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Weed Control and Yield Comparisons of Twin- and Single-Row Glyphosate-Resistant Cotton Production Systems

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A 2-yr field study was conducted during 2007 and 2008 at Stoneville, MS, to determine the effect of twin-row (two rows 38 cm apart on 102-cm beds) and single-row (on 102-cm beds) patterns and glyphosate POST applications with and without fluometuron + *S*-metolachlor PRE on cotton canopy closure, weed control, and lint yield in two cultivars ('DP117B2RF', early maturity, hairy leaf; 'DP164B2RF', mid to full maturity, smooth leaf) under an irrigated environment. The experiment was conducted in a split–split plot arrangement of treatments in a randomized complete block design with row pattern as the main plot, cultivars as the subplot, and herbicide programs as the subsubplot. Cotton canopy closed 2 wk earlier in the twin-row pattern compared to the single-row pattern. Canopy closure was unaffected by cultivars and herbicide programs. Control of nine predominant weeds was sufficient (≥ 95%) to support cotton production. Total weed dry biomass was reduced by 35% in twin rows compared to the single-row pattern, 15% in DP117B2RF compared to DP164B2RF cultivar, and ≥ 97% with glyphosate early POST (EPOST), EPOST followed by (fb) mid-season POST (MPOST), EPOST fb MPOST fb late POST (LPOST) following PRE herbicides or three applications of glyphosate POST only without PRE herbicides compared to no herbicide. Cotton grown in twin-row pattern produced 6% higher lint yield than single-row cotton. Cultivar DP117B2RF produced 23% higher lint yield than cultivar DP164B2RF. Lint yields were higher with glyphosate EPOST fb MPOST, EPOST fb MPOST fb LPOST following PRE herbicides or three applications of glyphosate POST only without PRE herbicides (1,210 to 1,230 kg/ha) compared to glyphosate EPOST following PRE herbicides (1,130 kg/ha). These results demonstrated that cotton grown in twin-rows closed canopy early and produced higher lint yields than cotton grown in single-rows.

Nomenclature: Fluometuron, glyphosate, *S*-metolachlor; cotton, *Gossypium hirsutum* L. 'DP117B2RF', 'DP164B2RF'.
Key words: Canopy, paired row, wide row, weed biomass, weed management.

En Stonville, MS, durante los años 2007 y 2008 se realizó un estudio de campo con el objetivo de determinar el efecto de sistemas de hilera sencilla y doble, y de aplicaciones POST de glifosato con y sin fluometuron + S-metachlor PRE, en variables tales como el control de maleza, el cierre de dosel en algodón, y el rendimiento de fibra de dos cultivares. Los cultivares fueron el DP117B2RF (de maduración precoz y hojas pubescentes) y el DP164B2RF (de madurez intermedia y hoja lisa); ambos se establecieron en condiciones de riego y en dos hileras con una separación de 38 cm entre sí sobre una cama de 102 cm de ancho, y en surcos de una sola hilera en camas de 102 cm. El experimento se condujo en un arreglo de tratamientos en parcelas sub-subdivididas en un diseño en bloques completos al azar, con el patrón de hileras como la parcela principal, los cultivares como la subparcela y los programas de los herbicidas como la sub-subparcela. El cierre del dosel ocurrió dos semanas más temprano en el patrón de doble hilera comparado con el de una sola hilera. El cierre del dosel no fue afectado por el tipo de cultivar o el programa de herbicidas. El control de nueve especies de maleza predominante fue suficiente (≥ 95%) para mantener la producción de algodón. El total de biomasa de maleza seca en las hileras dobles, se redujo 35% comparada con el de la hilera simple. La biomasa de maleza se redujo 15% en el cultivar "DP117B2RF" comparado con el cultivar "DP164B2RF". Contrastado con un testigo sin herbicida, glifosato aplicado de forma POSTT (postemergente temprano), POSTT seguido por (sp) POSTI (postemergente intermedio), POSTT sp POSTI sp POSTO (postemergente tardío) subsiguientes a herbicidas PRE, o tres aplicaciones POST de glifosato sin herbicidas PRE, disminuyeron ≥ 97% la biomasa de maleza. El algodón sembrado en surcos de doble hilera produjo un 6% más de rendimiento de fibra que el sembrado en surcos de una sola hilera. El cultivar DP117B2RF resultó con 23% de mayor rendimiento de fibra que el cultivar DP164B2RF. Los rendimientos de fibra de algodón fueron mayores con glifosato POSTT sp POSTI, POSTT sp POSTI sp POSTO subsiguientes a herbicidas PRE, o con tres aplicaciones POST de glifosato sin herbicidas PRE (1210 a 1230 kg/ha) comparado con glifosato POSTT en secuencia a herbicidas PRE (1130 kg/ha). Estos resultados demostraron que el algodón sembrado en doble hilera cerró su dosel más temprano y produjo mayor rendimiento de fibra que el sembrado en una sola hilera.

