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PREEMERGENCE

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Summary

Two experiments were conducted from 1987 through 1989 to establish the most effective and consistent preemergence control of velvetleaf and common cocklebur in cotton. Velvetleaf control was more consistent with norflurazon applied preplant incorporated at either 1.0 or 1.5 lb a.i./A followed by diuron.

In 1988, crop injury at 2 weeks varied and was 29% or greater for treatments of norflurazon tank-mixed with diuron and applied preemergence. With one exception, cultivation did not improve velvetleaf control if control without cultivation was greater than 50%.

In 1987, norflurazon applied PPI at 1.5 lb a.i./A followed by fluometuron applied PRE at 1.5 lb a.i./A was the best treatment for common cocklebur control and did not result in crop injury or stand reduction.

Control in 1988 was less than in 1987 and, as a result, cultivation improved common cocklebur control for all treatments evaluated. However, cultivation did not improve control to acceptable levels and was similar to the cultivated untreated check.

Introduction

In a recent survey, velvetleaf (*Abutilon theophrasti* Medik.) was reported to infest 47,000 acres of cotton (*Gossypium hirsutum* L.) in Mississippi (5). Alabama, Missouri, North Carolina, South Carolina and Tennessee have reported velvetleaf as one of the 10 most troublesome weeds in cotton (8). In 1977, Baldwin (1) included velvetleaf in the "difficult to control" group of broadleaf weeds for the Midsouth.

Full season competition of velvetleaf at a density of 16 plants per 40 feet of row caused significant yield reductions (6). When velvetleaf interfered with cotton for 45 days after emergence, lint yield was significantly reduced (18). When kept velvetleaf-free for a period of 4 to 6 weeks after emergence, seed cotton yields were not reduced.

Velvetleaf also serves as a host plant for the pathogens *Phymatotricham omnivorum* and *Verticillium albo-atram* and for insects such as the bollworm [*Heliothis zea* (Boddie)] and tobacco budworm [*Heliothis virescens* (F.)] (17). Extracts from velvetleaf seeds have been shown to adversely affect germination and seedling growth of various crops (9, 11). While not considered a serious pest in cotton in Mississippi, velvetleaf has the potential to increase infestation levels and reduce yields if uncontrolled. Velvetleaf plants produce 750 reproductive structures per season, which provides an abundant source of seed (15). Lueschen and Anderson (16) reported that after 4 years of intensive tillage, 1,300 viable velvetleaf seeds per square yard remained to a depth of 9 inches. Assuming a 25% germination and/or survival rate of these 1,300 seeds, this would produce 325 plants per square yard or 350 times that needed for a significant yield reduction as reported by Chandler (6).

Although velvetleaf is moderately competitive with cotton, and troublesome in only 5 of the 14 cotton producing states, it continues to be a nuisance in certain areas of the Midsouth. Control measures are limited to cultural practices, which are limited in effectiveness (14), or to chemical means. Recently, a biological agent or mycoherbicide, *Fusarium lateritium* Nees ex. Fr., was shown to suppress growth of velvetleaf, but control was only 40% and 46% for postemergence and preemergence applications, respectively (2). Chemical control has not been well documented. However, velvetleaf control with diuron was reported to be better than fluometuron (9, 11), and norflurazon was reported to give only 78% control in a one-year study (11).

One of the more competitive and prevalent weeds in cotton fields today is common cocklebur (*Xanthium strumarium* L.). In 1989, approximately 2.4 million acres of cotton throughout the entire cotton belt were infested with common cocklebur (5). These infestations caused an estimated 11% cotton yield loss, the second highest yield loss caused by any individual weed that year (5). In Mississippi, 500,000 acres were reported infested in 1989, accounting for a yield loss of 13%.

In 1973, Cooley and Smith (7) reported that common cocklebur plants grown with cotton produce 600 to 1000 burs/plant. Each bur is covered with hook-shaped spines, which cling to clothing and machinery, aiding in seed dispersal. Optimum emergence of common cocklebur seedlings occurs when the seed is planted 1 inch or less below the soil surface, however, emergence from depths as great as 4 inches has been documented (7). Each bur contains a lower embryo and an upper embryo, which do not germinate simultaneously (22). This provides common cocklebur with a unique mechanism to perpetuate plants for a minimum of two seasons from a single bur.

Buchanan and Burns (3) reported cotton yield reduc-

tions from two soil types of 20 to 60% with a common cocklebur density of 8 weeds/25 feet of row. Higher weed densities of 48 plants/25 feet of row resulted in losses as high as 90% for both soil types. They reported that competition from common cocklebur had no effect on cotton lint percentage or fiber properties, and that vegetative growth, boll size, and seed size were not as sensitive as cotton yield to common cocklebur competition.

