COTTON (GOSSYPIUM HIRSUTUM) RESPONSE AND SILVERLEAF NIGHTSHADE (SOLANUM ELAEAGNIFOLIUM) CONTROL WITH GLYPHOSATE

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INTRODUCTION

Each chapter of this thesis is a manuscript which has been or will be submitted for publication in Weed Technology, a Weed Science Society of America journal. Articles in that journal are peer reviewed and report original research from experiments repeated over time, space, or both.

CHAPTER I

COTTON (*GOSSYPIUM HIRSUTUM*) RESPONSE TO GLYPHOSATE SPOT APPLIED

COTTON (<u>GOSSYPIUM</u> <u>HIRSUTUM</u>) RESPONSE TO GLYPHOSATE SPOT APPLIED[1]

R. BRENT WESTERMAN and DON S. MURRAY[2]

Abstract. Weed-free field experiments were conducted for 3 yr at one location to measure the response of cotton to glyphosate spot applied once, twice, and three times. Glyphosate treatments frequently used for silverleaf nightshade control were applied at specified intervals after cotton emergence to in-row, uniformly spaced densities of "simulated" weeds. The number and application timing influenced cotton injury each year. Frequently, cotton lint yields following treatments applied once at four, six, or eight sites/9 m of row were not reduced significantly compared to the untreated plots; however, average yield

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[2]Sr. Res. Spec. and Prof., respectively, Dep. Agron., Okla. State Univ., Stillwater, OK 74078.

reductions ranged from 10 to 14%. Glyphosate, applied more than once generally, caused more crop injury and reduced lint yields by 13 to 39%. Nomenclature: Glyphosate, N-(phosphonomethyl)glycine; cotton, Gossypium hirsutum L., 'Paymaster 145' and 'Westburn M'; silverleaf nightshade, Solanum elaeagnifolium Cav. #[3] SOLEL.

Additional index words: Timing of application, crop response, weed densities, simulated weed, SOLEL.

INTRODUCTION

Perennial weeds such as bermudagrass [Cynodon dactylon (L.)Pers.] (5), yellow nutsedge (Cyperus esculentus L.) (7), johnsongrass [Sorghum halepense (L.)Pers.] (8), and silverleaf nightshade (1) are major problems in cotton production. Silverleaf nightshade infests over 800 000 ha of cotton on the Southern High Plains of Texas (1) with several thousand additional hectares in southwestern Oklahoma. Each silverleaf nightshade plant/10 m of cotton row is estimated by prediction models to reduce lint yield by 1.5% (6). Declines were noted in boll size at densities of 2 or more silverleaf nightshade plants/10 m of cotton row, in cotton plant height at densities of 4 or more, and in mechanical harvest efficiency at densities of 16 or more (6).

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[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

Producers have controlled perennial weeds by selective placement of a nonselective postemergence herbicide such as glyphosate. Equipment including the ropewick (1, 8, 9), roller (9, 10), recirculating sprayer (1, 9), directed sprayer (5), hooded or shielded sprayer (5, 7, 17, 19), and spot applicator (3, 4, 11, 17, 18, 19) has been used successfully to achieve selective placement. For example, Abernathy and Keeling (1) controlled 95% or more mature silverleaf nightshade plants with glyphosate applied with a ropewick applicator. They estimated that approximately 0.21 kg ae ha^{-1} of glyphosate actually was deposited on the weeds. Westerman and Murray (17) controlled 93% of the silverleaf nightshade by broadcast applying glyphosate at 1.65 or 2.48 kg ae ha^{-1} to weeds emerged on bedded soil before planting and followed with two spot treatments of glyphosate. In a later report (18), they controlled 96% of the silverleaf nightshade with a 7.2 g ae L^{-1} solution of glyphosate applied as one spot treatment 7 wk after crop emergence. Glyphosate applied 3 and 5 wk after emergence controlled 75 and 85% of the silverleaf nightshade, respectively.

Banks and Santelmann (2) reported excellent horsenettle (Solanum carolinense L.) control when glyphosate was applied to the weed at blooming or fruiting stages and less than 50% control when applications were made earlier. Overton et al. (13) conducted experiments involving cotton response to topical and directed applications of glyphosate. They found that cotton response was related to application method, cotton growth stage, and glyphosate rate.

Since silverleaf nightshade grows not only between cotton rows but within the cotton row, selective spot applications are difficult especially if the herbicide is phytotoxic to cotton. Spot treatment applications of nonselective herbicides like glyphosate have been used to control perennial species such as silverleaf nightshade (17). Applications of herbicides in this manner, to weeds which are growing in close association with the crop, results in unavoidable contact with the crop. The objective of this research was to evaluate the effect of off-target treatments of glyphosate to cotton injury and yield when spot applied at specific intervals after crop emergence.

MATERIALS AND METHODS

Field studies were conducted in 1985, 1986, and 1987 near Chickasha in south central Oklahoma on a Reinach silt loam (coarse-silty, mixed, thermic Pachic Haplustoll) with 0.3% organic matter. Experimental design was a randomized complete block with four replications. Individual plots were four rows by 9 m in length with 102-cm row spacing. Soil pH was 7.6, and soil fertility levels were adjusted each year according to state extension soil test recommendations for cotton.

Each year, trifluralin [2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine] at 0.83 kg ai ha^{-1} was applied preplant incorporated. The experimental area was planted to 'Westburn M' cotton June 14, 1985, and to 'Paymaster 145' June 20, 1986, and June 4, 1987. Crop densities of approximately 15 plants/m of row were established each year. Supplemental furrow irrigation was applied when needed throughout the growing season.

Wire flags were distributed spacially throughout the four crop rows to designate positions to receive glyphosate spot treatments. The flags represented "simulated" weeds. During all years, flags were placed spacially approximately 5 cm from the cotton row. In 1985, uniformly spaced densities of 4 and 8 weeds/9 m of crop row were used. In 1986 and 1987, only one density of 6 weeds/9 m of row was used.

All applications were made with a commercial pull-type spot treater[4]. During 1985, a 10.8 g ae L^{-1} (3% v/v of 3 lb ae gal^{-1}) solution of glyphosate was used while a 7.2 g ae L^{-1} (2% v/v of 3 lb ae gal^{-1}) solution was used in 1986 and 1987. Preliminary results from other research (18, 19) had indicated effective silverleaf nightshade control with the lower and more affordable glyphosate rate.

Glyphosate was spot applied to the cotton plants in the immediate area of the flags as though they were weeds; however, individual applications were made as one squirt of the hand-gun directed through the top of the crop canopy as

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[4]Wylie Manufacturing Co., P.O. Box 249, Petersburg, TX 79250.

though the weed were of equal height with the cotton. To complement other ongoing research (17, 18, 19), the simulated population of weeds was considered to be silverleaf nightshade.

In 1985, glyphosate was spot applied according to all seven possible combinations of single and sequential treatments 5, 8, and 11 wk after crop emergence July 25, Aug. 20, and Sept. 3, respectively. The 5-wk treatment was applied to 33- to 41-cm tall cotton with squares. The 8-wk treatment was applied to 91-cm tall cotton in full bloom. The final application also was made to 91-cm tall cotton; however, the plants contained fewer blooms, but had bolls. The DD-15.5[5] units for the 5-, 8-, and 11-wk treatments were 432, 781, and 953, respectively.

During 1986 and 1987, individual applications of glyphosate and in selected two- and three-time interval combinations were applied 2, 4, 6, 8, and 10 wk after cotton emergence to the simulated weeds. The treatment dates in 1986 were July 2, July 16, July 30, Aug. 13, and Aug. 28. The 2-, 4-, 6-, 8-, and 10-wk treatments were applied to approximately 8-, 20-, 36-, 61-, and 84-cm tall cotton, respectively. This corresponded to cotton growth stages of cotyledon to 2-true leaves, 5- to 6-true leaves, 10- to 12-true leaves, early bloom, and early boll formation; and DD-15.5 of 120, 319, 542, 724, and 907.