Cotton production is characterized by high input costs (seed premiums and technology fees associated with transgenic cotton) coupled with fluctuating cotton commodity prices resulting in narrow or no profit margins. Research is needed to improve profitability by manipulating agronomic practices such as row spacing, cultivars, and herbicide applications. Cotton traditionally has been grown in single rows spaced 91 to 102 cm apart. The recent introduction of John Deere PRO-12 VRS spindle-type picker[1] (Karnei 2005) capable of picking cotton on virtually any row spacing from 38 to 102 cm has rejuvenated interest in narrow-row cotton production (Buehring et al. 2006; Harrison et al. 2006; Nichols et al. 2004; Reddy et al. 2009; Willcutt et al. 2006; Wilson et al. 2007). Cotton grown in 38-cm rows produced higher (Buehring et al. 2006; Karnei 2005; Wilson et al.

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Figure 1. Twin-row pattern consists of two rows 38 cm apart planted on 102-cm beds compared to one row planted on 102-cm beds in single-row pattern. Photographs taken at 7 wk after planting in 2007. Twin-row cotton canopy closed 50% vs. 30% in single-row cotton at 7 wk after planting. A color version of this figure is available in the online journal.

2007; Reddy et al. 2009) or equal (Harrison et al. 2006; Nichols et al. 2004; Willcutt et al. 2006) yield than cotton grown in conventional 97- to 102-cm-wide rows. Cotton grown in narrow rows (38 cm) can provide early canopy closure similar to that grown in ultranarrow rows (19 and 25 cm) without requiring high plant populations. Recent studies in Mississippi (Reddy et al. 2009) and in North Carolina (Wilson 2006) have demonstrated that cotton can be grown in 38-cm rows using equal or lower plant populations than cotton grown in wide rows (> 97 cm).

The weed species encountered in narrow- and wide-row cotton are similar; however, there are fewer late-season options to control weeds that escape early-season control in narrow-row cotton. Although glyphosate can provide effective and economical postemergence control of weeds in glyphosate-resistant (Roundup Ready[2]) cotton cultivars, its applications over-the-top are limited to the 4-leaf stage (Anonymous 2008a). Furthermore, POST-directed and hooded sprayer herbicide applications as well as interrow cultivation are not possible in narrow-row cotton. Planting second generation glyphosate-resistant (Roundup Ready Flex[2]) cotton cultivars would allow glyphosate applications over-the-top beyond the 4-leaf stage and up to 60% open bolls (Anonymous 2008a). Therefore, weed escapes, partially controlled weeds, and weeds emerging after the 4-leaf stage can be effectively managed with glyphosate in Roundup Ready® Flex cotton. Narrow-row cotton has the potential to reduce weed control costs through early canopy closure compared to wide-row cotton system.

Yield advantage in twin-row (also referred to as paired-row in the literature) pattern over single row has been reported in several crops. Corn (*Zea mays* L.) yields in twin rows spaced 19 to 25 cm apart were equal (Sorensen et al. 2006), lower (Nelson 2007), or higher (Karlen and Camp 1985), compared to single-row pattern. In peanut (*Arachis hypogaea* L.), yields were higher in twin-row pattern (rows spaced 18 cm apart on 91-cm centers) than in single-row pattern (Jordan et al. 2001; Lanier et al. 2004). In the lower Mississippi River Valley alluvial flood plain, soybean [*Glycine max* (L.) Merr.] produced higher yields in twin rows spaced 25 cm apart compared to single-row pattern (Koger 2007). In cotton, yields in twin rows spaced 25 cm apart were equal compared to single rows spaced 102 cm apart (Reddy et al. 2009). However, we know of no spindle-type harvester available to harvest cotton in 25-cm twin-rows.