In later studies, it was shown that seed cotton yield decreased with increasing common cocklebur density, but only to a certain limit (21). When densities reached 16 common cocklebur plants per 50 feet of row, yields were not further reduced by higher densities. This curvilinear response indicated intraspecific competition among common cocklebur. Percent yield reductions ranged from 17% to 70% for cocklebur densities ranging from 2 to 32 plants per 50 feet of row (21). In 1987, Snipes et al. (19) reported that the weed-free maintenance period for common cocklebur was 8 to 10 weeks, and competition periods longer than 4 weeks adversely affected yield. These predicted values were more restrictive than previous findings for other species (4, 13).

Early season competition of velvetleaf or common cocklebur with cotton is critical, and height differential of crop and weed is necessary for effective postemergence control in cotton. An effective preemergence herbicide program usually enhances subsequent weed control measures and thus overall weed control in cotton (12, 20). The objective of the research summarized in this bulletin was to establish the most consistent and effective means of preemergence chemical control of velvetleaf and common cocklebur in cotton.

Materials and Methods

Two separate experiments were conducted at the MAFES Delta Branch Experiment Station in Stoneville, MS, from 1987 through 1989. Soil type in the experimental area was a Dundee silty clay loam (fine-silty, mixed, thermic Aeric ochraqualf) with a pH of 6.3 and organic matter content of 1.26%. Individual plots were four 40-inch rows 20 feet in length. A randomized complete block design with four replications was utilized each year. Trifluralin at 0.75 lb a.i. /A was applied preplant incorporated (PPI) to the entire area in March of each year for grass and small-seeded broadleaf weed control. Fertilization, insect control, and other production practices were utilized for optimum cotton productivity.

In the velvetleaf experiment conducted from 1987 to 1989, herbicide treatments were norflurazon applied preplant soil incorporated (PPI) or preemergence (PRE) at 1.0 or 1.5 lb/A; norflurazon applied PPI at 0.5 or 0.75 lb/A followed by norflurazon at equivalent rates applied PRE (herein referred to as a "split" application); norflurazon applied PPI at 0.5, 0.75, 1.0, and 1.5 lb/A followed by diuron at 1.0 lb/A PRE; norflurazon at 0.5, 0.75, 1.0 or 1.5 lb/A tank-mixed with diuron at 1.0 lb/A applied PRE and norflurazon at 0.5 or 0.75 lb/A applied PPI followed by norflurazon at either 0.5 or 0.75 lb/A tank mixed with diuron at 1.0 lb/A.

In the common cocklebur experiments conducted in 1987 and 1988, treatments were: fluometuron applied PRE; norflurazon at 1.5 lb/A applied PPI or PRE; diuron applied PRE; norflurazon at 0.75 lb/A applied PPI followed by norflurazon at 0.75 lb/A, fluometuron, or diuron applied PRE; norflurazon at 1.5 lb/A applied PPI followed by fluometuron or diuron applied PRE; norflurazon applied PPI at 0.75 lb/A followed by fluometuron or diuron tank-mixed with norflurazon at 0.75 lb/A applied PRE; combinations of norflurazon at 1.5 lb/A, fluometuron or diuron in two-way tank-mixes applied PRE; and a three-way tank-mix of each material applied PRE. Fluometuron and diuron rates were 1.5 and 1.0 lb/A, respectively, for all treatments.

Treatments in both experiments were applied with a tractor-mounted compressed air sprayer calibrated to deliver 15 gallons per acre. Treatments to be incorporated were applied broadcast after winter beds were leveled on April 22, 1987; April 21, 1988; and April 20, 1989. In 1987, incorporation was accomplished with one pass of a two-way combination implement set to operate 1 to 2 inches deep. The same method was used in 1988, however, the area was rehipped after shallow incorporation. In 1989, the combination implement was replaced with a flexible-shank cultivator equipped with S-tine shanks and cultivator sweeps operated at a depth of 2 inches. Cotton (DES 119) was planted on April 22, 1987, May 16, 1988, and May 2, 1989. All preemergence applications were broadcast applied on April 23, 1987, May 17, 1988, and May 2, 1989. Cotton emerged on May 1, 1987, May 21, 1988, and May 15, 1989. The common cocklebur experiment was not conducted in 1989, therefore all 1989 dates pertain only to the velvetleaf experiment.

