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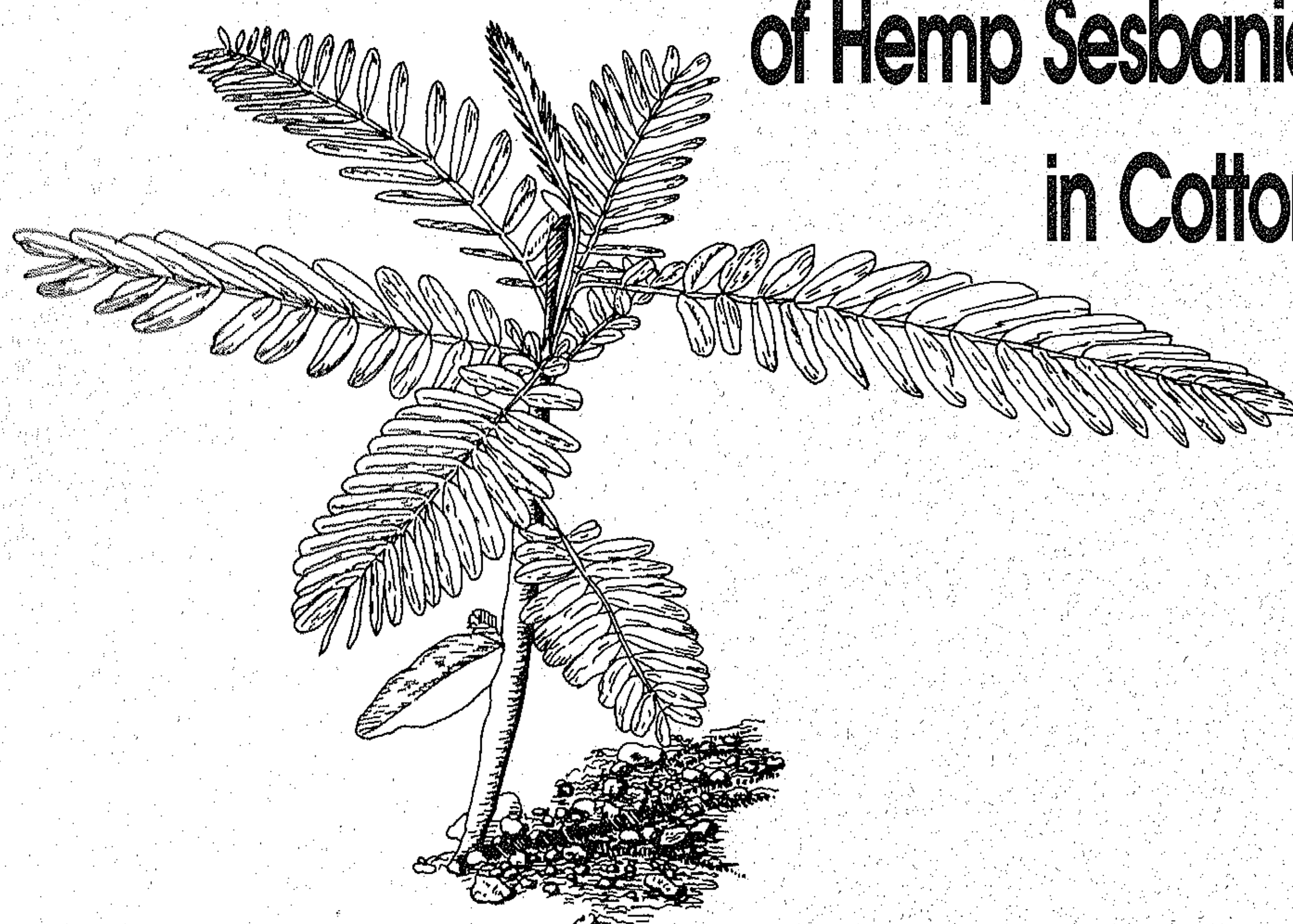

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MISSISSIPPI AGRICULTURAL & FORESTRY EXPERIMENT STATION Verner G. Hurt, Director Mississippi State, MS 39762
Donald W. Zacharias, President Mississippi State University R. Rodney Foil, Vice President

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Charles E. Snipes
Associate Plant Physiologist
Delta Branch Experiment Station
Stoneville, Mississippi

and

Charles T. Bryson
Botanist, USDA-ARS
Southern Weed Science Laboratory
Stoneville, Mississippi

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Introduction

Hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. ex A. W. Hill], also known as coffeebean to a number of producers, is a troublesome weed in several Mississippi row crops, including cotton and soybeans. Of a total infestation of 298,000 acres beltwide, Mississippi cotton had 150,000 acres infested with hemp sesbania (4). It is a hard-seeded annual legume that is most severe in the alluvial clay soils of the lower Mississippi River Valley, but it also occurs throughout the Coastal Plain and Piedmont regions of the southeastern United States, northward to southern New York and Pennsylvania and westward to southern Illinois, Missouri, and Texas (6).

