WEED AND HELIOTHINE-COMPLEX MANAGEMENT IN TRANSGENIC COTTON

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Abstract

Weed control and heliothine management were evaluated at Marianna and Rohwer, AR. Systems that used glyphosate with or without PRE applications of pendimethalin tended to have better control of Palmer amaranth than BXN or conventional herbicide systems. Conventional systems tended to control pitted morningglory better than glyphosate-based systems early-season. In 2001, systems that used glyphosate had significantly lower numbers of reproductive Palmer amaranth, prickly sida, and barnyardgrass at harvest. There were no differences in final season numbers of pitted morningglory when comparing glyphosate-based systems to conventional herbicide systems. B.t. cultivars had lower heliothine and damaged squares than CONV and BXN cotton. In 2001, under higher weed pressure, systems using glyphosate showed trends of increased yield compared to the same variety under conventional systems.

Introduction

Weeds are known to cause dramatic yield losses in cotton. Competitive weed species such as Palmer amaranth can significantly reduce yield with densities inside the seed-drill as low as 3 plants per 30 ft of row (Morgan et al. 1997). The advent of herbicide-resistant cotton (*Gossypium hirsutum*) varieties has allowed foliar postemergence control of many problematic weed species in cotton. Transgenic cotton has also offered protection from the heliothine-complex, consisting of mainly tobacco budworm (*Heliothis virescens)* and cotton bollworm (*Helicoverpa zea)*. These two insect species have been known to infest more than 70% of the U.S. cotton acreage (Hardee and Burris 2000) causing losses greater than 300 million dollars (Williams 2001). Weed control and heliothine management may have, in part, fueled the widespread adoption of these technologies. This rate of adoption is apparent from the decrease in acres planted to conventional cotton from 1999 to 2001 in Arkansas (Dr. Bill Robertson, personal communication) (Table 1).

Objectives

The objectives of this study are to determine the advantages of using transgenic cotton technologies with respect to weed control and management of the heliothine-complex and to identify possible shifts in weed species over time from using a specific technology.

Materials and Methods

Studies were conducted at Marianna and Rohwer, AR, in 2000 and 2001. The study design was a randomized complete block with four replications. Experimental units were 25- by 50-ft plots that were overseeded with seed of Palmer amaranth (*Amaranthus palmeri*), pitted morningglory (*Ipomoea lacunosa*), prickly sida (*Sida spinosa*), large crabgrass (*Digitaria sanguinalis*), and barnyardgrass (*Echinochloa crus-galli*) during both years. Following incorporation of weed seed, cotton varieties DP 451BR, DP 425RR, BXN 47, DP 428B (Marianna-only), DP 33B (Rohwer-only), ST 474 (Rohwer-only), and SG 747 (Marianna-only). These varieties were planted with a cone planter set on a 38-in. row spacing, seeding population of 96,000 seed acre^{-1}, and a depth of 3 cm accompanied by an in-furrow application of the insecticide Temik® at a rate of 2 lb ai acre^{-1}. Where appropriate, experimental units planted to the five varieties were treated with four herbicide treatments.

Herbicide treatments consisted of four herbicide systems: 1) A conventional system (CONV) consisting of preemergence (PRE) applications of Pendimax® 3.3 (pendimethalin) @ 1 lb ai acre^{-1} + Meturon® (fluometuron) @ 1 lb ai acre^{-1} followed by (fb) fluometuron @ 1 lb ai acre^{-1}+ Ansar® 6.6 (MSMA) @ 2 lb ai acre^{-1} PDIR fb Direx® (diuron) @ 0.8 lb ai acre^{-1}+ AgriDex® crop oil concentrate (COC) @ 1% LAYBY; 2) A PRE+RR system of Pendimethalin 1 lb ai acre^{-1} PRE fb Roundup Ultra® (2000) or Roundup Ultramax® (2001) (glyphosate) @ 0.75 lb ai acre^{-1} POST fb glyphosate @ 0.75 lb ai acre^{-1} PDIR fb glyphosate @ 0.75 lb ai acre^{-1} + diuron @ 0.8 lb ai acre^{-1} LAYBY; 3) A total POST RR system of glyphosate @ 0.75 lb ai acre^{-1} POST fb glyphosate @ 0.75 lb ai acre^{-1} PDIR fb glyphosate @ 0.75 lb ai acre^{-1} + diuron @ 0.8 lb ai acre^{-1} LAYBY; and 4) a BXN system consisting of pendimethalin + fluometuron PRE fb Buctril® 4EC (bromoxynil) @ 0.5 lb ai acre^{-1} + Staple® 85SP (pyrithiobac) @ 0.042 lb ai acre^{-1} EPOST fb bromoxynil @ 0.5 lb ai acre^{-1} + pyrithiobac @ 0.042 lb ai acre^{-1} MPOST fb diuron @ 0.8 lb ai acre^{-1} + COC @ 1.0% v/v at LAYBY. Heliothine control regimes of no control and standard control were applied to each herbicide system by variety combination. Varieties expressing the endotoxin for *Bacillus thuringiensis* (B.t.), in addition to no control and standard heliothine control systems had heliothine control based on B.t. cotton threshold of 9 to 10 larvae per 100 plants with at least a ¼ in. length. Heliothine control measures were based on the University of Arkansas publication MP 144, Recommended Insecticides for Arkansas.