Velvetleaf control was estimated visually at 2 and 8 weeks after PRE application in 1988 and 1989, and at 4 and 6 weeks for all 3 years. Cotton phytotoxicity in the velvetleaf experiment was visually estimated 2 weeks after preemergence treatment in 1988 and 1989, and at 4 weeks in 1987, 1988, and 1989. Common cocklebur control was estimated at 4, 6, and 8 weeks in 1987, and at 2, 4, and 6 weeks in 1988. Crop injury was estimated at 2 weeks in 1988, and at 4 weeks in 1987 and 1988. All visual rating data were based on a scale of 0 to 100 with 0 indicating no con-

trol or crop injury and 100 indicating total control or complete crop kill.

In 1988, two rows of each plot in both experiments were cultivated beginning one day after the 4-week rating and continuing until three cultivations were completed. The 6-week rating was performed separately on the two uncultivated rows and the two cultivated rows. In 1989, the entire velvetleaf experiment was cultivated immediately after the 6-week rating. Therefore, the 8-week rating is after one cultivation. There was no cultivation in either experiment in 1987.

Cotton stand counts were made each year in the velvetleaf experiment by counting all plants along one row 4 weeks after preemergence treatment. Cotton stand counts were made in the cocklebur experiment in 1988 only. After weed removal and at crop maturity, seed cotton determinations were made by mechanically harvesting one row of each plot. Seed cotton yields were determined in 1987 and 1989 in the velvetleaf experiment only.

Analysis of variance was conducted on all data and differences among means were compared at the 5% level of probability using Duncan's Multiple Range Test (DMRT). In 1988, when one-half of each plot was cultivated, each plot was treated as a split-plot. Analysis of variance was conducted and a Least Significant Difference (LSD) at the 5% level of probability was determined to compare cultivated versus uncultivated within each treatment. Arc-sine transformation was conducted on the velvetleaf data prior to analysis on visual ratings from the 4-, 6-, and 8-week rating periods.

Results and Discussion

Velvetleaf

At 2 weeks, cotton injury ranged from 0 to 48% in 1988 (Table 2). All preemergence treatments of norflurazon + diuron resulted in injury greater than 25%. However, those treatments caused 15% injury or less by 4 weeks after treatment. Injury ratings made at 4 weeks after preemergence treatment varied from year to year. In 1987 and 1989, no injury was encountered when norflurazon was applied alone or in any combination. In 1988, norflurazon applied PRE at 1.5 lb/A resulted in 10% phytotoxicity. In 1989, crop injury was greatest when PPI applications of norflurazon at rates greater than 0.75 lb/A preceeded the diuron application. However, injury did not exceed 12%. In 1987, all norflurazon/diuron combination treatments displayed injury symptoms but ratings did not exceed 15%. Overall, injury in 1988 was greater than in 1987 and 1989.

In 1988, the norflurazon plus diuron tank-mix applied preemergence at 1.5 and 1.0 lb/A, respectively, resulted in 29% injury at 4 weeks and reduced cotton stand below that of the untreated check (Table 2).

Table 1. Environmental conditions for 14 days after treatment of various soil applied herbicides for preemergence velvetleaf control in cotton.[1]

Days after preemergence treatment	Year[2]					
	1987		1988		1989	
	Min/Max temp	Rainfall	Min/Max temp	Rainfall	Min/Max temp	Rainfall
	(°F)	(in)	(°F)	(in)	(°F)	(in)
0	79/49	0	92/67	0	75/49	0
1	82/49	0	88/56	0	69/50	0.64
2	78/51	0	86/57	0	62/52	0.10
3	77/52	0	88/59	0	70/60	2.76
4	85/54	0	93/64*	0.16	79/55	0.15
5	92/58	0	85/65	0.14	72/48	0
6	81/49	0	84/61	0.11	74/50	0
7	85/54	0	74/61	0.06	81/59	0.07
7 DAT avg.	83/52	0	85/60	0.07	72/53	0.46
8	92/60*	0	80/61	Trace	79/55	0.01
9	89/62	Trace	78/52	0	71/47	0
10	74/61	0	83/53	0	74/45	0
11	80/61	0	87/59	0	73/50	0.11
12	83/62	0	89/60	0	70/53	1.39
13	83/65	0	90/63	0	73/58*	0
14	82/63	0.70	92/62	0	80/59	0
14 DAT avg.	83/62	0.1	85/59	0	74/52	0.21
Grand avg.	83/57	0.05	82/60	0.035	73/52	0.33

[1]Source: National Oceanic and Atmospheric Administration Midsouth Agricultural Weather Service Center, Stoneville, MS, Station ID 228445 04

[2]* denotes crop emergence.