Hemp sesbania infestations have increased in some cotton areas of the Southeast (1, 2, 9). According to a 1989 Southern Weed Science Society Survey, hemp sesbania was the ninth most troublesome weed in Mississippi cotton (5). In 1986, it was considered one of the ten most costly weeds of all crop, industrial, forest, and aquatic weeds in Mississippi (5), and continues to be the eighth most troublesome weed in Mississippi rice.

In addition to competing for nutrients and water, hemp sesbania may reduce cotton yields by shading. Shading alone by hemp sesbania may cause cotton plants to abort squares, bolls, and blooms. Cotton is not a shade-tolerant species, and insufficient light causes stress in cotton plants (10). Abortion of squares, blooms, and bolls may be caused by water deficiency or other environmental factors, including lack of sunlight (7, 8, 11).

Jordan (9) reported that neither norflurazon or fluometuron at 1.5 lb ai/A preemergence provided acceptable season-long control. However, excellent hemp sesbania control ($\geq 90\%$) was obtained when these treatments were followed by directed postemergence treatments of cyanazine, oxyfluorfen, linuron, and prometryn before hemp sesbania plants were 3 inches tall.

In a later study, post-directed applications of fluometuron + MSMA were more effective when following a preemergence application of trifluralin plus fluometuron as compared to the use of norflurazon preemergence (12). Hemp sesbania control with various postemergence herbicides was excellent provided the proper preemergence program preceded postemergence application; however, these treatments were evaluated on sesbania less than 3 inches tall.

Several products have been introduced for post-directed broadleaf weed control since these studies were reported. Lactofen, methazole, and oxyfluorfen are materials that have good activity on hemp sesbania, but little is known about their activity relative to more traditional compounds such as fluometuron, diuron, or prometryn. In addition, weed size contributes to relative performance of most postemergence herbicides, and research is needed to evaluate the performance of newer herbicides relative to older ones with respect to hemp sesbania size.

The objectives of these studies were to (1) determine early-season interference of hemp sesbania with cotton; (2) determine season-long interference from various hemp sesbania densities on cotton growth and yield; (3) determine the critical weed-free period required after simultaneous emergence of hemp sesbania and cotton; and (4) establish effective postemergence chemical control of hemp sesbania at two growth stages.

Materials and Methods

Competition Studies

In the greenhouse, cotton and hemp sesbania were planted in ratios of 4:0, 3:1, 2:2, 1:3, and 0:4 (cotton:hemp sesbania) at equal distances apart and from the sides of 6-inch diameter pots. Plants were grown in a Dubbs very fine sandy loam (Aeric ochraqualf) soil. Each pot was watered twice daily and fertilized after cotton and hemp sesbania emergence. The greenhouse was maintained at an average daytime temperature of 88°F and nighttime temperature of 70°F. Plant heights were measured and plants were harvested at 3 and 5 weeks after emergence (WAE). Plants were oven-dried for 3 weeks at 100°F and then weighed. These experiments were conducted to determine the intra- and inter-specific, early-season competitive effects that could not be adequately evaluated under field conditions.

The experiments were established in a nine-replicated, split plot design with main units (species ratios) as a randomized complete block and sub units as plant location within each pot. Experiments were conducted twice at Stoneville, Mississippi, during 1985. Data were subjected to an analysis of variance, and LSD values were calculated at the 5% (0.05) level of significance.

Field studies were conducted from 1983 to 1987 on a Dundee very fine sandy loam soil (Aeric Ochraqualf) at Stoneville, Mississippi. Field preparation during the 5 years was typical for cotton production, including fall subsoiling and spring chisel plowing. Trifluralin at 0.5 lb/A was applied broadcast and double-disk incorporated followed by preparation (listing) of beds 40 inches apart. Immediately before planting, beds were leveled with conventional bed conditioning equipment. Hemp sesbania seeds were evenly dispensed by hand at five seeds/foot along the top of each row except in the weed-free plots. 'Stoneville 213' cotton was hilldrop-planted at 16 lb/A. Plots were four rows wide by 40 feet long. Row middles were cultivated three times each year, leaving a 6-inch band of cotton and hemp sesbania plants. Supplemental furrow irrigation equivalent to 2 inches of rainfall was applied to each plot once in 1983 and 1985 and twice in 1984 and 1987.

The desired population levels of hemp sesbania were established and maintained by hand-thinning. Hemp sesbania was thinned to uniform densities of 0, 1, 2, 5, and 10 plants/10 row feet or 0, 1,300, 2,600, 6,500, and 13,000 plants/A, respectively. The season-long interference studies were conducted in 1983, 1984, and 1985. In the time-of-removal tests conducted in 1985, 1986, and 1987, hemp sesbania populations were established and maintained at 1 plant/foot or 13,000 plants/A. Hemp sesbania plants were removed by hand each year at 28, 42, 56, 70, and 84 days after planting. The 1986 data are not reported because of stand failure.