The lower Mississippi River Valley alluvial flood plain receives about 133 cm of rainfall annually, of which about 50% is received during November through March (Boykin et al. 1995). In this Mississippi Delta region, cotton is predominantly grown on raised seedbeds spaced 91 to 102 cm apart that had been prepared the preceding fall. The raised seedbeds ensure adequate surface drainage during winter and enable furrow irrigation during summer. Prior to planting, the raised beds can be conditioned by flattening the top and firming up with bed conditioners. The conditioned seedbeds (slightly raised flat tops of about 50-cm wide with small furrows) enable growers to plant cotton in 38-cm twin rows and to use furrow irrigation. Two rows spaced 38 cm apart can be planted on the flat top of the bed with a 64 cm gap between rows. The agronomic and weed control benefits of cotton production in 38-cm twin-rows on 102-cm centers merits investigation.

This study was designed to investigate the feasibility of growing cotton in 38-cm twin-rows on 102-cm raised seedbeds in the lower Mississippi River Valley alluvial flood plain. The objectives were to determine: (1) canopy closure and lint yield responses of cotton grown in 38-cm twin-rows on a 102-cm raised seedbeds compared to single-rows on raised seedbeds spaced 102-cm apart, (2) cotton cultivar responses to twin-rows vs. the single-row pattern, and (3) weed control efficacy of glyphosate POST applications with and without PRE herbicides in cotton planted in twin rows vs. single rows.

Materials and Methods

A 2-yr field study was conducted during 2007 and 2008 at the USDA–ARS Southern Weed Science Research farm, Stoneville, MS, under an irrigated environment. The soil was a Dundee silty clay loam (fine-silty, mixed, thermic Aeric

Table 1. Weed densities in nontreated plots 12 wk after planting in 2007 and 2008.

Weed species	2007	2008
	plants/m^2	
Browntop millet [*Urochloa ramosa* (L.) Nguyen]	15	3
Common purslane (*Portulaca oleracea* L.)	9	164
Hyssop spurge [*Chamaesyce hyssopifolia* (L.) Small]	3	6
Johnsongrass [*Sorghum halepense* (L.) Pers.]	9	13
Junglerice [*Echinochloa colona* (L.) Link]	5	11
Palmer amaranth (*Amaranthus palmeri* S. Wats.)	5	15
Pitted morningglory (*Ipomoea lacunosa* L.)	3	1
Prickly sida (*Sida spinosa* L.)	29	6
Yellow nutsedge (*Cyperus esculentus* L.)	5	10

Ochraqualf) with pH 6.9, 1.6% organic matter, a cation exchange capacity of 23 cmol/kg, and soil textural fractions of 15% sand, 56% silt, and 29% clay. Field preparation consisted of disking, subsoiling, disking, and bedding in the fall of previous year. The experimental area was treated with paraquat at 1.1 kg ai/ha 1 wk prior to cotton planting to kill the existing vegetation. At planting, the raised beds were conditioned by flattening the top and firming up with a bed conditioner as needed to plant cotton in 38-cm twin rows or 102-cm single rows (Figure 1). The conditioned seedbeds of twin rows had slightly raised flat tops of about 50 cm wide with small furrows, which enable cotton planting in 38-cm twin rows and furrow irrigation during the growing season.

Second-generation glyphosate-resistant cotton cultivars DP117B2RF (hairy leaf, early maturity) and DP164B2RF (smooth leaf, mid to full maturity) were planted on April 23, 2007 and on April 23, 2008. Cotton was planted in 102-cm single rows using a MaxEmerge 2 planter[3] and in 38-cm twin rows using a John Deere 1730 planter[4] with modifications. Seed rate was 5.5 and 12 seed/m of row, which resulted in approximately 110,000 and 120,000 planted seed/ha in twin-row and single-row patterns, respectively. Actual plant populations estimated at harvest were 110,000 plants/ha in single rows and 95,000 plants/ha in twin rows. In Mississippi, a final plant population of 100,000 to 125,000 plants/ha is recommended for 102-cm row cotton (Anonymous 2008b). Cotton planted in 102-cm single rows was included as a standard cotton production system to compare yield potential of cotton planted in a 38-cm twin-row system.