Other treatments that resulted in significant reductions in stand were norflurazon at 0.75 lb/A plus diuron applied preemergence and norflurazon applied PPI at 0.75 lb/A followed by norflurazon at 0.75 lb/A and diuron applied preemergence. Stand reductions were not found for any treatment in 1987 or 1989 (data not shown).

Moisture and temperature subsequent to application were similar in 1987 and 1988 (Table 1), however, injury response varied. Apparently, rainfall and the optimum growing conditions following emergence in 1988 maximized the crop-herbicide response so that simultaneous emergence and herbicide activation resulted in more injury.

In 1989, excess moisture and cool growing conditions delayed cotton emergence. Hypocotyl and radicle development of cotton is largely dependent upon interactions of temperature, moisture, and soil impedance (23). Wanjura and Buxton (23) reported that intermediate soil moisture regimes produced the longest radicle in cotton, and that a dramatic decrease in hypocotyl/radicle ratios occurred when soil moisture changed from 0.3 to 3.0 bars. In dry conditions, such as in 1987 and 1988, root mass increased more than in the extremely wet conditions in 1989. This and delayed emergence accounted in part for the reduced response in 1989 so that at 2 weeks after treatment, cotton injury was not apparent (data not shown). However, slight injury was noted at 4 weeks. This was in response to the delayed emergence experienced in 1989, as well as to the extremely wet conditions. Rate of water uptake of developing cotton seedlings has been shown to increase with higher temperatures and lower soil moisture tension (23). After the wet, cool conditions for 14 days following application in 1989, minimum soil temperatures at a 2-inch depth warmed from a 14-day preemergence average of 59°F to a 7-day postemergence of 66°F. Therefore, seedling development and subsequent herbicide absorption may have increased.

Seed cotton yields from all treatments were similar and better than the check in 1989 (Table 2). The highest yield in 1987 came from the norflurazon at 1.5 lb/A applied PPI and followed by diuron applied preemergence. Treatments with similar yields were norflurazon applied PPI at either 0.5 or 0.75 lb/A followed by norflurazon at equivalent rates tank-mixed with diuron applied PRE and the 0.5 or 1.0 lb/A rate of norflurazon applied PPI followed by diuron. All treatments increased seed cotton yields over that of the untreated control except for norflurazon applied preemergence at 1.5 lb/A. In general terms, when all or part of the norflurazon treatment was applied PPI, seed cotton yields were higher than when it was not.

Velvetleaf control with the norflurazon split at a total rate of 1.5 lb/A with diuron applied preemergence was better than 90% in all years at all timings (Table 3). However, this treatment resulted in crop

Table 2. Cotton phytotoxicity, cotton stand, and seed cotton yield following application of herbicides for preemergence velvetleaf control.[1]

Treatments			Cotton phytotoxicity				Cotton stand		
Method			2 weeks	4 weeks[2]			4 weeks	Seed cotton yield	
PPI	PRE	Rate	1988	1987	1988	1989	1988	1987	1989
		(kg/ha)	(%)					(kg/ha)	
Norflurazon		1.0	0 ef	0 e	0 e	0 b	54,230 ab	980 cde	1,440 a
Norflurazon		1.5	2 ef	0 e	0 e	0 b	58,150 a	1,230 b-e	1,390 a
Norflurazon	Norflurazon	0.5/0.5	6 def	0 e	0 e	0 b	55,210 a	1,010 cde	1,700 a
Norflurazon	Norflurazon	0.75/0.75	12 cde	0 e	0 e	0 b	57,500 a	1,100 b-e	1,710 a
	Norflurazon	1.0	12 de	0 e	0 e	0 b	55,380 a	920 cde	1,280 a
	Norflurazon	1.5	26 bc	0 e	10 cd	0 b	50,970 ab	640 ef	1,221 a
Norflurazon	Diuron	0.5/1.0	29 b	1 de	14 cd	2 b	45,410 a-d	1,350 a-d	1,610 a
Norflurazon	Diuron	0.75/1.0	16 cd	5 cde	4 de	11 a	53,270 ab	1,230 b-e	1,080 a
Norflurazon	Diuron	1.0/1.0	26 bc	11 abc	12 bcd	12 a	48,520 ab	1,470 abc	1,780 a
Norflurazon	Diuron	1.5/1.0	16 cd	8 abc	3 de	12 a	48,690 ab	1,900 a	1,560 a
	Norflurazon + Diuron	0.5 + 1.0	30 b	8 abc	8 abc	0 b	43,120 a-d	1,160 b-e	1,090 a
	Norflurazon + Diuron	0.75 + 1.0	45 a	9 abc	26 ab	0 b	33,160 cd	1,000 cde	1,330 a
	Norflurazon + Diuron	1.0 + 1.0	29 b	6 bcd	11 cd	0 b	51,960 ab	790 de	1,400 a
	Norflurazon + Diuron	1.5 + 1.0	48 a	12 ab	29 a	1 b	31,850 d	1,300 bcd	1,440 a
Norflurazon	Norflurazon + Diuron	0.5/0.5 + 1.0	30 b	15 a	14 abc	1 b	47,210 abc	1,400 a-d	1,830 a
Norflurazon	Norflurazon + Diuron	0.75/0.75 + 1.0	35 b	8 abc	17 abc	2 b	39,040 bcd	1,710 ab	1,540 a
Untreated Control		–	0 f	0 e	0 e	0 b	57,820 a	135 f	396 b