Data collected consisted of weed control and crop injury ratings on a scale of "0" to "100" with "0" being no weed control or crop injury and "100" being complete weed control or total crop destruction. Late-season weeds in the reproductive stage were counted in each plot. Plots were scouted for heliothine species, damaged squares (chewing mouthparts), damaged bolls (chewing mouthparts), plant bugs, boll weevils, and beneficial insects based on counts from 25 terminals, squares, and small bolls per plot. Other data included final season plant mapping, yield, and fiber quality analysis (data not presented). All data except weed control, yield, and crop injury from the untreated control were tested for homogeneity of treatment variances, subjected to analysis of variance, and pooled when appropriate. Treatment means for yield were separated by Fisher's Least Significant Difference (LSD) at the 0.05 level of significance. Means for weed control and weed counts were grouped by herbicide treatments, and means for initial square damage and heliothine numbers were grouped by variety. These means were compared through construction of orthogonal contrasts and separated by p-values at the 0.05 level of significance.

Results and Discussion

In 2000, >95% control of Palmer amaranth was obtained with systems that used glyphosate or conventional herbicide systems. At both locations, this control was better than that from BXN systems (Tables 2 and 4). In 2000 there was a trend for CONV herbicide systems to provide better early-season control of pitted morningglory than systems that used glyphosate (Tables 3 and 8). BXN systems were equal to or better than PRE+RR or RR systems for early-season control of pitted morningglory. There were no significant differences in large crabgrass (data not shown), prickly sida (Table 9), or barnyardgrass control (Table 10) in 2000, with all treatments providing >95 control of all three species; however, in 2001 glyphosate-based systems provided better control of both prickly sida and barnyardgrass than CONV or BXN systems (Tables 9 and 10). In 2001 PRE+RR and RR systems controlled Palmer amaranth better than conventional or BXN systems (Tables 2 and 7). In 2001 PRE+RR and RR systems provided equal or better control of pitted morningglory than did CONV or BXN herbicide systems (Tables 3 and 8). This may be due in part to a change in glyphosate formulation (Roundup Ultra 2000) (Roundup Ultramax 2001). There were lower numbers of final-season reproductive Palmer amaranth in PRE+RR and RR systems as compared to CONV and BXN systems (Table 4 and 11). Systems that used glyphosate had equal or lower numbers of final-season reproductive pitted morningglory plants per plot compared with CONV and BXN systems (Table 4). Glyphosate systems also had lower numbers of final-season reproductive prickly sida than conventional systems (Table 11). There were no significant differences in yield between standard and no insecticide control for varieties treated with conventional herbicides in 2000 and 2001 (Tables 5 and 12). This lack of difference between standard and no insecticide treatments was due to low and late populations of heliothine species. B.t. varieties did have lower numbers of heliothine and damaged squares at initial insecticide application than CONV or BXN varieties (Table 14). There was a trend for a cultivar response in which DP 451BR under conventional herbicide systems or glyphosate based systems was one of the higher yielding cultivars over both years and locations (Tables 6 and 13).

Hardee, D. D. and E. Burris. 2000. 53rd annual conference report on cotton insect research and control. Proc. Beltwide Cotton Conf. 2:855-884.

Morgan, G.D., P.A. Baumann, and J.M. Chandler. 1997. How competitive is Palmer amaranth (Amaranthus palmeri) with cotton? Proc. Beltwide Cotton Conf. 1:798-799

Williams, M.R. 2001. Cotton insect loss estimates. 2000. Proc. Beltwide Cotton Conf. 2:774-776

Table 1. Trend of cotton varieties planted in Arkansas from 1999 to 2001.