The experiment was conducted in a split–split plot arrangement of treatments in a randomized complete block design with row pattern as main plots, cultivars as subplots, and herbicides as the subsubplots with four replications. Each subsubplot consisted of four 38-cm twin rows on a 102-cm center or four single rows spaced 102 cm apart and 13.7 m long. Main plot treatments were twin-row and single-row pattern. Subplot treatments were cultivars DP117B2RF and DP164B2RF. Subsubplot treatments were glyphosate applied early POST (EPOST) at 0.84 kg ae/ha; EPOST at 0.84 kg/ha followed by (fb) mid-season POST (MPOST) at 0.84 kg/ha; EPOST at 0.84 kg/ha fb MPOST at 0.84 kg/ha fb late POST (LPOST) at 0.84 kg/ha with fluometuron at 1.12 kg ai/ha, plus *S*-metolachlor at 1.12 kg ai/ha applied preemergence (PRE); glyphosate applied EPOST fb MPOST fb LPOST without PRE herbicides; and a no-herbicide treatment. Because the focus of this research was to compare feasibility of growing cotton in twin rows vs. single rows, only these four commonly used herbicide treatments in glyphosate-resistant cotton were included in the study. Herbicides were applied with a tractor-mounted sprayer with TeeJet 8004 standard flat spray nozzles,[5] delivering 187 L/ha water at 179 kPa. The PRE herbicide treatments were applied immediately after planting. The EPOST, MPOST, and LPOST treatments were applied 4, 7, and 9 wk after planting (WAP), respectively. Fertilizer application and insect control programs were standard for cotton production (Anonymous 2008b; Reddy 2004; Reddy et al. 2009). Cotton was furrow irrigated on an as-needed basis: six times in 2007 and seven times in 2008.

Cotton canopy closure was visually estimated based on the extent of interrow ground coverage by cotton foliage in relation to row width on a scale of 0 (bare ground) to 100% (complete ground cover with canopy). Canopy closure was estimated between the center two rows of 102-cm spaced plots. In 38-cm twin-row plots, canopy closure was estimated between the second and third pair of twin rows. However, it should be stressed that the canopy within the twin rows closed more rapidly than between the two twin rows. Canopy closure was estimated on a weekly basis until complete closure. Control of individual weed species was visually estimated on the basis of reduction in weed population and plant vigor on a scale of 0 (no control) to 100% (complete control) at 2 wk after LPOST (Table 1). Weeds were harvested from one 1-m^2 area between the center two rows of each plot at 2 wk after LPOST; dry weights of grasses, broadleaves, and yellow nutsedge were recorded separately. Seed cotton was hand picked from the two center rows (1 m length) at three randomly selected locations in each plot. Number of cotton plants and open bolls per plant were also recorded at hand picking. Seed cotton was ginned on a Continental Eagle 10-saw gin stand[6] and the lint yield was calculated on a land area basis.

Table 2. Cotton canopy closure as affected by twin-row and single-row pattern, averaged across cultivars and herbicides in studies conducted at Stoneville, MS, 2007 and 2008.

	Cotton canopy closure						
Row pattern	7 WAP[a]	8 WAP	9 WAP	10 WAP	11 WAP	12 WAP	13 WAP
	%						
38-cm twin	52 a[b]	66 a	90 a	95 a	100 a	100 a	100 a
102-cm single	33 b	41 b	60 b	70 b	83 b	93 b	100 a

[a] Abbreviations: WAP, weeks after planting cotton.

[b] Means within a column followed by same letter are not significantly different at the 5% level as determined by Fisher's LSD test.

Table 3. Total weed dry biomass, cotton plant population, lint yield, lint percent, and open bolls per plant as affected by row pattern, cultivar, and herbicide programs in cotton at Stoneville, MS, 2007 and 2008.[a]