These experiments were established as randomized complete block designs with the five hemp sesbania densities or times-of-removal (previously discussed) replicated six times.

Cotton stand counts, cotton seedling vigor (percent growth reduction), boll size, and seed cotton yields were recorded from the two center rows of each plot of the density experiment. Trunk diameter at the soil surface and number of leaves per plant were recorded from four randomly selected hemp sesbania plants from the center two rows of each plot 100 days after planting. Total hemp sesbania leaf area per plant was measured for 20 plants selected at random from adjacent plots 100 days after planting in 1985.

Light intensity was measured along the row, in the drill, at four levels in each plot as follows: (a) 3 feet above the cotton, (b) top of the cotton canopy, (c) 1.5 feet above the soil surface, and (d) at the soil surface. The amount of light was measured on a clear day between 10:00 and 11:30 a.m. CDT at four randomly selected locations in each plot approximately 100 days after planting. Total light was expressed as a percent of the weed-free plots.

Cotton was defoliated and 25 boll samples of seed cotton were hand-picked from each plot of the density study to determine average boll size in both experiments. The center two rows of each plot were machine-harvested on October 6 and 17, 1983; September 24 and November 5, 1984; September 18 and 24, 1985; and September 14 and 28, 1987.

All data were subjected to an analysis of variance and LSD values at the 5% level of significance were calculated. Data from seed cotton yield were subjected to regression analysis.

Chemical Control Studies

Evaluation of hemp sesbania control with currently available herbicides labeled for use in cotton was conducted in 1989 and 1990. Hemp sesbania and cotton seed were drill-planted in 12-inch rows, irrigated, and allowed to emerge. Weed stages of 1 to 3-inches or 3 to 5-inches were treated with herbicides as shown in Tables 5 and 6. Herbicide treatments and growth stages were factorially arranged as a randomized complete block with four replications. Individual plots were 5 feet by 10 feet. The experiment was conducted three times during the 2-year period. Visual estimations of sesbania control and cotton injury were made 7 and 14 days after treatment (DAT) on a scale of 0 to 100, where 0 = no crop injury or weed control and 100 = complete crop kill or weed control.

Herbicides were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 20 gallons of water per acre. All herbicides were applied at recommended rates with MSMA at 2 lb ai/A. The formulation of MSMA used contained surfactant.

All herbicides were applied postemergence over-the-top (POT) to both hemp sesbania and cotton. Cotton was over-sprayed to determine relative phytotoxicity of each treatment. With the exception of fluometuron or MSMA these treatments are not labeled for POT use in cotton. Treatments were applied POT in this experiment simply as a means to provide comparative phytotoxicity or control of each treatment relative to other treatments. Cotton height varied in each experiment and was 2-3 inches and 3-4 inches in Experiment 1, 3 inches and 3-4 inches in Experiment 2, and 1.5-3 inches and 3-5 inches in Experiment 3 for the 1-3 inch and 3-5 inch hemp sesbania stages, respectively.

Analysis of variance was conducted for each experiment and DAT combinations and means were separated at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Significant interactions across experiments and growth stages prevented pooling data.

Results and Discussion

Competition studies

Because there was no significant year by treatment interaction, all data were combined over years. Cotton and hemp sesbania height at 3 and 5 weeks after emergence did not differ in greenhouse pots with cotton to hemp sesbania ratios of 4:0, 3:1, 2:2, and 1:3 (data not shown). Likewise, individual cotton plant dry weights were not different among ratios at 3 weeks after emergence (data not shown) and 5 weeks after emergence (Table 1). Hemp sesbania dry weights were equivalent among treatments at 3 weeks after treatment (data not shown), but at 5 weeks were significantly lower in the 3:1 ratio (cotton:hemp sesbania) when compared to the other ratios. Therefore, at 5 weeks after emergence, hemp sesbania plants did not have an adverse effect on cotton growth and, at this stage, cotton seems to be more competitive than hemp sesbania, provided ratios favor cotton.

In both types of field experiments, cotton stand among treatments did not differ significantly during 1983, 1984, 1985, and 1987 (data not shown). Likewise, there were no visual differences in cotton seedling vigor or early-season growth and development of cotton among plots with various hemp sesbania densities or times-of-removal in any of the 5 years (data not shown).