[1]Means within a column followed by the same letter are not significantly different according to DMRT (0.05).
[2]Analysis of variance conducted on transformed data.

injury greater than 25% and significant stand reductions in 1988 (Table 2). Decreasing the total rate to 1.0 lb/A maintained a similar level of control and did not reduce stand in 1988 but cotton injury was not alleviated.

In 1988, control at 2 weeks after application was similar for all treatments except norflurazon applied at 1.0 lb/A PRE (Table 3). However, control decreased over time and several differences in treatments were noted at 4, 6, and 8 weeks.

At 4 weeks, control with norflurazon applied at 1.0 or 1.5 lb/A PPI and followed by diuron PRE provided the most consistent control all 3 years (Table 3). These treatments were also less injurious initially than the norflurazon split/diuron combinations at equivalent rates (Table 2). However, cotton injury at 4 weeks was similar for each of these treatments. In 1987 and 1988, diuron applied PRE following either norflurazon applied at 1.5 lb/A PPI or PRE with diuron was better than norflurazon at 1.5 lb/A without diuron. This was also true of the 1 lb/A rate in 1988.

In 1989, norflurazon applied PPI at 1.0 or 1.5 lb/A and followed by diuron was better than norflurazon applied at 1.0 or 1.5 lb/A PPI, PRE, or with diuron as a PRE tank-mix. As previously mentioned, this treatment resulted in slight cotton injury (Table 2). Treatments that provided less than 85% control at 4 weeks in 1989 were norflurazon at 1 or 1.5 lb/A applied PPI, and norflurazon at 0.5 lb/A applied with diuron PRE. In general, rates of norflurazon applied at 0.5 lb/A PRE with diuron, norflurazon applied at 1.0 lb/A PPI, or norflurazon applied at 1.0 or 1.5 lb/A PRE were inconsistent. This will vary according to soil type. However, incorporating at least half of the norflurazon seemed to safeguard against adverse conditions and improved herbicide performance more consistently.

Direct comparisons of norflurazon-only treatments revealed no difference in any treatment combination at 6 weeks in 1987 (Figure 1). In 1988, incorporation of both rates of norflurazon improved velvetleaf control when compared to both rates applied PRE. Also, the norflurazon split applications were better than either full rate applied PRE.

Velvetleaf control at 6 weeks in 1987 was 94% when norflurazon was applied PPI at 1.5 lb/A and followed by diuron PRE (Table 3). This treatment was not prohibitively injurious. Reducing the rate to 1 lb/A or applying the norflurazon as a split with diuron was equally effective. However, by 8 weeks, the norflurazon split at a total rate of 1.0 lb/A with diuron was not as effective as the norflurazon PPI/diuron treatment when rates were 1.5 and 1.0 lb/A, respectively.

When uncultivated, norflurazon at 1.5 lb/A applied PPI, both norflurazon split/diuron combinations, and norflurazon at 1.0 or 1.5 lb/A applied PPI followed by

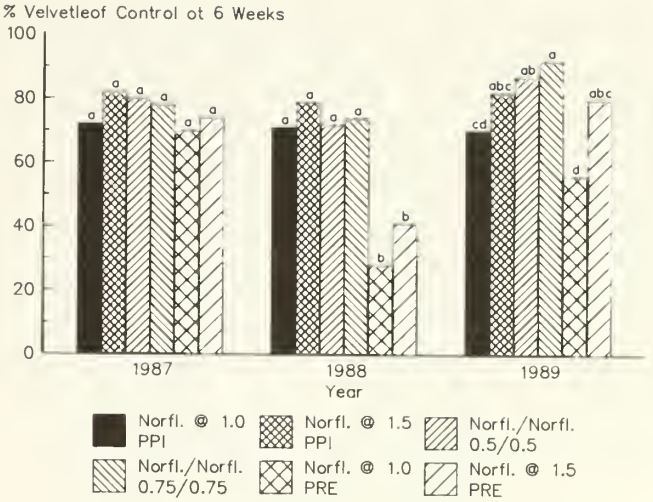

Figure 1. Influence of method of application of norflurazon (Norfl.) on velvetleaf control in cotton.