Main effect	Herbicide application		Total weed dry biomass[c,d]	Cotton			
	Rate	Timing[b]		Plant population	Lint yield	Lint percent	Open bolls
	kg/ha		kg/ha	plants/ha	kg/ha	%	no./plant
Row pattern							
38-cm twin	—		1,400 b	95,000	1,230 a	38.9 a	8.8 a
102-cm single	—		2,150 a	110,000	1,160 b	39.4 a	7.0 b
Cultivar							
DP117B2RF	—		1,630 b	102,000	1,320 a	40.0 a	8.1 a
DP164B2RF	—		1,920 a	103,000	1,070 b	38.3 b	7.7 a
Herbicide							
No herbicide	—	—	8,530 a	—	—	—	—
Fluometuron +	1.12	PRE	280 b	102,000	1,130 b	39.1 a	7.6 a
S-metolachlor fb	1.12	PRE					
glyphosate	0.84	EPOST					
Fluometuron +	1.12	PRE	30 b	102,000	1,210 a	39.0 a	8.2 a
S-metolachlor fb	1.12	PRE					
glyphosate fb	0.84	EPOST					
glyphosate	0.84	MPOST					
Fluometuron +	1.12	PRE	0 b	103,000	1,230 a	39.2 a	8.0 a
S-metolachlor fb	1.12	PRE					
glyphosate fb	0.84	EPOST					
glyphosate fb	0.84	MPOST					
glyphosate	0.84	LPOST					
Glyphosate fb	0.84	EPOST	30 b	103,000	1,210 a	39.4 a	7.8 a
glyphosate fb	0.84	MPOST					
glyphosate	0.84	LPOST					

[a] No-herbicide plots were not harvested because of heavy weed pressure.

[b] Abbreviations: EPOST, early postemergence; fb, followed by; MPOST, mid-season postemergence; LPOST, late postemergence; PRE, preemergence.

[c] Weed dry biomass was recorded at 2 wk after LPOST. Predominant weeds were browntop millet, common purslane, hyssop spurge, johnsongrass, junglerice, Palmer amaranth, pitted morningglory, prickly sida, and yellow nutsedge.

[d] Means within a column for each main effect followed by same letter are not significantly different at the 5% level as determined by Fisher's LSD test.

Data were subjected to analysis of variance with mean squares partitioned appropriately for a split–split plot treatment arrangement using PROC MIXED.[7] The treatment means were separated at the 5% level of significance using Fisher's protected LSD test. Data were pooled across years (as main effects), when interactions were not significant. Weed dry biomass and open bolls per plant were the only parameters for which the row pattern and herbicide program interaction was significant, and are presented separately by row pattern.

Results and Discussion

Cotton Canopy. Cotton canopy closure was affected by row pattern, but cultivars and herbicide programs had no effect on canopy closure. Cotton canopy closure averaged over cultivars and herbicide programs was 52% in the twin-row pattern compared to 33% canopy closure in the single-row pattern at 7 WAP (Figure 1 and Table 2). By 9 WAP, twin-rows had 90% canopy closure compared to 60% in the single-row pattern. Canopy closure was 100% by 11 WAP in the twin-row pattern compared to 13 WAP in the single-row pattern. There were no differences in canopy closure between cultivars and among herbicide programs. Overall, canopy closure occurred 2 wk earlier in the twin-row pattern compared to cotton planted in the single-row pattern. Similarly, other researchers have observed early canopy closure in cotton planted in 19-cm rows, 38-cm rows, and 25-cm twin rows compared to cotton planted in 102-cm rows (Jost and Cothren 2000; Reddy et al. 2009). Two wk earlier canopy closure in the twin-row pattern has greater potential to suppress germination and establishment of late-season weeds than for the single-row pattern.

Weed Control and Weed Biomass. Nine predominant summer annual weed species were observed in the experimental area (Table 1). Control of these weeds at 2 wk after LPOST was $\geq$ 98% with no significant differences between row patterns or cultivars except yellow nutsedge (data not shown). Yellow nutsedge control was slightly higher in the twin-row pattern (99%) compared to the single-row pattern (96%). Glyphosate POST applications with and without PRE herbicides controlled these weeds 95% or more compared with no herbicide.

Total weed dry biomass was reduced by 35% in the twin-row pattern compared to the single-row pattern (Table 3). The DP117B2RF cultivar had 15% lower total weed dry biomass compared to DP164B2RF. It was noted that DP117B2RF had a more robust growth habit compared to DP164B2RF under the conditions of this study. Total weed dry biomass was highest in no-herbicide plots (8,530 kg/ha). Glyphosate EPOST, EPOST fb MPOST, EPOST fb MPOST fb LPOST following PRE herbicides, or three applications of glyphosate POST-only without PRE herbi-

Table 4. Weed dry biomass and cotton open bolls per plant, averaged across cultivars as affected by row pattern and herbicide programs in studies conducted at Stoneville, MS, 2007 and 2008.