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[5]Abbreviations: DD-15.5, degree days to the base of 15.5 C (60 F); WAE, weeks after crop emergence.

In 1987, the treatment dates were June 23, July 8, July 21, Aug. 4, and Aug. 18. The 2-, 4-, 6-, 8-, and 10-wk treatments were applied to approximately 8-, 18-, 30-, 56- and 84-cm tall, respectively. This corresponded to cotton growth stages of 1-true leaf, 7- to 8-true leaves, 10-true leaves, early bloom, and late bloom to early boll formation; and DD-15.5 of 161, 311, 443, 626, and 813.

Visual ratings for percent cotton injury were taken Aug. 4 (6 WAE[5]), Aug. 29 (9 WAE), and Sept. 17 (13 WAE), 1985. Ratings were also taken July 30 (5 WAE), Aug. 13 (7 WAE), and Sept. 18 (12 WAE), 1986, and July 30 (7 WAE), Aug. 18 (10 WAE), and Sept. 1 (12 WAE), 1987.

Each year, one mature cotton boll was collected from 15 randomly selected plants/plot shortly before cotton harvest to calculate pulled lint percentage [(weight of lint/weight of seedcotton plus bur) X 100]. That percentage times the stripper-harvested weight from that plot provided an estimate of lint yield/plot. Cotton was harvested with a roller-brush mechanical stripper Dec. 7, 1985; Feb. 11, 1987; and Dec. 3, 1987.

Data were subjected to analyses of variance, and treatment means were compared using the protected least significant difference (LSD) test at the 0.05 probability level. Pooling the 1986 and 1987 data was not possible due to significant year by treatment interactions.

RESULTS AND DISCUSSION

One 10.8 g ae L^{-1} rate of glyphosate spot applied caused 20% or less visible injury to cotton regardless of treatment density or application time (Table 1). Treatments made two or three times with 4 simulated weeds/9 m of row caused 21% or less visible injury. Glyphosate applied as multiple applications with 8 simulated weeds/9 m of row caused up to 33% visible crop injury. The injury caused by each treatment remained fairly consistent based on ratings taken Aug. 4 (6 WAE) through Sept. 17 (13 WAE).

Cotton lint yield was numerically higher in every instance from plots treated at the lower simulated weed density compared to the same treatment at the higher simulated weed density. However, corresponding treatment frequencies differed significantly only at the 5/8-, 8/11-, and 5/8/11-wk treatment intervals. Lint yield from the low simulated density treatments and with single-time applications made either 5 or 11 wk after cotton emergence did not differ significantly from the untreated check. All other treatments yielded less than the check. Cotton receiving one spot application yielded 77 to 97% of the untreated cotton; cotton receiving multiple applications at the lower theoretical weed density yielded from 72 to 86% as much and at the higher density from 52 to 76%.

Comparisons of cotton injury on Sept. 17 (13 WAE) with percentage of lint yield loss for single spot treatments regardless of simulated density resulted in very similar values. Ratings estimated 13% injury while the yields were reduced by an average of 14%. Comparisons of average cotton injury with actual lint yield loss for multiple spot treatments with the lowest density showed a 4% difference. Visually, 18% injury was estimated; whereas, the lint yield was actually reduced by 22%. Comparison of average cotton injury with actual lint yield loss for multiple spot treatments with the highest density showed a 13% difference. Visually, 26% injury was estimated; whereas, the lint yield was actually reduced by 39%.

Maximum visible cotton injury in 1986 from the spot application of glyphosate 7.2 g ae L^{-1} was 23% for one application, 26% for two, and 28% for three (Table 2). The frequency and timing of application did not appear to be correlated with cotton injury. All glyphosate treatments caused significantly more visible injury than in the untreated check. Visual ratings taken on Sept. 18 (12 WAE) indicated lower cotton injuries of 15 and 11% when applications were made early in the growing season at 2 and 4 wk, respectively. Single applications after 4 wk generally had more severe symptoms. Highest cotton injury in September of 26 and 28% occurred from the treatments applied at 6/10- and 4/8/10-wk, respectively.

Approximately half of the glyphosate treatments significantly reduced cotton lint yield in 1986 (Table 2). One treatment made 2, 4, and 8 wk after emergence and multiple applications with the first treatment applied at 2 wk did not reduce yield compared to the untreated check. In contrast, the lower cotton yields of 630 kg ha^{-1} (or 81% of the check) occurred when successive applications were made at 6/10- and 4/8/10-wk.

Comparisons of average cotton injury on Sept. 18 (12 WAE) with actual percentage of lint yield loss with single spot treatments resulted in an 8% difference. Visually, 18% injury was estimated; whereas, lint yield was reduced 10%. Comparison of average cotton injury with actual lint yield loss with multiple spot treatments showed a 10% difference. Visually, 23% injury was estimated; whereas, the actual lint yield was reduced by 13%.

Glyphosate spot applied at 7.2 g ae L^{-1} in 1987 caused as much as 44% visible injury early in the season; however, by season's end, the highest recorded injury was 28%, and the lowest was 11% (Table 2). All glyphosate treatments caused significantly more visible injury than in the untreated check. When comparing injury in September (12 WAE) among the single application treatments, only the 2-wk application had significantly greater damage than the 10-wk spot treatment.

The higher cotton injuries of 28, 24, 23, and 23% occurred from spot applications made 2/4/8-, 2/8-, 4/8-, and 4/8/10-wk after emergence, respectively. All but individual treatments at 6 and 10 wk reduced cotton lint yield significantly compared to the check (Table 2). The lowest yield of 1030 kg ha^{-1} or 71% of the check was caused by spot treatments made 2/4/8 wk after emergence.

In general, higher lint yields were obtained with single spot applications of glyphosate. Cotton lint was reduced with multiple applications of two or three spot treatments. Cotton lint yields from single applications of glyphosate ranged from 83 to 94% of the check. Yields from multiple applications ranged from 71 to 88% of the check.

Comparisons of average cotton injury on Sept. 1 (12 WAE) with actual percentage of lint yield loss with single spot treatments resulted in a 4% difference. Visually, 14% loss was estimated; whereas, lint yield was reduced 10%. Comparison of average cotton injury with actual lint yield loss with multiple spot treatments showed a 1% difference. Visually, 20% injury was estimated; whereas, the actual lint yield was reduced by 19%.

Cotton injury and lint yield loss during 1985, 1986, and 1987 depended to some extent upon the number of applications. In many cases, single treatments caused no significant lint yield reductions when compared to the check. Multiple applications generally increased the injury observed and in many instances significantly decreased lint yield.

Timing of application did not appear to be a factor in determining cotton injury or yield loss. Wills (20) reported that glyphosate was more toxic to cotton when applied to mature stem tissue than when applied to immature stem tissue or leaves. That research illustrated the activity of glyphosate as affected by cotton growth stage and site of application; however, in our research entire cotton plants adjacent to simulated weeds were treated.

When applicators riding on pull-type sprayers are spot treating actual weeds, crop plants inadvertently are treated as evidenced by reported herbicide injury (11, 13, 17, 18, 19). Measuring herbicide injury by using wire flags to simulate weed position within the row may result in higher crop injury ratings than if a portion of the herbicide had been intercepted by the weed foliage. This technique may set an upper limit on the visual herbicide injury to the crop. However, without an actual weed in the position being treated, competition with the crop is nonexistent. Therefore, the actual yield of the crop is probably also an upper limit; and yield losses are minimized (lower limits).