Full-season competition of hemp sesbania at all densities reduced seed cotton yields (Table 2). Average total seed cotton yields at hemp sesbania densities of 1, 2, 5, and 10 plants/10 row ft were 1,930, 1,760, 1,250, and 1,030 lb/A, representing yield reductions of 19, 25, 45, and 53%, respectively. All hemp sesbania densities also reduced seed cotton yields within individual harvest for each year (Table 2). However, an increasing hemp sesbania population did not delay cotton maturity. Boll size was 5 and 9% smaller for hemp sesbania densities of 1 and 5 plants/10 row ft, respectively, when compared to the boll weight from the weed-free plots (Table 2). Regression analysis revealed a decrease in seed cotton yield with increasing hemp sesbania density up to 10,000 plants/A (Figure 1). Further yield decreases were not evident for higher densities. Based on the derived equation, one thousand hemp sesbania plants per acre (approximately 2 plants per 25 row feet) reduced seed cotton yield approximately 80 lb/A.

Typical plant heights for cotton and hemp sesbania were averaged for 1983, 1984, and 1985 (Figure 2). Hemp sesbania and cotton plants were the same height up to 56 days after planting. After this date, hemp sesbania height increased more rapidly than cotton height. By harvest, hemp sesbania plants were about three times taller than cotton. At 100 days after planting, hemp sesbania, regardless of density, reduced light penetration at the top of the cotton canopy and at 1.5 feet above the soil surface (Table 3). A hemp sesbania density of 10 plants/10 row ft was required to reduce light at the soil surface. Conversely, one

Table 1. Cotton and hemp sesbania weights per plant grown at different ratios for 5 weeks in the greenhouse.

Ratio Cotton:Hemp sesbania	Plant dry weight x 10^{-3}	
	Cotton	Hemp sesbania
	(oz)	
4:0	18.0	–
3:1	17.6	4.6
2:2	18.0	5.6
1:3	18.0	6.0
0:4	–	6.4
LSD (0.05)	1.1	0.7

Table 2. Cotton maturity, boll size, and seed cotton yield with increasing hemp sesbania densities, based on averages in 1983, 1984, and 1985 near Stoneville, MS.

Hemp sesbania density	Boll size	Percent First harvest	Seed cotton yields		
			First harvest	Second harvest	Total
(plants/10 row ft)	oz/25 bolls	(%)	(lb/A)		
0	5.05	71	1,630	650	2,280
1	4.84	74	1,420	510	1,930
2	4.84	76	1,340	420	1,760
5	4.55	77	960	290	1,250
10	4.59	75	770	260	1,030
LSD (0.05)	0.21	NS	180	80	210

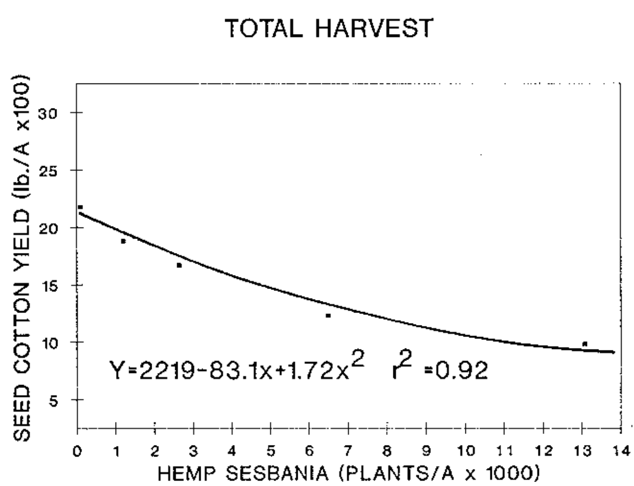

Figure 1. Relationship of seed cotton yield and increasing hemp sesbania densities, based on averages in 1983, 1984, and 1985 near Stoneville, MS.

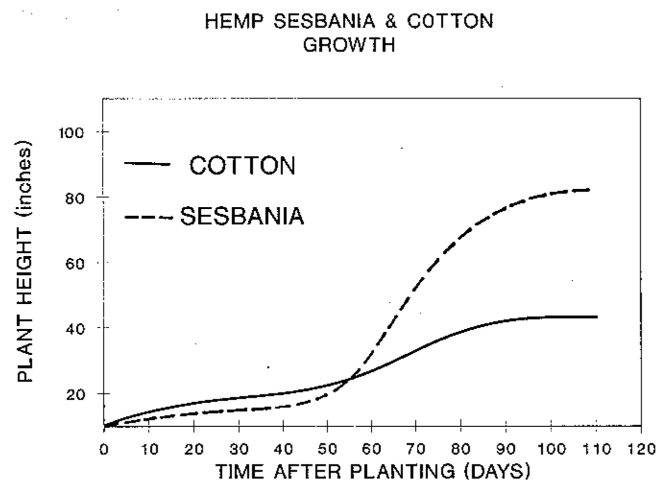

Figure 2. Relationship of cotton and hemp sesbania plant heights based on averages in 1983, 1984, and 1985 near Stoneville, MS.

hemp sesbania/10 row ft reduced light penetration 18% at 3 feet above the cotton canopy.