Variety	Percentages of total cotton planted in Arkansas by technology 1999	2000	2001
Bollgard	14	15	8
Roundup Ready	7	7	10
Bollgard/Roundup Ready	4	20	51
BXN	46	34	13
Conventional	29	24	18

Dr. Bill Robertson, personal communication, County Extension Agent Surveys.

Table 2. Palmer amaranth control, grouped by herbicide system, 6 and 12 weeks after planting (WAP), Marianna 2000 and 2001.

	% control			
	2000		2001	
Herbicide system	6 WAP	12 WAP	6 WAP	12 WAP
PRE+RR	95 a*	95 a	95 a	95 a
RR	95 a	95 a	95 a	94 a
CONV	95 a	95 a	83 b	69 b
BXN	79 b	75 b	51 c	50 c

* Means within a column followed by the same letter are not significantly different, P (0.05).

Table 3. Pitted morningglory control, grouped by herbicide system, 6 and 12 weeks after planting (WAP), Marianna 2000 and 2001.

	% control			
	2000		2001	
Herbicide system	6 WAP	12 WAP	6 WAP	12 WAP
PRE+RR	77 c*	95 a	90 a	93 a
RR	81 bc	95 a	93 a	93 a
CONV	95 ab	95 a	92 a	83 b
BXN	77 c	95 a	83 b	61 c

* Means within a column followed by the same letter are not significantly different, P (0.05).

Table 4. Comparison of Palmer amaranth[1](AMAPA) and pitted morningglory (IPOLA) density (no. per plot), grouped by herbicide system, 6 and 12 weeks after planting (WAP), Marianna 2000 and 2001.

	No. per plot	
Herbicide system	AMAPA	IPOLA
PRE+RR	1.6 a*	0.33 a
RR	1.9 a	2.75 ab
CONV	11.8 b	2.42 ab
BXN	34.0 c	9.75 bc

[1]Female plants only

* Means within a column followed by the same letter are not significantly different, P (0.05)

Table 5. Yield comparisons of varieties and insecticide system, conventional herbicide system, Marianna 2000 and 2001.

Variety	Insecticide program	lb seed cotton acre^{-1} 2000	lb seed cotton acre^{-1} 2001
BR	Standard	4230 a*	2907 a
BR	None	3813 a	3363 a
BT	Standard	4078 ab	2858 a
BT	None	4139 ab	2572 a
RR	Standard	3857 abc	2576 a
RR	None	3632 c	2555a
BXN[1]	Standard	1796 d	2323 a
BXN	None	1962 d	2241 a
CONV	Standard	3705 bc	2092 a
CONV	None	3739 bc	2624 a

* Means within a column followed by the same letter are not significantly different, P (0.05). 2000 LSD = 436, 2001 LSD =NS.

[1]Variety was replanted 3 weeks after initial planting date in 2000.

Table 6. Yield comparisons varieties and herbicide systems, standard insecticide system, Marianna 2000 and 2001.

Variety	Herbicide system	lb seed cotton acre^{-1} 2000	lb seed cotton acre^{-1} 2001
BR	PRE+RR	3567 b*	3830 a
BR	RR	3654 b	3664 ab
BR	CONV	4230 a	2907 bcd
RR	PRE+RR	3476 b	2856 cde
RR	RR	3538 b	3178 abc
RR	CONV	3857 ab	2576 cde
BXN[1]	BXN	2148 c	2219 de
BXN	CONV	1796 c	2323 de
CONV	CONV	3704 b	2092 e

* Means within a column followed by the same letter are not significantly different, P (0.05). 2000 LSD = 478, 2001 LSD = 787.

[1]Variety was replanted 3 weeks after initial planting date in 2000.

Table 7. Palmer amaranth control, grouped by herbicide system, 6 and 12 weeks after planting (WAP), Rohwer 2000 and 2001.

	% control			
	2000		2001	
Herbicide system	6 WAP	12 WAP	6 WAP	12 WAP
PRE+RR	95 a*	95 a	95 a	95 a
RR	95 a	95 a	95 a	94 a
CONV	95 a	95 a	63 b	72 b
BXN	79 b	95 a	58 c	63 c

* Means within a column followed by the same letter are not significantly different, P (0.05).