diuron provide similar control and were superior to most other treatments. In situations where the uncultivated control was less than 50%, such as preemergence application of norflurazon alone, and the 0.5-lb/A rate of norflurazon applied PRE with diuron, cultivation improved control significantly. When norflurazon was applied as a split with diuron, cultivation improved control if the total norflurazon rate was 1.0 but not for the 1.5 lb /A rate. Other treatments provided better than 70% control and were not improved by cultivation.

In 1989, treatment effects were optimized at 6 and 8 weeks by excessive rainfall throughout the season. Control varied little between the 6- and 8-week rating dates and indicated little response of velvetleaf control to cultivation. At 6 weeks, all treatments provided 80% or better control of velvetleaf except norflurazon applied PPI or PRE at 1.0 lb/A, and norflurazon applied at 0.5 or 1.0 lb/A plus diuron PRE.

Norflurazon applied PPI and followed by diuron provided the most consistent and effective control with only slight crop injury. At 6 weeks in 1987, application of 1.5 lb/A of norflurazon PPI followed by diuron was superior to the same norflurazon rate applied PRE with diuron (Figure 2). In 1988 and 1989, incorporation of norflurazon at 1.5 lb/A and followed by diuron provided better control than equivalent rates applied PRE. Generally, the same was true when comparing the 1.0 lb norflurazon rate similarly (Figure 3). However, in 1987 and 1988 the 0.5-lb and 0.75-lb rate did not provide control at 6 weeks comparable to that of the 1.5-lb rate applied PPI when all were applied in conjunction with diuron.

In conclusion, maximum crop injury occurred in

Table 3. Preemergence velvetleaf control in cotton.[1]

Treatment			Velvetleaf control				
Method			2 weeks[2]		4 weeks[3]		
PPI	PRE	Rate	1988	1989	1987	1988	1989
		(lb ai/A)	(%)				
Norflurazon		1.0	68 ef	77 d	78 e	70 cde	63 f
Norflurazon		1.5	74 de	85 cd	85 b-e	75 b-e	81 de
Norflurazon	Norflurazon	0.5/0.5	72 de	86 bcd	85 b-e	72 b-e	90 b-e
Norflurazon	Norflurazon	0.75/0.75	76 cde	98 abc	88 b-e	81 a-d	94 abc
	Norflurazon	1.0	56 f	95 abc	82 cde	40 f	82 cde
	Norflurazon	1.5	76 cde	97 abc	78 e	64 e	88 cde
Norflurazon	Diuron	0.5/1.0	84 a-d	98 abc	91 bcd	78 a-e	90 b-e
Norflurazon	Diuron	0.75/1.0	81 b-e	96 abc	89 b-e	85 ab	91 abc
Norflurazon	Diuron	1.0/1.0	95 ab	99 a	90 bcd	92 a	98 a
Norflurazon	Diuron	1.5/1.0	78 cde	96 abc	96 a	83 abc	97 ab
	Norflurazon + Diuron	0.5 + 1.0	75 cde	96 abc	89 bcd	66 de	79 e
	Norflurazon + Diuron	0.75 + 1.0	84 a-d	95 abc	81 de	75 b-e	86 cde
	Norflurazon + Diuron	1.0 + 1.0	81 b-e	99 a	87 b-e	77 b-e	86 cde
	Norflurazon + Diuron	1.5 + 1.0	89 abc	100 a	92 ab	82 abc	88 cde
Norflurazon	Norflurazon + Diuron	0.5/0.5 + 1.0	82 a-e	98 ab	93 ab	82 a-d	93 a-d
Norflurazon	Norflurazon + Diuron	0.75/ 0.75 + 1.0	97 a	96 abc	93 ab	91 a	94 abc
Untreated Control			0 g	0 e	0 f	0 g	0 g

[1]Means within a column followed by the same letter are not significantly different according to DMRT (0.05).
[2]14 DAT in 1988 and 10 DAT in 1989. No Transformation on data.
[3]Analysis of variance conducted on transformed data.