In 1985 using glyphosate at 10.8 g ae L^{-1} and simulated densities of 4 and 8 weeds/9 m of row, cotton lint yield reductions ranged from 3 to 48%. With glyphosate at 7.2 g ae L^{-1} and 6 weeds/9 m of row, yield reductions ranged from 5 to 19% in 1986 and 6 to 29% in 1987. Green et al. (6) reported that cotton lint yield was reduced 1.5% for each silverleaf nightshade plant/10 m of crop row when interference was permitted over the entire growing season. Using that prediction equation, if the silverleaf nightshade stand was 4, 6, or 8 weeds/9 m of row (4.4, 6.6, and 8.8 weeds/10 m of row), a yield reduction of 6.7, 10.1, and 13.5%, respectively, could be expected. Cotton yield will be reduced from weed interference and/or herbicide injury. However, if the weed is not controlled, this loss likely will continue to occur in subsequent years (6, 16). Future losses probably will be of greater magnitude because the density of the weed will increase (16). If spot treatments are used, net yield may decrease the year of use, but crops grown in seasons following control will not be affected (19).

The benefits of using spot treatments of glyphosate could also be determined with the aid of cotton prediction models for other weed species. For example, Mercer et al. (12), Rushing et al. (14), and Rushing et al. (15) researched the effects on cotton of full-season interference from devil's-claw [Proboscidea louisianica (Mill.) Thellung], buffalobur (Solanum rostratum Dun.), and tumble pigweed (Amaranthus albus L.), respectively. Devil's-claw at densities of 4, 6, and 8 plants/9 m of cotton row would decrease estimated cotton lint yield 21, 30, and 38%, respectively. Buffalobur at those densities would decrease estimated yield 11, 17, and 22%; and tumble pigweed at those densities would decrease estimated yield 3, 5, and 7%.

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Table 1. Cotton response to a glyphosate rate of 10.8 g ae L^{-1} made as a spot treatment and applied at three intervals and two simulated weed densities of 4 and 8/9 m of row in 1985.

Treatment			Cotton injury			Lint yield	
Frequency	Time after emergence	Density/ 9 m of row	Aug. 4 6 WAE[a]	Aug. 23 9 WAE	Sept. 17 13 WAE		
no.	wk	no.	%			kg ha^{-1}	%[b]
1	5	4	16	10	8	930	97
1	5	8	15	20	15	810	84
1	8	4	--	11	10	800	83
1	8	8	--	15	14	740	77
1	11	4	--	--	15	880	92
1	11	8	--	--	18	780	81
2	5/8	4	18	14	11	830	86
2	5/8	8	24	21	25	570	59
2	5/11	4	15	13	18	790	82
2	5/11	8	20	20	19	730	76
2	8/11	4	--	13	21	700	73
2	8/11	8	--	21	28	550	57
3	5/8/11	4	11	18	20	690	72
3	5/8/11	8	24	26	33	500	52
Untreated	--	--	0	0	0	960	100
LSD (0.05)			4	6	5	120	13

[a]WAE = weeks after crop emergence.

[b]Relative to the untreated check.

Table. Cotton response to a glyphosate rate of 7.2 g ae L^{-1} made as a spot treatment and applied at three intervals and a simulated weed density of 6/9 m of row in 1986 and 1987.

Treatment		1986					1987				
		Cotton injury					Cotton injury				
	Time after	July 30	Aug. 13	Sept. 18			July 30	Aug. 18	Sept. 1		
Frequency	emergence	5 WAE[a]	7 WAE	12 WAE	Lint yield		7 WAE	10 WAE	12 WAE	Lint yield	
no.	wk	%			$kg\ ha^{-1}$	%[b]	%			$kg\ ha^{-1}$	%
1	2	21	20	15	740	95	44	33	18	1200	83
1	4	15	14	11	710	91	25	18	13	1300	90
1	6	--	15	21	660	85	21	18	16	1360	94
1	8	--	--	19	720	92	--	16	13	1290	89
1	10	--	--	23	680	87	--	--	11	1340	92
2	2/6	24	26	21	710	91	40	31	19	1240	86
2	2/8	21	21	21	700	90	34	33	24	1140	79
2	2/10	23	21	21	710	91	35	26	16	1190	82
2	4/8	18	19	23	650	83	24	24	23	1190	82
2	4/10	18	14	21	660	85	21	16	11	1270	88
2	6/10	--	13	26	630	81	21	16	19	1150	79
3	2/4/8	24	24	20	730	94	40	36	28	1030	71
3	4/8/10	16	14	28	630	81	21	21	23	1230	85
Untreated	--	0	0	0	780	100	0	0	0	1450	100
LSD (0.05)		4	4	6	90	12	6	6	6	120	8

[a]WAE = Weeks after crop emergence.

[b]Relative to the untreated check.

CHAPTER II

SILVERLEAF NIGHTSHADE (SOLANUM ELAEAGNIFOLIUM) CONTROL AND COTTON (GOSSYPIUM HIRSUTUM) RESPONSE TO SPOT-APPLIED GLYPHOSATE

SILVERLEAF NIGHTSHADE (SOLANUM ELAEAGNIFOLIUM) CONTROL AND COTTON (GOSSYPIUM HIRSUTUM) RESPONSE TO SPOT-APPLIED GLYPHOSATE

Abstract. Field experiments were conducted for 2 yr at one location to evaluate the effects of spot-applied glyphosate on silverleaf nightshade control and to measure cotton injury and lint yield. The higher rate of glyphosate (10.8 g ae L^{-1}) in 1985 on dryland provided better silverleaf nightshade control than did the lower rate (7.2 g ae L^{-1}) in 1986 under irrigation. However, the lower glyphosate rate in 1986 caused less crop injury than did the higher rate in 1985. Cotton lint yields were 67 to 92% of the weed-free check in 1986 under irrigation with the reduced glyphosate rate. The higher herbicide rate used in 1985 on dryland resulted in cotton yields of 57 to 77% of the weed-free check. Nomenclature: Glyphosate, N-(phosphonomethyl) glycine; cotton, Gossypium hirsutum L., 'Coker 500'; silverleaf nightshade, Solanum elaeagnifolium Cav. #[1] SOLEL.

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[1]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

Additional index words: Timing of application, crop response, weeks after crop emergence, SOLEL.

INTRODUCTION

The advent of effective herbicides for control of annual weeds and the reduced cultivation which resulted therefrom have enhanced the development and spread of perennial weeds (13). Bermudagrass [*Cynodon dactylon* (L.) Pers.] (5), yellow nutsedge (*Cyperus esculentus* L.) (11), johnsongrass [*Sorghum halepense* (L.) Pers.] (9), silverleaf nightshade (1), and others are now major problems in cotton production. Silverleaf nightshade infests over 800 000 ha of cotton on the Southern High Plains of Texas (1) with several thousand additional hectares in southwestern Oklahoma (14).

Silverleaf nightshade is a deep-rooted, perennial, broadleaf weed with a root system capable of propagation by seed, root segments, and creeping lateral roots (3). Smith et al. (12) reported that one silverleaf nightshade plant/10 m of cotton row could increase to 10 stems/10 m of row after 1 yr of uncontrolled growth. After 2 yr of growth, the stem number had increased to 40/10 m of row.

The extensive root system of silverleaf nightshade allows it to be highly competitive. A negative linear relationship was reported between cotton lint yield and silverleaf nightshade biomass and between cotton lint yield and weed stem numbers (12). Green et al. (7) reported that cotton plant height was reduced at silverleaf nightshade densities of 4 plants or more/10 m of row. They also reported a reduction in cotton boll size at densities of 2 or more weeds/10 m of row and reduced mechanical harvest efficiency at densities of 16 or more plants/10 m of row. Other scientists (1) have reported that infestations of silverleaf nightshade have reduced cotton lint yields up to 75%.

In other research, Green et al. (6) reported the competitive effects between silverleaf nightshade and cotton for soil water. When cotton was grown with silverleaf nightshade, soil water loss was greater from the lower portion of the soil profile earlier in the growing season than when cotton was grown alone.