In the time-of-removal experiment, total seed cotton yields were not lower among treatments that were weed-free and those where hemp sesbania plants were removed at 28, 42, and 56 days after planting (Table 4). Total seed cotton yield was lower in treatments where hemp sesbania plants were not removed until 70 days after planting or later. Total seed cotton weights were 1,810, 1,440, and 950 lb/A for treatments where hemp sesbania plants were allowed to compete for 70 and 84 days after planting or season long, respectively.

By utilizing regression analysis, predictive models were calculated for total seed cotton yield (Figure 3). Thresholds for each harvest were established utilizing the LSD (0.05) value less than the weed-free treatments. Predictive critical periods of weed control or removal of hemp sesbania were calculated based on the intercept of the regression curve and the threshold. The critical period of control or removal of hemp sesbania necessary to achieve optimum yield was 62 days after planting. Based on the 5-year average, hemp sesbania at 10 plants/10 row ft reduced seed cotton yields 50% (Figures 1 and 3).

Results of competition studies indicate that early-season control of hemp sesbania, prior to 8 weeks after planting, is required for optimum cotton yields. Large populations of hemp sesbania, particularly in the late season must be avoided to prevent cotton yield reduction. One thousand hemp sesbania plants (approximately 2 plants per 25 row feet), or 2% of the total plant population in a planted acre of cotton, can reduce seed cotton yields by 80 lb/A. It is extremely

Table 3. Percent light penetrating in cotton at various population densities of hemp sesbania during 1985 near Stoneville, MS.

	Light penetration[a]			
Hemp sesbania density	3 ft above cotton	Cotton canopy top	1.5 ft above soil	Soil level
(plants/10 row ft)	(%)			
0	100	100	34	14
1	82	80	21	13
2	63	64	19	12
5	60	55	18	11
10	56	50	16	8
LSD (0.05)	18	15	6	4

[a]Expressed as a portion of the total amount of light in $\mu E.m^{-2}.S^{-1}$.

Table 4. Relationship of seed cotton weight and time of removal of hemp sesbania at 1 plant/row ft, based on an average of 1985 and 1987 near Stoneville, MS.

Hemp sesbania removal	Seed cotton yields		
	First harvest	Second harvest	Total
(days)	(lb/A)		
weed-free	1,710	470	2,185
28	1,780	540	2,310
42	1,810	480	2,290
56	1,680	520	2,190
70	1,360	460	1,810
84	1,200	240	1,440
season-long	760	200	950
LSD (0.05)	230	70	250

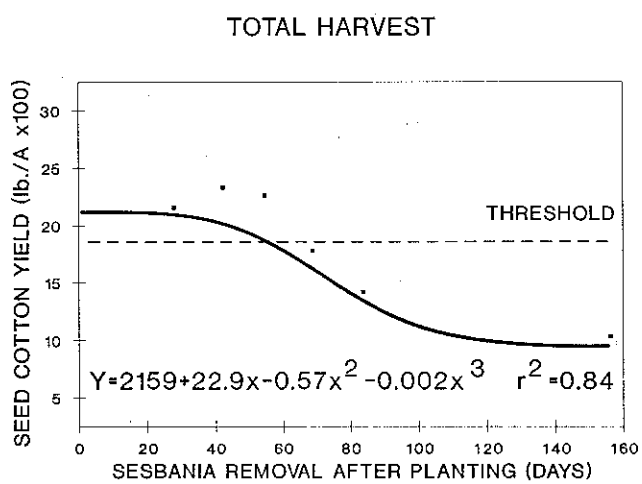

Figure 3. Estimated effects of time of removal of hemp sesbania on seed cotton yield in 1985 and 1987 near Stoneville, MS. Threshold = the point at which the seed cotton yield is significantly less than that of the hemp sesbania-free treatment (P=0.05).

important that producers control hemp sesbania within the first 60 days after planting or yield reductions cannot be overcome. Removal at this stage requires expensive hand labor. Effective hemp sesbania control must utilize a combination of good cultural practices and an effective herbicide program that combines both preemergence and postemergence directed herbicide applications.

Chemical control studies

Environmental conditions during the course of Experiment 3 were extremely dry as compared to those during Experiments 1 and 2. The fluometuron plus MSMA treatment provided 85, 82, and 41% control of 1-3 inch hemp sesbania in Experiments 1, 2, and 3, respectively (Table 5). In each experiment, evaluations made at 7 DAT, indicated control of 3-5 inch hemp sesbania with this treatment was less than when applications were made to 1-3 inch hemp sesbania. This was not the case when evaluations were made 14 DAT for Experiments 1 and 3.