Row pattern	Herbicide program			Weed dry biomass[a,b]				Open bolls[d]
	Herbicide	Rate	Timing[c]	Grasses	Broadleaves	Yellow nutsedge	Total	
		kg/ha		kg/ha				no./plant
38-cm twin	No herbicide	—	—	3,160 b	3,520 a	40 a	6,720 b	—
	Fluometuron +	1.12	PRE	130 c	120 c	< 10 a	250 c	7.9 b
	S-metolachlor fb	1.12	PRE					
	glyphosate	0.84	EPOST					
	Fluometuron +	1.12	PRE	30 c	10 c	< 10 a	40 c	9.4 a
	S-metolachlor fb	1.12	PRE					
	glyphosate fb	0.84	EPOST					
	glyphosate	0.84	MPOST					
	Fluometuron +	1.12	PRE	0 c	0 c	0 a	0 c	8.9 a
	S-metolachlor fb	1.12	PRE					
	glyphosate fb	0.84	EPOST					
	glyphosate fb	0.84	MPOST					
	glyphosate	0.84	LPOST					
	Glyphosate fb	0.84	EPOST	0 c	0 c	0 a	0 c	8.9 a
	glyphosate fb	0.84	MPOST					
	glyphosate	0.84	LPOST					
102-cm single	No herbicide	—	—	8,410 a	1,890 b	40 a	10,340 a	—
	Fluometuron +	1.12	PRE	150 c	140 c	20 a	310 c	7.2 bc
	S-metolachlor fb	1.12	PRE					
	glyphosate	0.84	EPOST					
	Fluometuron +	1.12	PRE	20 c	0 c	< 10 a	20 c	7.0 c
	S-metolachlor fb	1.12	PRE					
	glyphosate fb	0.84	EPOST					
	glyphosate	0.84	MPOST					
	Fluometuron +	1.12	PRE	0 c	0 c	< 10 a	< 10 c	7.2 bc
	S-metolachlor fb	1.12	PRE					
	glyphosate fb	0.84	EPOST					
	glyphosate fb	0.84	MPOST					
	glyphosate	0.84	LPOST					
	Glyphosate fb	0.84	EPOST	0 c	0 c	60 a	60 c	6.8 c
	glyphosate fb	0.84	MPOST					
	glyphosate	0.84	LPOST					

[a] Means within a column followed by same letter are not significantly different at the 5% level as determined by Fisher's LSD test.

[b] Weed dry biomass was recorded at 2 wk after LPOST. Predominant grasses were browntop millet, johnsongrass, and junglerice, and broadleaves were common purslane, hyssop spurge, Palmer amaranth, pitted morningglory, and prickly sida.

[c] No-herbicide plots were not harvested because of heavy weed pressure.

[d] Abbreviations: EPOST, early postemergence; fb, followed by; MPOST, mid-season postemergence; LPOST, late postemergence; PRE, preemergence.

cides reduced total weed dry biomass by at least 97%. Analysis of variance of weed dry biomass indicated a significant interaction between row patterns by herbicide programs. There were no differences in dry weights (grasses, broadleaves, and yellow nutsedge) among herbicide programs within either row pattern, and dry weights were invariably lower than their respective no herbicide plots (Table 4). Interactions between row pattern and herbicide programs also suggest that the twin-row pattern was detrimental to weeds. In the no-herbicide check plots, the twin-row pattern reduced total weed dry biomass by 35% compared with the single-row pattern (Table 4). In no-herbicide check plots, grass weed dry biomass was reduced by 62% in twin-row vs. single-row patterns and broadleaf dry biomass was reduced by 46% in twin-row vs. single-row patterns. Yellow nutsedge dry biomass was unaffected by either row pattern. These differences might have been due to competition among weed species. Overall, the twin-row pattern was more effective in suppression of weed establishment and growth.