Interference from silverleaf nightshade has also been reported to reduce yields of peanut (Arachis hypogaea L.) (8) and cereal grains (3). Hackett et al. (8) reported that in-shell peanut yields were reduced by 17% when silverleaf nightshade was allowed to compete with the crop for 4 weeks. Full-season interference decreased peanut yields by 66%. Infestations of silverleaf nightshade at a density of 9 plants/m^2 have reduced cereal grain yields by 12% (3).

Smith and Wiese (13) reported that populations of seedling silverleaf nightshade were not controlled with preplant incorporated herbicides, five substituted urea compounds, or two s-triazines. They also reported that many Solanum species are tolerant to trifluralin [2,6-dinitro-

N,N-dipropyl-4-(trifluoromethyl)benzenamine]; and consequently, seedling silverleaf nightshade has not been suppressed where that herbicide has been used.

Selective placement of a nonselective postemergence herbicide such as glyphosate is one of the few alternatives cotton producers have for perennial weed control. Specialized equipment including the roller (10), directed sprayer (5), recirculating sprayer (10), hooded or shielded sprayer (5), ropewick (1,9), and spot applicator (2,4) has been used for selective herbicide placement. Keeley et al. (9) reported that plots infested with johnsongrass and treated with a ropewick applicator containing glyphosate yielded an average of 81% more seedcotton than cultivated control plots. Treated plots averaged 33% less than plots maintained weed-free by hand hoeing; this loss was judge to be the result of johnsongrass competition prior to the initiation of treatment. Abernathy and Keeling (1) controlled 95% or more of mature silverleaf nightshade using a ropewick applicator with 0.21 kg ae ha^{-1} of glyphosate.

Silverleaf nightshade grows between and within cotton rows making selective applications difficult because the herbicide is phytotoxic to cotton. Westerman and Murray (14) reported that glyphosate spot applied to "simulated" weeds resulted in cotton injury and reduced cotton lint yield. The severity of injury and yield reductions depended on the timing and number of applications.

The objective of this research was to measure the effects of spot-applied glyphosate on silverleaf nightshade control as well as on cotton injury and lint yield.

MATERIALS AND METHODS

Field studies were conducted in 1985 and 1986 near Altus in southwest Oklahoma on a Tillman clay loam (fine, mixed, thermic Typic Paleustoll) and Hollister clay loam (fine, mixed, thermic Pachic Paleustoll) with 1.0% organic matter. Experiments were conducted on different locations each year. Experimental design was a randomized complete block with four replications. Individual plots were four rows by 15 m in length with 102-cm row spacing. Soil pH was 7.6, and soil fertility levels were adjusted each year according to state extension soil test recommendations for cotton.

Preplant bedded applications of glyphosate at 0.68 kg ae ha^{-1} were applied each year 2 wk before planting to reduce the severe infestation of silverleaf nightshade present to a more manageable stand for spot application. At the time of those applications, silverleaf nightshade represented a generally uniform 10 to 15% ground cover and 5 to 30 cm in height with a small percentage of the plants in the early bloom stage. Later in the growing season if untreated, the weed represented a 50 to 60% ground cover.

Each year, trifluralin at 0.83 kg ai ha^{-1} was applied preplant incorporated. The experimental areas were planted to 'Coker 500' cotton June 14, 1985, and May 30, 1986.

Prometryn [N,N'-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] at 1.09 kg ai ha^{-1} was applied as a preemergence treatment during both years. In 1986, cotton was replanted to 'Coker 500' on June 14, 1986; and fluometuron {N,N-dimethyl-N'-[3-(trifluoromethyl) phenyl]urea} at 0.68 kg ai ha^{-1} was applied as a preemergence treatment. Crop densities of approximately 12 plants/m of row were established each year.
Research was conducted under dryland conditions during 1985 and under irrigated conditions during 1986.

During 1985 and 1986, all spot applications were made with a commercial pull-type spot treater[2]. During 1985, a 10.8 g ae L^{-1} (3% v/v of 3 lb ae gal^{-1}) solution of glyphosate was used; and a 7.2 g ae L^{-1} (2% v/v of 3 lb ae gal^{-1}) solution was used in 1986. Glyphosate was spot applied to the silverleaf nightshade with a single squirt of the hand-gun directed to cover most of the weed.

In 1985, glyphosate was spot applied to 10 selected combinations of single and sequential treatments made 3, 6, 9, and 12 WAE[3] on July 9, July 30, Aug. 21, and Sept. 5, respectively. The 3 WAE treatment was applied to 20- to 25-cm tall cotton with 4-true leaves and 5- to 30-cm tall silverleaf nightshade in the early bloom-stage. The 6 WAE treatment was applied to 40- to 46-cm tall cotton with

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[2]Wylie Manufacturing Co., P.O. Box 249, Petersburg, TX 79250.

[3]Abbreviations: WAE, weeks after crop emergence.

squares and 25- to 30-cm tall silverleaf nightshade in full bloom. The 9 WAE application was made to 60-cm tall cotton with blooms and in early boll formation and to 30-cm tall silverleaf nightshade with some mature fruit. The 12 WAE application was made to 60- to 75-cm tall cotton with late boll formation and 36-cm tall silverleaf nightshade with mature fruit. The sequential treatments included applications at 3/6, 3/9, 3/12, 6/12, 3/6/9, and 3/6/12 WAE.

During 1986, single applications of glyphosate were applied 2, 4, 6, 8, and 10 WAE to the silverleaf nightshade. Sequential treatments were made at 4/8, 4/10, and 6/10 WAE. Application dates in 1986 were July 2, July 17, July 30, Aug. 13, and Aug. 28. The 2-, 4-, 6-, 8-, and 10-wk applications were made to approximately 10-, 20-, 30-, 40-, and 75-cm tall cotton and to 5-, 10-, 15-, 20-, and 30-cm tall silverleaf nightshade, respectively. This corresponded to cotton growth stages of 2-true leaves, 5- to 6-true leaves, 10- to 12-true leaves, early bloom, and late bloom to early boll formation.

Visual ratings for percent cotton injury and silverleaf nightshade control were taken on July 23 (5 WAE), Aug. 6 (7 WAE), Aug. 29 (10 WAE), and Sept. 17 (13 WAE) in 1985 and on July 30 (6 WAE), Aug. 13 (8 WAE), and Sept. 18 (12 WAE) in 1986, respectively.

Each year, one mature cotton boll was collected from 15 randomly selected plants in each plot shortly before cotton harvest to calculate pulled lint percentage [(weight of lint/weight of seedcotton plus bur) X 100]. That percentage times the stripper-harvested weight from that plot provided an estimate of lint yield/plot. Cotton was harvested with a roller-brush mechanical stripper Dec. 5, 1985, and Feb. 12, 1987.

Data were subjected to analyses of variance, and treatment means were compared using the protected least significant difference (LSD) test at the 0.05 probability level.

RESULTS AND DISCUSSION

The preplant bedded applications of glyphosate made 2 wk before planting provided approximately 50% silverleaf nightshade control when evaluated on June 14, 1985, and May 23, 1986 (data not shown). Those applications accomplished the objective of reducing overall stand of weeds to a level more typical for spot treatments.

A single application made 3 WAE provided 81% control on July 23 (5 WAE) and remained relatively constant throughout the growing season (Table 1). Single applications made 6, 9, and 12 WAE provided silverleaf nightshade control of 90, 98, and 83%, respectively, on Sept. 17 (13 WAE). Applications made twice resulted in 85 to 93% control. Applications made three times resulted in 90 to 93% control. During the growing season, visual silverleaf nightshade control remained relatively constant for all applications. With control ranging from 75 to 98% throughout the season, it was apparent that the herbicide rate may have been higher than required, especially when also considering the extent of cotton injury.