Application of cyanazine plus MSMA to 1-3 inch or 3-5 inch hemp sesbania resulted in control of 95% or greater in Experiments 1 and 2. In Experiment 3, under the drier conditions, control was 85% for 1-3 inch and 60% for 3-5 inch hemp sesbania for the cyanazine plus MSMA treatment. In Experiment 3, control obtained with this treatment on 1-3 inch hemp sesbania was as good as any treatment at that stage. However, control from applications made to 3-5 inch hemp sesbania were significantly less than cyanazine combinations containing oxyfluorfen or lactofen.

In Experiments 1 and 3, hemp sesbania control with diuron plus MSMA, and fluometuron plus MSMA, was less than 90% in Experiment 1 and less than 50% in Experiment 3, 7 and 14 DAT. In Experiment 2, fluometuron plus MSMA was significantly better for hemp sesbania control than diuron plus MSMA at both treatment stages. Hemp sesbania control at 7 and 14 DAT was greater than 90% for prometryn plus MSMA when applied to 1-3 inch hemp sesbania in all three experiments. Prometryn plus MSMA application to 3-5 inch hemp sesbania was less in Experiments 1 and 3 for both evaluation dates, indicating that control can only be obtained on small plants. In Experiments 1 and 2, hemp sesbania control with linuron plus MSMA was greater than 90% at both growth stages 7 and 14 DAT. However, in Experiment 3, under drier growing conditions, linuron plus MSMA provided 70% or less control at the 1-3 inch growth stage and significantly less control when applications were delayed until 3-5 inch hemp sesbania. As with most herbicides, optimum environmental conditions and early growth stages are necessary to achieve adequate herbicide performance. This was indeed the case with the conventional standard herbicides (fluometuron, diuron, prometryn, linuron, and cyanazine) evaluated.

Lactofen plus MSMA was equal to or superior in controlling hemp sesbania when compared to single mixes of the conventional standards. In Experiment 3, under drier conditions, control of 3-5 inch hemp sesbania was significantly less 7 and 14 DAT with this treatment when compared to 1-3 inch hemp sesbania applications. Within an application timing, lactofen plus MSMA was superior to conventional standards 7 DAT, and superior to all but cyanazine plus MSMA at 14 DAT in Experiment 3. Addition of cyanazine to the lactofen plus MSMA tank-mix provided better than 90% hemp sesbania control across all weed stages and environments (experiments).

Methazole, a re-introduced herbicide for use in cotton, was evaluated at rates of 0.5 lb and 0.75 lb/A. In Experiments 1 and 2, hemp sesbania control was significantly better for both growth stages at the 0.75 lb/A rate. In Experiment 3, control with the higher rate was 78% for applications made to 1-3 inch hemp sesbania. In Experiment 2, hemp sesbania control with both rates was significantly higher when applications were made to 1-3 inch hemp sesbania. In Experiment 3, the low rate of methazole plus MSMA provided less than 25% hemp sesbania control at either stage evaluated. Based on these results, hemp sesbania control with methazole plus MSMA was best when the 0.75 lb/A rate was used on 1-3 inch hemp sesbania. Lower rates and later timings proved ineffective.

Oxyfluorfen, a compound with chemistry similar to lactofen, was also evaluated at two different rates. In Experiment 1, hemp sesbania control was the same for both growth stages and both rates evaluated. In Experiment 2 at 7 DAT, control of 3-5 inch hemp sesbania was significantly less with the 0.25 lb ai/A rate of oxyfluorfen. In Experiment 3, hemp sesbania control was similar with both rates of oxyfluorfen when applied to 1-3 inch hemp sesbania. Control of 3-5 inch hemp sesbania was significantly less for both rates in Experiment 3, but control was significantly higher with oxyfluorfen at 0.5 lb/A when compared to oxyfluorfen at 0.25 lb/A. Oxyfluorfen applied at 0.5 lb/A was as effective as lactofen in Experiments 1 and 3. However, at 14 DAT in Experiment 2, the higher rate of oxyfluorfen was significantly greater than lactofen for applications made to 3-5 inch hemp sesbania.

In general, control of hemp sesbania with oxyfluorfen or lactofen was similar, especially when applications were made to 1-3 inch hemp sesbania. Control with both compounds in Experiment 3 was significantly less when applications were made to 3-5 inch hemp sesbania. In any event, hemp sesbania control with either compound should be timed at a hemp

Table 5. Hemp sesbania control with various cotton herbicides applied postemergence over-the-top at two weed stages in three experiments conducted in 1989[1]

