Main plot[1]				
(A) Conventional-Till	64	68	68	67 a
(B) No-Till	71	70	65	65 a
Subplot[1]				
(1) PPI + PRE + 2 PODIR + 1-3 OT + Lay-by	90	89	80	71 b
(2) PRE + 1-2 OT + 1-2 PODIR	93	98	99	98 a
(3) 1-2 OT + 1-2 PODIR	86	89	89	95 a
(4) None	0	0	0	0 c
Main plot X Subplot[2]				
AX1	91 a A	97 a A	91 b A	76
AX2	87 ab B	96 a A	98 a A	97
AX3	78 b B	78 b B	83 b A	96
AX4	0 c A	0 c A	0 c A	0
BX1	89 b A	81 b B	68 c B	66
BX2	100 a A	100 a A	99 a A	98
BX3	94 b A	99 a A	94 b A	94
BX4	0 c A	0 c A	0 d A	0

[1]Within each column of main plot or subplot means, different letters indicate a significant difference (P=.05).
[2]Within each column, different lowercase letters indicate a significant difference (P=.05) between subplot means with the same main plot (for example, compare means 1-4 in A and means 1-4 in B). Uppercase letters indicate a significant difference (P=.05) between main plot means with the same subplot (for example, compare means AX1, BX1; AX2, BX2; etc.).

Table 9. Influence of conventional-till and no-till production systems and weed control practices on seed cotton yield of herbicide treatments with Roundup Ready® cotton, 1997-2000.

Treatments	Seed cotton yield				
	1997	1998	1999	2000	4-yr Avg.
	lb/A	lb/A	lb/A	lb/A	lb/A
Main plot					
(A) Conventional-Till	2,803	1,854	1,805	1,346	1,952
(B) No-Till	3,058	2,248	1,864	1,807	2,244
Subplot					
(1) PPI + PRE + 2 PODIR + 1-3 OT + Lay-by	3,214	1,924	1,580	1,171	1,972
(2) PRE + 1-2 OT + 1-2 PODIR	3,020	2,488	1,962	1,788	2,314
(3) 1-2 OT + 1-2 PODIR	2,558	1,741	1,963	1,770	2,008
Main plot X Subplot[1]					
AX1	3,290 a A	1,951 a A	1,883 a A	1,061 a A	2,046 a A
AX2	2,972 a A	2,329 a A	1,769 a B	1,485 a A	2,139 a A
AX3	2,148 b B	1,281 b B	1,763 a B	1,491 a A	1,671 b B
BX1	3,139 a A	1,897 b A	1,276 b A	1,282 b A	1,899 b A
BX2	3,067 a A	2,646 a A	2,154 a A	2,091 a A	2,490 a A
BX3	2,967 a A	2,201 ab A	2,163 a A	2,048 a A	2,345 a A

[1]Within each column, different lowercase letters indicate a significant difference (P=.05) between subplot means with the same main plot (for example, compare means 1-3 in A and means 1-3 in B). Uppercase letters indicate a significant difference (P=.05) between main plot means with the same subplot (for example, compare means AX1, BX1; AX2, BX2; etc.).

CONCLUSIONS

With large populations of johnsongrass and Palmer amaranth, the use of Roundup alone provided excellent control with no-till. The use of half-rates of Cotoran + Staple PRE followed by Roundup provided increased control with conventional-till in 3 of 4 years, but the PRE herbicides were not needed with no-till. The herbicide treatment that did not include Roundup was inconsistent and offered inadequate control of either weed, especially with no-till. Lower weed control ratings generally resulted in reduced seed cotton yields. The 4-year average seed cotton yields for herbicide treatments with conventional-till and no-till were 1,678 and 2,245 pounds per acre, respectively.

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