A single application of glyphosate early in the growing season (3 WAE) caused 18 to 26% estimated cotton injury (Table 1). An application 6 WAE caused 10 to 14% injury, 9 WAE caused 13 to 15%, and 12 WAE caused 10%. The multiple treatments ranged from 10 to 23% by the end of the growing season. Only the 3/9 WAE multiple treatment was significantly higher in injury than any of the single treatments at the end of the season; and even then, it was not significantly different from the 3 WAE single treatment.

Cotton lint yield was numerically and significantly lower in every instance from plots treated one, two, or three times compared to the weed-free check (Table 1). Cotton receiving one spot application yielded 58 to 78% of the weed-free plots. Single applications made 6 and 12 WAE did not differ from the weedy check. Single applications made 3 or 9 WAE yielded significantly less. Multiple spot applications yielded 61 to 73% of the weed-free check. Visually, 10 to 23% cotton injury was estimated on Sept. 17 (13 WAE) from all spot treatments; whereas, lint yield was actually reduced 23 to 39% when compared to the weed-free check. Full-season competition of silverleaf nightshade with cotton has been estimated to reduce lint yield by up to 50% (7). Because of the severe yield reductions obtained in 1985, application rates were reduced by one-third in 1986.

In 1986, single applications made at 2 and 4 WAE resulted in 49 to 45% silverleaf nightshade control, respectively, on July 30 (6 WAE), but declined to 13% or less by Sept. 18 (12 WAE) (Table 2). Single applications made 6, 8, and 10 WAE provided weed control of 21, 65, and 78%, respectively, by the end of the season. Applications made twice resulted in 44 to 83% control. During the growing season, silverleaf nightshade control declined from single applications. In contrast, weed control from multiple applications remained constant or increased.

Single applications of glyphosate made at 2, 4, 6, 8, or 10 WAE resulted in 13% or less estimated visual cotton injury on Sept. 18 (12 WAE) (Table 2). Applications made two times resulted in cotton injury of 10 to 22% at the end of the season.

Cotton lint yields from plots treated one or two times were numerically lower in every instance when compared to the weed-free check (Table 2). Four of the eight treatments were also significantly lower. Cotton receiving a single spot application yielded 78 to 91% of the weed-free cotton plots. A single spot application made 4, 8, or 10 WAE did not differ from the weed-free plots. However, the loss had to be greater than 18.6% to be significant. Comparisons were not highly sensitive. There were no significant differences in yield between any of the single spot applications and the weedy check. Multiple spot applications yielded 67 to 91% of the weed-free check. In this experiment, full-season competition of silverleaf nightshade resulted in a 12% reduction in cotton lint yield. Visually, 3 to 22% cotton injury was estimated from all spot treatments at the end of the season; whereas, lint yield was actually reduced 9 to 33% when compared to the weed-free check.

Multiple applications made 4/8 and 6/10 WAE significantly reduced lint yield by 23 and 33%, respectively. Only the 6/10 WAE treatment yielded significantly less than the weedy check.

Silverleaf nightshade control on Sept. 17, 1985, ranged from 83 to 98%; whereas, on Sept. 18, 1986, it ranged from was 6 to 83%. In 1986, the combination of a lower glyphosate rate (7.2 g ae L^{-1}) and an earlier application time probably resulted in less control. Likewise, cotton injury from single treatments of glyphosate during 1986, in general, were lower in 1985. Differences between years in cotton injury for multiple treatments were not large.

In 1986 under irrigated conditions, the cotton lint yield was less affected by single applications than in 1985. In 1986, the cotton yielded 78 to 91% of the weed-free check; and in 1985, it only yielded 58 to 78%. Adequate moisture and a decreased glyphosate rate enabled the cotton to overcome some of the phytotoxic effects of the chemcials. The same observations were noted between 1985 vs. 1986 for multiple spot applications.

Spot applications of glyphosate should benefit producers by reducing herbicide quantity, by targeting the weed problem, and by reducing costs required to control this perennial weed.

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Table 1. Silverleaf nightshade control and cotton response to spot-applied glyphosate at 10.8 g ae L^{-1} at selected intervals in 1985.

Treatment		Silverleaf nightshade control				Cotton injury					
		July 23	Aug. 6	Aug. 29	Sept. 17	July 23	Aug. 6	Aug. 29	Sept. 17	Lint yield	
Frequency	Time	5 WAE[a]	7 WAE	10 WAE	13 WAE	5 WAE	7 WAE	10 WAE	13 WAE		
No.	WAE	%								kg ha^{-1}	%[b]
1	3	81	84	75	83	20	26	18	18	190	58
1	6	--	86	81	90	--	14	13	10	220	67
1	9	--	--	91	98	--	--	15	13	190	58
1	12	--	--	--	83	--	--	--	10	250	78
2	3/6	84[c]	91	88	85	18[c]	26	21	15	240	73
2	3/9	85[c]	84[c]	90	93	26[c]	28[c]	23	23	210	64
2	3/12	89[c]	89[c]	78[c]	88	21[c]	24[c]	16[c]	10	210	64
2	6/12	--	90[c]	83[c]	90	--	18[c]	15[c]	15	220	69
3	3/6/9	90[c]	94[c]	93	90	24[c]	26[c]	19	15	200	61
3	3/6/12	88[c]	91[c]	85[c]	93	18[c]	34[c]	19[c]	14	220	67
Check (weed-free)	--	100	100	100	100	0	0	0	0	330	100
Check (weedy)	--	0	0	0	0	0	0	0	0	260	79
LSD (0.05)	--	7	5	7	7	12	10	6	8	60	18

[a] WAE = weeks after crop emergence.

[b] Relative to the weed-free check.

[c] All applications had not yet been applied to these treatments on these data-collection dates.

Table 2. Silverleaf nightshade control and cotton response to spot-applied glyphosate at 7.2 g ae L^{-1} at selected intervals in 1986.

Treatment		Silverleaf nightshade control			Cotton injury				
		July 30	Aug. 13	Sept. 18	July 30	Aug. 13	Sept. 18		
Frequency	Time	6 WAE[a]	8 WAE	12 WAE	6 WAE	8 WAE	12 WAE	Lint yield	
No.	WAE	%						kg ha^{-1}	%[b]
1	2	49	25	6	21	20	3	510	80
1	4	45	28	13	18	11	9	560	88
1	6	--	71	21	--	13	13	500	78
1	8	--	--	65	--	--	8	580	91
1	10	--	--	78	--	--	10	540	84
2	4/8	49[c]	53[c]	44	11[c]	14[c]	10	490	77
2	4/10	50[c]	59[c]	83	14[c]	10[c]	18	580	91
2	6/10	--	53[c]	73	--	14[c]	22	430	67
Check (weed-free)	--	100	100	100	0	0	0	640	100
Check (weedy)	--	0	0	0	0	0	0	560	88
LSD (0.05)	--	22	29	23	11	7	13	120	19

[a] WAE = weeks after crop emergence.

[b] Relative to the weed-free check.

[c] All applications had not yet been applied to these treatments on these data-collection dates.

CHAPTER III

SILVERLEAF NIGHTSHADE (<u>SOLANUM</u> <u>ELAEAGNIFOLIUM</u>) MANAGEMENT IN COTTON (<u>GOSSYPIUM</u> <u>HIRSUTUM</u>) WITH HERBICIDES

SILVERLEAF NIGHTSHADE (*SOLANUM ELAEAGNIFOLIUM*) MANAGEMENT IN COTTON (*GOSSYPIUM HIRSUTUM*) WITH HERBICIDES

Abstract. A field study was initiated in the spring of 1988 and continued through 1989 to evaluate the use of selected herbicides, methods of application, and frequency of application for silverleaf nightshade control and to measure cotton response to those treatments. During 1988, single or multiple spot applications of glyphosate were effective for silverleaf nightshade control when applied 7 WAE. Applications made with a shielded sprayer provided less control; however, control increased when shielded applications were followed with a single backpack spot application. In 1989, retreatments resulted in 95% or greater silverleaf nightshade control. Cotton injury in 1988 was lower from shield applications than when glyphosate was spot applied. In 1989, cotton injury was the lowest when the retreatments followed one of the more successful silverleaf nightshade control treatments made the previous year. Generally, in 1988, no yield increases were observed as a result of the herbicide treatments. However, in 1989, single spot applications of glyphosate which followed the better 1988 treatments resulted in significant increases in

cotton lint yield.