		7 DAT						14 DAT					
		Exp. 1		Exp. 2		Exp. 3		Exp. 1		Exp. 2		Exp. 3	
Treatment	Rate	1-3 in	3-5 in	1-3 in	3-5 in	1-3 in	3-5 in	1-3 in	3-5 in	1-3 in	3-5 in	1-3in	3-5 in
	(lb ai/A)												
fluometuron + MSMA	0.8 + 2	85 bc	72 d	82 cde	68 f	41 gh	24 ij	84 b-e	72 ef	74 gh	68 ji	30 ij	30 ij
cyanazine + MSMA	0.6 + 2	100 a	100 a	100 a	99 ab	82 bcd	62 ef	98 a	98 a	96 abc	95 a-d	85 abc	60 fg
diuron + MSMA	0.5 + 2	84 cd	80 cd	65 fg	24 i	35 hi	10 jk	88 a-d	76 def	64 ij	22 k	22 jk	11 kl
prometryn + MSMA	0.5 + 2	100 a	72 d	100 a	94 ab	96 ab	21 j	92 ab	71 f	94 a-e	95 a-d	96 a	16 jk
linuron + MSMA	0.5 + 2	100 a	100 a	100 a	100 a	70 de	52 fg	96 ab	94 ab	92 a-e	100 a	69 def	48 gh
lactofen + MSMA	0.2 + 2	100 a	100 a	95 ab	89 bcd	100 a	80 cd	89 abc	95 ab	85 def	86 c-f	100 a	75 c-f
cyanazine + lactofen + MSMA	0.6 + 0.2 + 2	100 a	100 a	99 ab	100 a	100 a	91 abc	99 a	98 a	98 ab	100 a	100 a	91 ab
methazole + MSMA	0.5 + 2	84 cd	76 cd	80 de	42 h	21 j	14 j	80 c-f	74 ef	78 fg	29 k	12 kl	12 kl
methazole + MSMA	0.75 + 2	96 ab	100 a	98 ab	58 g	75 de	21 j	94 ab	98 a	95 a-d	58 j	78 b-e	24 jk
oxyfluorfen + MSMA	0.25 + 2	96 a	98 a	90 abc	79 e	90 abc	55 f	88 a-d	94 ab	88 b-e	84 ef	92 ab	42 hi
oxyfluorfen + MSMA	0.5 + 2	99 a	100 a	95 ab	92 ab	91 abc	70 de	96 ab	99 a	94 a-e	98 ab	94 a	66 ef
cyanazine + oxyfluorfen + MSMA	0.6 + 0.25 + 2	100 a	100 a	100 a	100 a	100 a	79 cd	96 ab	100 a	100 a	100 a	100 a	78 b-e
cyanazine + oxyfluorfen + MSMA	0.6 + 0.5 + 2	100 a	100 a	100 a	100 a	100 a	84 bcd	100 a	100 a	100 a	100 a	100 a	84 a-d
MSMA	2	22 e	19 e	5 j	0 j	15 j	0 k	8 g	5 g	0 l	0 l	12 kl	0 l
Untreated	–	0 f	0 f	0 j	0 j	0 k	0 k	0 g	0 g	0 l	0 l	0 l	0 l

[1]Means followed by the same letter within experiment and DAT combinations are not different according to DMRT (0.05).

Table 6. Cotton phytotoxicity to herbicides applied at two growth stages postemergence over-the-top, at two weed stages in three experiments conducted in 1989[1]

		7 DAT						14 DAT					
		Exp. 1		Exp. 2		Exp. 3		Exp. 1		Exp. 2		Exp. 3	
Treatment	Rate	1-3 in	3-5 in	1-3 in	3-5 in	1-3 in	3-5 in	1-3 in	3-5 in	1-3 in	3-5 in	1-3in	3-5 in
	(lb ai/A)												
fluometuron + MSMA	0.8 + 2	21 j	29 hij	25 lm	30 jkl	25 kl	24 kl	25 hi	22 hi	56 hij	35 kl	29 l	26 l
cyanazine + MSMA	0.6 + 2	86 bcd	86 bcd	84 bcd	78 cde	56 d-g	35 h-l	91 a-d	84 cde	94 abc	81 b-f	72 b-e	48 h-k
diuron + MSMA	0.5 + 2	45 fg	55 ef	38 ijk	41 ij	34 i-l	28 jkl	48 g	64 f	76 def	50 h-k	40 i-l	41 i-l
prometryn + MSMA	0.5 + 2	86 bcd	45 fg	70 ef	48 hi	70 bcd	32 i-l	75 ef	42 g	81 b-f	45 i-l	76 bcd	34 kl
linuron + MSMA	0.5 + 2	96 ab	74 d	86 bc	91 ab	69 bcd	64 e-f	85 b-e	81 de	99 a	92 a-d	82 bc	66 c-g
lactofen + MSMA	0.2 + 2	89 abc	92 ab	75 de	71 ef	80 abc	39 g-k	81 de	88 a-e	84 a-e	75 ef	86 ab	55 fi
cyanazine + lactofen + MSMA	0.6 + 0.2 + 2	99 ab	100 a	86 bc	95 ab	84 ab	81 abc	99 ab	100 a	94 abc	95 ab	86 ab	84 ab
methazole + MSMA	0.5 + 2	36 ghi	38 ghi	29 klm	35 jkl	30 jkl	20 l	42 g	35 gh	59 ghi	31 l	37 jkl	28 l
methazole + MSMA	0.75 + 2	34 ghi	40 gh	38 ijk	36 jk	44 g-j	22 kl	45 g	42 g	72 efg	41 jkl	59 e-h	41 i-l
oxyfluorfen + MSMA	0.25 + 2	75 d	62 e	52 gh	56 gh	68 b-e	48 f-i	65 f	61 f	78 c-f	65 fgh	71 b-f	41 i-l
oxyfluorfen + MSMA	0.5 + 2	78 cd	61 e	67 ef	61 fg	70 bcd	51 e-h	74 ef	64 f	79 b-f	74 efg	78 bcd	51 g-j
cyanazine + oxyfluorfen + MSMA	0.6 + 0.25 + 2	95 ab	98 ab	88 bc	100 a	92 a	56 d-g	96 abc	99 ab	99 a	99 a	100 a	61 d-h
cyanazine + oxyfluorfen + MSMA	0.6 + 0.5 + 2	99 ab	100 a	91 ab	100 a	92 a	76 abc	96 abc	100 a	100 a	100 a	100 a	71 b-f
MSMA	2	26 ij	19 j	19 m	29 klm	34 i-l	24 kl	25 hi	14 i	45 k-l	31 l	31 kl	24 l
Untreated	–	0 k	9 k	0 n	0 n	0 m	0 m	0 j	0 j	0 m	0 m	0 m	0 m