Table 8. Pitted morningglory control, grouped by herbicide system, 6 and 12 weeks after planting (WAP), Rohwer 2000 and 2001.

	% control			
	2000		2001	
Herbicide system	**6 WAP**	**12 WAP**	**6 WAP**	**12 WAP**
PRE+RR	84 c*	95 a	93 a	94 a
RR	88 b	95 a	86 a	90 a
CONV	95 a	95 a	93 a	95 a
BXN	95 a	95 a	86 a	88 a

* Means within a column followed by the same letter are not significantly different, P (0.05).

Table 9. Prickly sida control, grouped by herbicide system, 6 and 12 weeks after planting (WAP), Rohwer 2000 and 2001.

	% control			
	2000		2001	
Herbicide system	**6 WAP**	**12 WAP**	**6 WAP**	**12 WAP**
PRE+RR	95 a*	95 a	95 a	95 a
RR	95 a	95 a	95 a	95 a
CONV	95 a	95 a	78 b	79 b
BXN	95 a	95 a	79 b	84 b

* Means within a column followed by the same letter are not significantly different, P (0.05).

Table 10. Barnyardgrass control, grouped by herbicide system, 6 and 12 weeks after planting (WAP), Rohwer 2000 and 2001.

	% control			
	2000		2001	
Herbicide system	**6 WAP**	**12 WAP**	**6 WAP**	**12 WAP**
PRE+RR	95 a*	95 a	95 a	95 a
RR	95 a	95 a	95 a	95 a
CONV	95 a	95 a	65 b	84 b
BXN	95 a	95 a	66 b	88 b

* Means within a column followed by the same letter are not significantly different, P (0.05).

Table 11. Comparison of Palmer amaranth[1] (AMAPA) and prickly sida (SIDSP) density (no. per plot), grouped by herbicide system, 6 and 12 weeks after planting (WAP), Rohwer 2000 and 2001.

	No. per plot	
Herbicide system	**AMAPA**	**SIDSP**
PRE+RR	0.9 a*	0.1 ab
RR	0.0 a	0.0 ab
CONV	26.5 b	4.0 c
BXN	25.0 b	1.3 b

[1]Female plants only.

* Means within a column followed by the same letter are not significantly different, P (0.05).

Table 12. Yield Comparisons of Varieties and Insecticide Systems, Conventional Herbicide System, Rohwer 2000 and 2001.

		lb seed cotton acre^{-1}	
Variety	Insecticide program	2000	2001[1]
BR	Standard	4707 a*	2073 a
BR	None	4719 a	1794 ab
BT	Standard	4280 a	1523 abc
BT	None	4585 a	1083 bc
RR	Standard	4282 a	2017 a
RR	None	4455 a	1729 ab
BXN	Standard	4150 a	2120 a
BXN	None	4102 a	1759 ab
CONV	Standard	4253 a	1404 abc
CONV	None	4492 a	1187 bc

[1]Location was destroyed by hail and replanted 05-29-01.
* Means within a column followed by the same letter are not significantly different, P (0.05) 2000 LSD = NS, 2001 LSD = 775.

Table 13. Yield Comparisons of Herbicide Systems, Standard Insecticide System, Rohwer 2000 and 2001.

		lb seed cotton acre^{-1}	
Variety	Herbicide system	2000	2001[1]
BR	PRE+RR	4913 a*	3372 a
BR	RR	4791 a	3041 ab
BR	CONV	4707 ab	2073 bcd
RR	PRE+RR	4173 cd	2430 abc
RR	RR	4086 d	2282 bcd
RR	CONV	4282 bcd	2017 cd
BXN	BXN	4530 abc	1854 cd
BXN	CONV	4150 cd	2120 bcd
CONV	CONV	4253 cd	1404 d

[1]Location was destroyed by hail and replanted 05-29-01.
* Means within a column followed by the same letter are not significantly different, P(0.05). 2000 LSD = 437, 2001 LSD = 970.

Table 14. Average heliothine larval numbers and damaged squares at initial insecticide applications, grouped by variety, Rohwer 2001

	No. per plot	
Variety	Larvae	Squares
BR	0.4 a*	1.7 a
BG	0.0 a	1.5 a
RR	0.9 b	2.1 ab
CONV	2.6 d	4.0 b
BXN	1.6 c	4.2 b

[1]Counts (no. per 25 terminal, squares, and small bolls/plot) and insecticide applications were made on 8-16-01.
* Means within a column followed by the same letter are not significantly different, P (0.05).