Nomenclature: Glyphosate, N-(phosphonomethyl)glycine; cotton, Gossypium hirsutum L., 'Earlybird 3755' and 'Paymaster 145'; silverleaf nightshade, Solanum elaeagnifolium Cav. #[1] SOLEL.

Additional index words: Timing of application, crop response, shield applications, spot applications, application equipment, SOLEL.

INTRODUCTION

Common crop production practices are usually effective for control of most weeds; however, management systems have not been fully developed for control of the more difficult to control species. Weed control systems have been developed for peanuts (Arachis hypogaea L.) (25), soybeans [Glycine max (L.) Merr.] (4, 10, 26,), corn (Zea mays L.) (4), and cotton (5, 8, 19, 20).

Continuous use of trifluralin [2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine] in cotton weed control has substantially reduced the severity of large crabgrass [Digitaria sanguinalis (L.) Scop.] and Florida pusley (Richardia scabra L.) (8). Dowler and Hauser (8) also reported that weed control systems without a postemergence application of MSMA (monosodium salt of methylarsonic acid)

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[1]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

allowed common cocklebur (Xanthium strumarium L.) and Florida beggarweed [Desmodium tortuosum (Sw.) DC.] to remain in the cotton row thus reducing lint yield. Brown and Whitwell (5) reported that only systems with herbicide applications prior to crop emergence and postemergence directed herbicides provided good control in minimum-tillage cotton.

Keeling et al. (19) reported that treating continuous cotton with MSMA reduced the number of viable yellow nutsedge (Cyperus esculentus L.) tubers by 91% in 3 yr. In later experiments, a system involving cultivation, preplant applications of fluridone {1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1H)-pyridinone} or two hoeings for 2 yr preceding cotton treated with DSMA (disodium salt of methylarsonic acid) and MSMA reduced yellow nutsedge tubers 98 to 99% within 3 yr (20). Similarly, johnsongrass [Sorghum halepense (L.) Pers.] control in cotton (7) and soybean (4, 26) required a multiple-year management system.

Silverleaf nightshade is a deep-rooted, perennial, broadleaf weed with an extensive root system that propagates by seed, root fragments, and creeping later roots (6). Silverleaf nightshade infests over 800 000 ha of cotton on the Southern High Plains of Texas (1) and several thousand hectares in southwestern Oklahoma (24).

This perennial weed reduces boll size, cotton plant height, and decreases mechanical harvest efficiency (12). Silverleaf nightshade is also competitive for water (11, 6) and will spread rapidly (22) if not controlled.

Silverleaf nightshade interference has been reported to reduce the yield of cereal grains (6) and peanut (13). A density of 9 silverleaf nightshade plants/m^2 decreased cereal grain yields by 12%. Hackett et al. (13) reported that silverleaf nightshade must be controlled for the first 4 weeks or a 17% reduction in peanut yields would occur. Full-season interference of the weed reduced peanut yields 66%.

Smith and Wiese (23) reported that seedling silverleaf nightshade were not affected by preplant incorporated herbicides, five substituted urea compounds, or two s-triazine herbicides. Several Solanum species are tolerant to trifluralin; and consequently, seedling silverleaf nightshade establishment was not suppressed where this herbicide was used extensively (23).

Control of perennial weeds has been successful when selective placement of nonselective postemergence herbicides such as glyphosate are used. Specialized equipment such as a ropewick (1, 16), directed sprayer (9), hooded or shielded sprayer (9, 15), roller (18, 21), recirculating sprayer (18), and spot applicator (3, 7, 14) has been used for selective applications. A combination of selective placement equipment may be needed to control silverleaf nightshade in a crop production system since it grows not only in the row middles but also within cotton rows.

Westerman and Murray (24) reported that the timing and number of glyphosate spot applications affected cotton injury and lint yields. Banks and Santelmann (2) reported excellent control of horsenettle (Solanum carolinense L.) with glyphosate applications made to the weed in the blooming to fruiting growth stage, however, only 50% control was obtained from earlier applications.

To obtain a silverleaf nightshade management system, it is important to consider timing of applications and application methods. The objectives of this research were to evaluate the effects of glyphosate and glyphosate premixes in combination with several methods of application made at different time intervals on silverleaf nightshade control as well as on cotton injury and lint yield.

MATERIALS AND METHODS

In 1988 and 1989, an experiment was conducted on a Tillman clay loam (fine, mixed, thermic Typic Paleustoll) and Hollister clay loam (fine, mixed, thermic Pachic Paleustoll) in southwest Oklahoma near Altus. The experiment was conducted on an area having a natural infestation of silverleaf nightshade with a density of approximately 9 plants/m^2. The experiment was conducted at the same location for a period of 2 yr under dryland conditions. Soil pH was 7.6, and soil fertility levels were adjusted each year according to state extension soil test recommendations for cotton.

In 1988 and 1989, trifluralin was applied preplant incorporated at 0.34 and 0.45 kg ai ha^{-1}, respectively. The experimental area was planted to 'Earlybird 3755' cotton on May 12, 1988, and to 'Paymaster 145' cotton on June 21, 1989. Crop densities of approximately 15 plants/m of row were established each year.

Prometryn [N,N'-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] at 1.1 kg ai ha^{-1} was applied in 1988 and prometryn at 0.45 kg ai ha^{-1} plus alachlor [2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)acetamide] at 0.45 kg ai ha^{-1} were applied in 1989 as preemergence treatments.

Treatments were arranged in a randomized complete block design with four replications. Individual plots were four rows by 15 m in length with 102-cm row spacing.

During 1988, the herbicide treatments consisted of spot applications of glyphosate made at specific time intervals, shielded applications of glyphosate in a 2% w/v $(NH_4)_2SO_4$ carrier, glyphosate premixes, and combinations of shielded applications followed by late backpack spot applications of glyphosate (Table 1).

Spot applications were made with a commercial pull-type spot treater[2]. Applying glyphosate at 7.2 g ae L^{-1} (2% v/v of 3 lb ae gal^{-1}) solution were applied to six combinations of single and sequential treatments 3, 5, and 7 WAE[3] on June 10, June 21, and July 6, 1988, respectively. The 3 WAE

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[2]Wylie Manufacturing Co., P.O. Box 249, Petersburg, TX 79250.

[3]Abbreviations: WAE, weeks after crop emergence.

treatment was applied to 15-cm tall cotton with 5-true leaves and 25- to 30-cm tall blooming silverleaf nightshade. The 5 WAE treatment was applied to 20- to 25-cm tall cotton with 5- to 8-true leaves and 2 to 35-cm tall blooming silverleaf nightshade. The 7 WAE treatment was applied to 35- to 40-cm tall cotton with blooms and 2 to 50-cm tall blooming silverleaf nightshade.

All shielded applications of glyphosate and glyphosate premixes were applied in a carrier volume of 95 L ha^{-1} 7 WAE. These applications included glyphosate at 0.34, 0.68, and 1.01 kg ae ha^{-1} in an $(NH_4)_2SO_4$ carrier (2% w/v), glyphosate premixes which included glyphosate at 0.13 and 0.17 kg ae ha^{-1} plus 2,4-D at 0.21 and 0.28 kg ae ha^{-1}, respectively, and glyphosate at 0.15 and 0.20 plus alachlor at 0.81 and 1.10 kg ai ha^{-1}, respectively. Late-season spot applications were applied with a commercially available backpack sprayer[4] 11 WAE. The cotton was 75- to 90-cm tall, late bloom to early-boll growth stage and the silverleaf nightshade was 2- to 60-cm tall in the late bloom to early-berry growth stage.