Cotton Yield. Untreated plots were not harvested because of severe weed infestations and were excluded from the statistical analyses. Cotton plant population at harvest was similar between cultivars and among herbicide programs, but was 14% lower in the twin-row pattern compared to the single-row pattern cotton (Table 3). In an earlier study, cotton production in 25-cm twin rows was investigated using plant populations above and below a recommended plant population for conventional 102-cm row cotton (Reddy et al. 2009). Reddy et al. (2009) noted cotton plant populations of 90,000 to 194,000 plants/ha in 25-cm twin rows produced lint yield comparable to cotton in 102-cm single rows with 127,000 plants/ha. The lint percent was similar between twin-row and single-row patterns (Table 3). Cotton grown in the twin-row pattern produced 6% higher lint yield than single-row cotton. Increased yield in the twin-row pattern compared to the single-row pattern might have been due to greater number of open bolls (8.8 vs. 7.0 per plant, respectively) and lower total weed dry biomass (1,400 vs. 2,150 kg/ha, respectively).

Furthermore, cotton plants in twin-row patterns were spaced competitively better within the row (more space per plant) compared to plants in single-row patterns. In other research, cotton grown in 25-cm twin row patterns with plant populations of 90,000 to 194,000 plants/ha produced lint yields similar to cotton grown in 102-cm rows with about 127,000 plants/ha under a weed-free environment (Reddy et al. 2009). In the present study, the twin-row pattern was more detrimental to weeds compared to the single-row pattern.

Cultivar DP117B2RF produced 23% higher lint yield than cultivar DP164B2RF (Table 3). Increased lint yield in DP117B2RF was attributed to higher lint percent (4%) and lower total weed dry biomass (15%), suggesting less weed competition compared to cultivar DP164B2RF. There were no differences in lint percent and open bolls per plant among the four herbicide programs. Lint yields were higher with glyphosate EPOST fb MPOST, EPOST fb MPOST fb LPOST following PRE herbicides, or three applications of glyphosate-only without PRE herbicides (1,210 to 1,230 kg/ha) compared to glyphosate EPOST following PRE herbicides (1,130 kg/ha). Evidently, all four herbicide programs reduced total weed dry biomass by 97% or more compared with no herbicide (Table 3). Therefore, the slight reduction in lint yield ($\leq$ 8%) in glyphosate EPOST following PRE herbicides might have been due to an interaction effect. Glyphosate EPOST following PRE herbicides had fewer open bolls per plant (7.9 bolls/plant) compared to other herbicide programs (8.9 to 9.4 bolls/plant) in the twin-row pattern (Table 4).

Results of this study indicate cotton grown in the twin-row pattern with lower plant population (95,000 plants/ha) can close the cotton canopy 2 wk earlier and produce lint yields 6% higher than in single-row cotton with 110,000 plants/ha. Cotton cultivar DP117B2RF (with more robust growth characteristics) reduced total weed dry biomass and produced higher lint yields than cultivar DP164B2RF. Weed management with glyphosate POST (1 to 3 applications) following PRE herbicides or glyphosate POST-only program is feasible in the twin-row pattern where POST-directed herbicide applications and interrow cultivation are not possible. Although glyphosate POST-only was nearly as effective as glyphosate POST following PRE herbicides, in the long term, use of residual herbicides is critical to reduce detrimental early-season weed interference especially in the 38-cm space within the twin rows and to widen the window of application for glyphosate as well as to manage glyphosate-resistant weeds. The present study demonstrated that cotton production in 38-cm twin rows on 102-cm seedbeds is an agronomically feasible option for farmers in the lower Mississippi River Valley alluvial flood plain who are looking for simple production practices that increase lint yield with the benefits of narrow row spacing without increased seed cost.

Sources of Materials

[1] John Deere PRO-12 VRS spindle-type picker, Deere and Co., 501 River Drive, Moline, IL 61265.

[2] Roundup Ready® and Roundup Ready® Flex cotton, Monsanto Agricultural Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.

[3] MaxEmerge 2 planter, Deere and Co., 501 River Drive, Moline, IL 61265.

[4] John Deere 1730 planter, Deere and Co., 501 River Drive, Moline, IL 61265.

[5] TeeJet standard flat spray nozzles, Spraying Systems Co., North Avenue and Schmale Road, Wheaton, IL 60189.

[6] Continental Eagle 10-saw gin stand, Continental Eagle Corporation, 201 Gin Shop Hill Road, Prattville, AL 36067.

[7] SAS Proprietary software, release 8.2, Windows version 5.1.2600, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513.

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