[1]Means followed by the same letter within experiment and DAT combinations are not different according to DMRT (0.05).

sesbania stage of 1-3 inches. Although control of 3-5 inch hemp sesbania is possible with either compound, environmental conditions dictate the response to these products and caution should be exercised in their use under conditions inappropriate for optimum herbicide activity.

As with lactofen, the addition of cyanazine to the oxyfluorfen plus MSMA tank-mix improved hemp sesbania control under those conditions not favorable for oxyfluorfen alone. Oxyfluorfen plus MSMA or lactofen plus MSMA provided good to excellent control of hemp sesbania in most cases. When control with oxyfluorfen or lactofen was inadequate, cyanazine provided additional control.

For comparison purposes MSMA was included as a treatment without the addition of any other compounds. MSMA provided very little hemp sesbania control. However, MSMA is inexpensive and improves control provided by various other compounds for other weed species that may be present in cotton, especially seedling grasses. Therefore, consideration should be given to the inclusion of MSMA into a complete weed control program in cotton. Selection of an MSMA formulation that contains surfactant negates the need for additional surfactant for the herbicides evaluated and offers broader spectrum weed control.

Cotton phytotoxicity was evaluated at the same time as hemp sesbania control. As expected, over-the-top applications of all herbicides resulted in considerable injury to cotton. Most injurious of these treatments were cyanazine plus lactofen and cyanazine plus oxyfluorfen (Table 6). These were also the most effective combinations for hemp sesbania control. Extreme caution should be exercised in the applications of these combinations for weed control in cotton. A suitable crop height differential is essential and applications should be carefully directed to the base of cotton plants so that application to the leaves or upper portion of the cotton plant does not occur. In direct comparisons of lactofen and oxyfluorfen without cyanazine as part of the tank-mix, both compounds resulted in similar crop injury, but injury was less than when cyanazine was included.

All other herbicides produced intermediate crop injury relative to that of lactofen, oxyfluorfen, cyanazine, or combinations of lactofen or oxyfluorfen with cyanazine. Although crop injury was greater than 20% in all cases, fluometuron plus MSMA produced the least amount of phytotoxicity of any treatment evaluated. There were some instances where methazole plus MSMA was similar to fluometuron plus MSMA with respect to cotton phytotoxicity. However, there were more instances where phytotoxicity to cotton was greater with methazole, especially at the higher rate and the earlier timings needed for adequate hemp sesbania control.

In conclusion, most treatments evaluated provided good to excellent control of hemp sesbania, especially when applied at the 1-3 inch weed stage. In general terms, fluometuron plus MSMA, diuron plus MSMA, and methazole at the 0.5 lb/A rate plus MSMA did not provide acceptable control. However, control with fluometuron plus MSMA and methazole plus MSMA was obtained by using appropriate rates and when applied at early weed stages. In those situations where weed stage was greater than 3 inches and under dry environmental conditions, lactofen plus MSMA, oxyfluorfen at 0.5 lb/A plus MSMA, or these two treatments tank-mixed with cyanazine were the most appropriate treatments for hemp sesbania control. However, on a relative scale these were also the most injurious to cotton. An adequate height differential of cotton to hemp sesbania must be obtained in order that crop safety is not an issue. Oxyfluorfen, lactofen, and cyanazine were all excellent choices for hemp sesbania control in cotton. However, due to label restrictions, post-directed applications cannot be implemented until cotton is 6 inches or taller.

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