In 1989, plots were retreated with spot applications of glyphosate at 7.2 g ae L^{-1} solution. Treatments included seven combinations of single and sequential treatments 5, 8, and 12 WAE Aug. 1, Aug. 22, and Sept. 19, respectively (Table 1). The 5 WAE treatment was applied to 20- to 35-cm

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[4]SOLO Backpack Sprayers, Forestry Suppliers, Inc., P.O. Box 8397, Jackson, MS 39284.

tall cotton with 6- to 10-true leaves and 10- to 40-cm tall silverleaf nightshade in early bloom. The 8 WAE treatment was applied to 40- to 60-cm tall cotton in full bloom and 15- to 60-cm tall silverleaf nightshade in late-bloom to early-berry growth stage. The 12 WAE treatment was applied to 75- to 90-cm tall cotton in late boll and 60- to 75-cm tall silverleaf nightshade in the late-berry stage.

Data collected for 1988 included silverleaf nightshade control, cotton injury, and lint yield. In 1989, silverleaf nightshade control was evaluated 2 wk before cotton seedbed preparation and planting and before any retreatment of the plots. Data collected during 1989 included visual silverleaf nightshade control, cotton injury, and lint yield.

Each year immediately before cotton harvest, one mature cotton boll was collected from the center of 15 randomly selected plants/plot. The cotton bolls were used to calculate pulled lint percentage [(weight of lint/weight of seedcotton plus bur) X 100]. That percentage times the stripper-harvest weight from that plot provided an estimate of lint yield/plot. Cotton was harvested with a roller-brush mechanical stripper Oct. 15, 1988, and Nov. 16, 1989.

Data were subjected to analyses of variance, and treatment means were compared using the protected least significant difference (LSD) test at the 0.05 probability level.

RESULTS AND DISCUSSION

On Aug. 25, 1988, all applications provided 63% or greater silverleaf nightshade control (Table 1). Single applications of glyphosate at 7.2 g ae L^{-1} provided good to excellent control depending on application timing. The 7 WAE spot application provided significantly greater silverleaf nightshade control than the 3 WAE application with 96% and 75% control, respectively. Multiple spot applications provided excellent control only when the second application was made 7 WAE. Multiple applications made at either the 3/7 or 5/7 WAE provided significantly greater silverleaf nightshade control of 95% than applications made at 3 WAE and again at 5 WAE.

Differences were not apparent among rates of the shielded applications of glyphosate alone in a 2% w/v $(NH_4)_2SO_4$ carrier (71 to 85% control). Prepackaged mixes of glyphosate plus 2,4-D or alachlor applied with a shielded sprayer provided 63 to 81% silverleaf nightshade control. All shield applications followed by a late season backpack spot application 11 WAE resulted in excellent silverleaf nightshade control of 94% or greater.

On June 6, 1989, approximately 10 months after the initial herbicide application and before retreatment in 1989, silverleaf nightshade control ranged from a low of 31 to a high of 96% (Table 1). Single and multiple spot applications made 7 WAE provided control of 94 to 96%. Glyphosate at 1.01 kg ae ha^{-1} with a 2% w/v $(NH_4)_2SO_4$

carrier gave 84% silverleaf nightshade control. All shielded applications, with the exception of the highest glyphosate rate resulted in 66% or less control. Those shielded applications contained lower rates of glyphosate. Silverleaf nightshade control was 80% or greater when shielded treatments were followed with a single backpack spot application.

On Oct. 18, 1989, all treatments provided 95% or greater silverleaf nightshade control (Table 1). The generally poor silverleaf nightshade control in 1988 from glyphosate prepackaged with either alachlor or 2,4-D and applied with a shielded sprayer increased to 98% or greater when glyphosate was spot applied the second year.

Cotton injury in 1988, was 24% or less from all treatments (Table 2). Glyphosate spot applied one time at 7.2 g ae L^{-1} caused 18% or less visible injury. The highest visible cotton injury in 1988 of 24% was caused by multiple spot applications of glyphosate made at both 3 and 5 WAE. Westerman and Murray (24) also reported that glyphosate spot applied more than once caused greater cotton injury than single application.

Shielded applications of glyphosate in an $(NH_4)_2SO_4$ carrier and glyphosate premixes caused visible cotton injury of 5 to 15%. Several shielded applications caused significantly less cotton injury than when glyphosate was spot applied. This finding would be expected since the applicator design prevents direct contact of the herbicide with the crop. Cotton injury was 9 to 14% when shielded applications were followed by a backpack spot application of glyphosate.

In 1988, a single spot glyphosate application at 5 WAE caused a significant reduction in cotton lint yield of 23% (Table 2). A significant correlation (r = -0.56) indicated that 31% of the variation in cotton lint yield was due to cotton injury. Multiple spot applications made at 3/5 and 5/7 WAE reduced cotton lint yields 34 and 26%, respectively. The remaining spot treatments reduced cotton lint yields but not significantly. A prepackaged mix of glyphosate plus 2,4-D at 0.13 + 0.21 kg ae ha^{-1} was the only shielded application that caused a significant reduction of 37% in cotton lint yield.

Cotton injury on Oct. 18, 1989 ranged from 3 to 24% for all treatments (Table 2). A significant correlation (r = -0.80) indicated 64% of the variation in cotton yield was due to cotton injury. In general, late spot glyphosate applications caused less cotton injury than early applications. This trend was also noted during 1988.

Multiple applications in 1989 following the 3/5, 3/7, and 5/7 WAE multiple spot applications in 1988 did not cause significant cotton injury. Multiple applications in 1989 following shielded applications of prepackaged mixtures of glyphosate plus 2,4-D at 0.13 + 0.21 and 0.17 + 0.28 kg ae ha^{-1}, and glyphosate plus alachlor at 0.15 + 0.81, kg ae ha^{-1} and kg ai ha^{-1}, respectively, in 1988 resulted in significant visual cotton injury of 16 to 24%. Cotton injury was not significant when a single spot applied glyphosate 8 WAE in 1989 followed a combination of shield plus backpack spot application in 1988.

A significant cotton lint yield reduction of 60% was caused in 1989 from a spot applied glyphosate 5 WAE followed by a shield application of glyphosate plus ammonium sulfate at 0.34 + 2% in 1988 (Table 2). Cotton lint yield reductions were not significant in 1989 when multiple spot glyphosate was applied for two yr. These plots yielded 83 to 117% of the weed-free check. Multiple spot applied treatments in 1989 following shield applied prepackages of glyphosate plus 2,4-D at 0.13 + 0.21 and 0.17 + 0.28 kg ae ha^{-1} in 1988 caused significant cotton lint yield reductions of 47 and 40%, respectively. The remaining retreatments had no effect on cotton lint yield.

In general, during 1988, silverleaf nightshade control was greater when glyphosate was spot applied and in many plots control was significantly greater than contol from shielded applications. A correlation between silverleaf nightshade control and cotton lint yield was not significant ($r = 0.13$). This correlation indicates that there was no yield response after the first year of treatment. Consequently the correlation ($r = 0.20$) between silverleaf nightshade control on June 6, 1989 and cotton lint yield in 1988 was also not significant.

Cotton injury was the highest in 1989 when previous applications in 1988 resulted in poor silverleaf nightshade control. Significant lint yield reductions occurred when glyphosate was applied at 5 WAE alone or in combination with 8 and 12 WAE following poor silverleaf nightshade control applications in 1988. A correlation (r = 0.80) indicated that 64% of the variation in cotton lint yield was to due to cotton injury.