Treatments			Velvetleaf control					
			6 weeks					
Method			1988[3]				8 weeks[4]	
PPI	PRE	Rate	1987	Uncult.	Cult.	1989	1987	1989
		(lb ai/A)	(%)					
Norflurazon		1.0	72 f	71 cde	74 c-f	70 de	65 f	75 def
Norflurazon		1.5	82 b-f	79 abc	83 a-e	82 cd	76 de	83 bcd
Norflurazon	Norflurazon	0.5/0.5	80 c-f	72 b-e	78 b-e	87 bc	80 de	89 a-d
Norflurazon	Norflurazon	0.75/0.75	78 def	74 bcd	83 a-d	92 abc	81 de	85 bcd
	Norflurazon	1.0	70 f	28 g	44 gh	56 e	65 f	60 fg
	Norflurazon	1.5	74 ef	41 fg	59 fgh	80 cd	64 f	75 def
Norflurazon	Diuron	0.5/1.0	85 b-e	73 bcd	74 c-f	88 abc	82 cde	92 abc
Norflurazon	Diuron	0.75/1.0	82 c-f	77 bcd	84 a-d	95 ab	83 cde	99 a
Norflurazon	Diuron	1.0/1.0	88 a-d	90 a	92 a	96 a	91 ab	92 abc
Norflurazon	Diuron	1.5/1.0	94 a	88 ab	88 abc	98 a	95 a	97 ab
	Norflurazon + Diuron	0.5 + 1.0	82 b-f	42 fg	61 fg	68 de	79 de	65 ef
	Norflurazon + Diuron	0.75 + 1.0	82 b-f	58 ef	66 ef	80 cd	72 ef	78 def
	Norflurazon + Diuron	1.0 + 1.0	81 c-f	65 cde	70 def	79 cd	76 de	8 2 cde
	Norflurazon + Diuron	1.5 + 1.0	86 bcd	60 de	74 c-f	83 cd	85 bcd	88 a-d
Norflurazon	Norflurazon + Diuron	0.5/0.5 + 1.0	90 abc	80 abc	90 ab	97 a	86 bcd	96 abc
Norflurazon	Norflurazon + Diuron	0.75/0.75 + 1.0	92 ab	91 a	90 ab	97 a	90 abc	99 a
Untreated Control			0 g	0 h	41 h	0 f	0 g	42 g

[1]Means within a column followed by the same letter are not significantly different according to DMRT (0.05).
[2]Analysis of variance conducted on transformed data.
[3]LSD at (0.05) for uncultivated (Uncult) versus cultivated (Cult) within each treatment = 9.
[4]Eight-week ratings for 1989 are after one cultivation of the entire experiment. There was no cultivation in 1987.

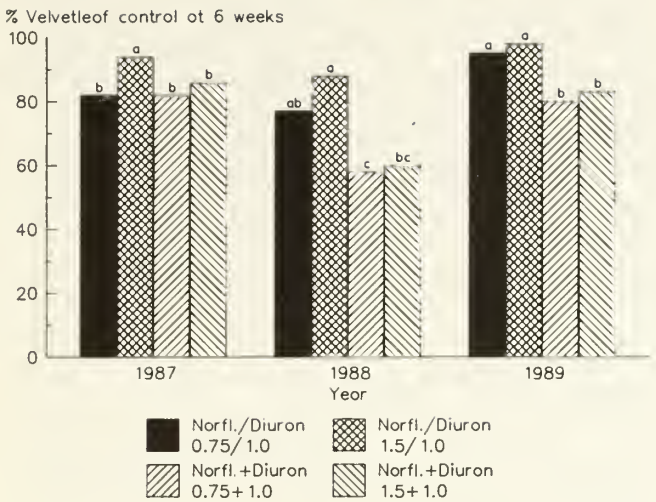

Figure 2. Influence of method of application on 0.75 lb/A and 1.0 lb/A norflurazon (Norfl.) rates in conjunction with diuron for preemergence velvetleaf control in cotton.

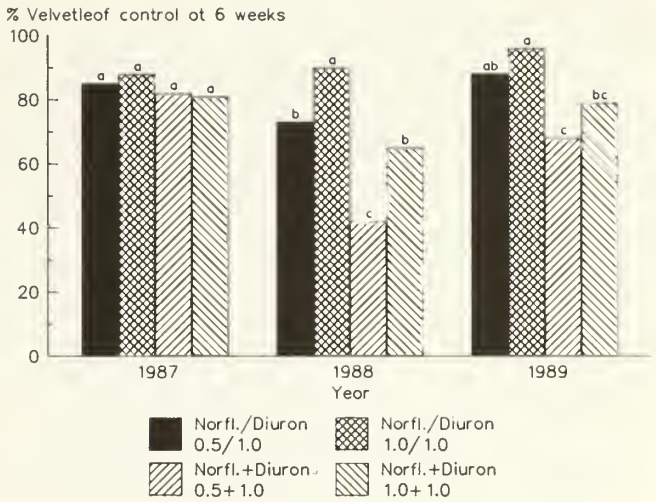

Figure 3. Influence of method of application on 0.5 lb/A and 1.0 lb/A norflurazon (Norfl.) rates in conjunction with diuron for preemergence velvetleaf control in cotton.