With heavy infestations of silverleaf nightshade (this research was conducted with 9 plants/m^2) the producer will not realize an increase in cotton lint yield the first year; however, the second year, after a retreatment of spot applied glyphosate, it is possible to achieve a yield increase of 60% greater than untreated plots. Left untreated, silverleaf nightshade can propagate and spread rapidly (22).

Producers will benefit by taking measures to control silverleaf nightshade in their fields. Single spot applications of glyphosate at 7.2 g ae ha^{-1} made at approximately 7 WAE or later can be used effectively to control silverleaf nightshade with a minimum amount of cotton injury.

Silverleaf nightshade is competitive (12) and therefore early removal is desirable. Selective placement with glyphosate is the best available treatment for silverleaf nightshade control. Glyphosate performs better on larger weeds; and therefore, a delay in treatment until around the 7 WAE is desirable. This delay in treatment will result in competitiion of silverleaf nightshade with cotton and a increased cotton lint yield may not result during the year of treatment. Repeated applications the following year will result in excellent silverleaf nightshade control and increased cotton lint yields.

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Table 1. Silverleaf nightshade control from selected herbicide applications in 1988 and from spot-application retreatments with glyphosate in 1989.

1988						1989 - Retreated with spot applications of glyphosate at 7.2 g L^{-1}		
	Application			Silverleaf nightshade control				Silverleaf nightshade control
Initial treatment	Method[a]	Rate[c]	Time	8/25/88	6/6/89	Retreatment	Time	10/18/89
			(WAE[b])	(%)			(WAE[b])	(%)
Glyphosate	Spot	7.2	3	75	75	Glyphosate	5	100
Glyphosate	Spot	7.2	5	85	76	Glyphosate	8	99
Glyphosate	Spot	7.2	7	96	94	Glyphosate	12	98
Glyphosate/glyphosate	Spot/Spot	7.2/7.2	3/5	74	81	Glyphosate/glyphosate	5/8	99
Glyphosate/glyphosate	Spot/Spot	7.2/7.2	3/7	95	96	Glyphosate/glyphosate	5/12	100
Glyphosate/glyphosate	Spot/Spot	7.2/7.2	5/7	95	94	Glyphosate/glyphosate	8/12	100
Glyphosate + $(NH_4)_2SO_4$	Shield	0.34 + 20	7	71	50	Glyphosate	5	95
Glyphosate + $(NH_4)_2SO_4$	Shield	0.68 + 20	7	81	59	Glyphosate	8	97
Glyphosate + $(NH_4)_2SO_4$	Shield	1.01 + 20	7	85	84	Glyphosate	12	100
Glyphosate + 2,4-D[d]	Shield	0.13 + 0.21	7	71	39	Glyphosate/glyphosate	5/8	98
Glyphosate + 2,4-D[d]	Shield	0.17 + 0.28	7	81	31	Glyphosate/glyphosate	5/12	99
Glyphosate + alachlor[d]	Shield	0.15 + 0.81	7	63	61	Glyphosate/glyphosate	8/12	100
Glyphosate + alachlor[d]	Shield	0.20 + 1.10	7	79	66	Glyphosate/glyphosate/glyphosate	5/8/12	100
Glyphosate/glyphosate	Shield/BP	0.68/7.2	7/11	94	80	Glyphosate	8	98
Glyphosate + $(NH_4)_2SO_4$/glyphosate	Shield/BP	0.68 + 20/7.2	7/11	95	91	Glyphosate	8	100
Glyphosate + 2,4-D[d]/glyphosate	Shield/BP	0.13 + 0.21/7.2	7/11	94	89	Glyphosate	8	100
Check (weed-free)	--	--	--	100	100	Check (weed-free)	--	100
Check (weedy)	--	--	--	0	0	Check (weedy)	--	0
LSD (0.05)	--	--	--	15	22	LSD (0.05)	--	3

[a] Application method: Spot = conventional pull-type spot applicator, Shield = shielded sprayer, BP = backpack sprayer.

[b] WAE = Weeks after crop emergence.

[c] Rates of glyphosate spot and BP applied are in g L^{-1} (2% v/v), $(NH_4)_2SO_4$ rates are in g L^{-1} (2% w/v), all other treatment rates are in kg ha^{-1}.

[d] Prepackaged herbicide mixtures.

Table 2. Cotton response to selected herbicide applications in 1988 and to spot-application retreatments with glyphosate in 1989.

1988							1989 - Retreated with spot applications of glyphosate at 7.2 g L^{-1}				
	Application			Cotton injury					Cotton injury		
Initial treatment	Method[a]	Rate[c]	Time	8/25/88	Lint yield		Retreatment	Time	10/18/89	Lint yield	
			(WAE[b])	(%)	kg ha^{-1}	%[e]		(WAE[b])	(%)	kg ha^{-1}	%[e]
Glyphosate	Spot	7.2	3	18	530	85	Glyphosate	5	11	250	83
Glyphosate	Spot	7.2	5	16	480	77	Glyphosate	8	13	280	93
Glyphosate	Spot	7.2	7	14	490	79	Glyphosate	12	3	360	120
Glyphosate/glyphosate	Spot/Spot	7.2/7.2	3/5	24	400	65	Glyphosate/glyphosate	5/8	8	250	83
Glyphosate/glyphosate	Spot/Spot	7.2/7.2	3/7	18	560	90	Glyphosate/glyphosate	5/12	6	350	117
Glyphosate/glyphosate	Spot/Spot	7.2/7.2	5/7	19	460	74	Glyphosate/glyphosate	8/12	10	260	87
Glyphosate + $(NH_4)_2SO_4$	Shield	0.34 + 20	7	6	580	94	Glyphosate	5	18	120	40
Glyphosate + $(NH_4)_2SO_4$	Shield	0.68 + 20	7	14	490	79	Glyphosate	8	14	280	93
Glyphosate + $(NH_4)_2SO_4$	Shield	1.01 + 20	7	9	580	94	Glyphosate	12	8	340	113
Glyphosate + 2,4-D[d]	Shield	0.13 + 0.21	7	15	390	63	Glyphosate/glyphosate	5/8	24	160	53
Glyphosate + 2,4-D[d]	Shield	0.17 + 0.28	7	11	500	81	Glyphosate/glyphosate	5/12	19	180	60
Glyphosate + alachlor[d]	Shield	0.15 + 0.81	7	6	640	103	Glyphosate/glyphosate	8/12	16	270	90
Glyphosate + alachlor[d]	Shield	0.20 + 1.10	7	5	710	115	Glyphosate/glyphosate/glyphosate	5/8/12	15	220	73
Glyphosate/glyphosate	Shield/BP	0.68/7.2	7/11	14	490	79	Glyphosate	8	6	380	127
Glyphosate + $(NH_4)_2SO_4$/ glyphosate	Shield/ BP	0.68 + 20/ 7.2	7/ 11	13	560	90	Glyphosate	8	3	370	123
Glyphosate + 2,4-D[d]/ glyphosate	Shield/ BP	0.13 + 0.21/ 7.2	7/ 11	9	550	89	Glyphosate	8	6	330	110
Check (weed-free)	--	--	--	0	620	100	Check (weed-free)	--	0	300	100
Check (weedy)	--	--	--	0	480	77	Check (weedy)	--	0	180	60
LSD (0.05)	--	--	--	6	130	21	LSD (0.05)	--	11	120	40

[a] Application method: Spot = conventional pull-type spot applicator, Shield = shielded sprayer, BP = backpack sprayer.
[b] WAE = Weeks after crop emergence.
[c] Rates of glyphosate spot and BP applied are in g L^{-1} (2% v/v), $(NH_4)_2SO_4$ rates are in g L^{-1} (2% w/v), all other treatment rates are in kg ha^{-1}.
[d] Prepackaged herbicide mixtures.
[e] Relative to the weed-free check.

VITA

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