1988 when norflurazon was tank-mixed with diuron and applied preemergence. Applying norflurazon at either 1.0 or 1.5 lb/A PPI and following this with diuron at 1.0 lb/A provided the most reliable velvetleaf control with only slight crop injury.

Based on 1988 results, cultivation of these treatments did not improve control. When velvetleaf control was less than 50% without cultivation, control was improved significantly by cultivation. However, cultivation typically did not increase velvetleaf control for higher control ratings even though unacceptable infestation levels remained. One notable exception was the norflurazon split/diuron combination when the total norflurazon rate was 1.0 lb/A. Increasing the total split rate to 1.5 lb/A negated the need for cultivation.

Table 4. Cotton phytotoxicity and cotton stand following application of various herbicides for preemergence control of common cocklebur.[1]

Treatments			Crop Injury			Cotton stand
Method of Application		Rate	2 weeks	4 weeks		4 weeks
PPI	PRE	lb ai/A	1988	1987	1988	1988
				(%)		No./A
–	Fluometuron	1.5	0 h	0 c	0 b	51,670 a
–	Norflurazon	1.5	16 cd	0 c	5 b	47,740 ab
–	Diuron	1.0	6 fgh	10 ab	0 b	47,740 ab
Norflurazon	–	1.5	0 h	0 c	0 b	52,320 a
Norflurazon	Norflurazon	0.75/0.75	11 def	0 c	2 b	52,320 a
Norflurazon	Fluometuron	0.75/1.5	2 gh	0 c	0 b	56,240 a
Norflurazon	Diuron	0.75/1.0	9 efg	8 b	1 b	51,610 a
Norflurazon	Fluometuron	1.5/1.5	0 h	0 c	0 b	51,670 a
Norflurazon	Diuron	1.5/1.0	9 d-g	10 ab	2 b	51,670 a
Norflurazon	Norflurazon + Fluometuron +	0.75/0.75 1.5	14 cde	0 c	5 b	56,900 a
Norflurazon	Norflurazon + Diuron +	0.75/0.75 1.0	30 b	9 ab	19 a	39,890 bc
–	Norflurazon + Fluometuron	1.5 + 1.5	20 c	0 c	6 b	52,320 a
–	Diuron + Fluometuron	1.0 + 1.5	35 ab	11 ab	20 a	38,590 bc
–	Norflurazon + Diuron	1.5 + 1.0	30 b	13 a	19 a	35,320 cd
–	Norflurazon + Diuron + Fluometuron	1.5 + 1.0 1.5	38 a	13 a	25 a	26,160 d
Untreated			0 h	0 c	0 b	56,240 a

[1]Means within columns followed by the same letter are not significantly different at the 5% level of probability according to DMRT.

Common Cocklebur

In 1988, the three-way tank-mix combination of norflurazon, diuron, and fluometuron caused the most injury (Table 4). A tank-mix combination of diuron plus fluometuron was similar. As in the velvetleaf study, injury appeared more severe when diuron was tank-mixed with norflurazon and applied PRE. At 4 weeks, injury was 25% or less for all treatments. However, all preemergence tank-mixes containing diuron caused more injury than any other treatment evaluated. At 4 weeks after treatment, diuron applied alone as a preemergence application resulted in no injury. However, diuron combined with fluometuron or norflurazon caused injury in the 20 to 25% range with 25% injury resulting in a three-way tank-mix of the three compounds.

In addition to crop injury, stand counts made at 4 weeks after treatment indicated that stands were reduced by treatments that contained diuron as part of the preemergence tank-mix (Table 4). Although each component when applied alone did not reduce stands, combining norflurazon or fluometuron with diuron and applied preemergence reduced stands below that of the untreated check. Further stand reductions were caused by a three-way tank-mix of all compounds evaluated. A two-way tank-mix of norflurazon plus fluometuron applied preemergence did not reduce stands when compared to the check and was similar to those treatments showing no crop injury. In 1987, crop injury at 4 weeks after treatment was less than 15% for all treatments evaluated. Diuron and all combinations including diuron resulted in injury greater than that of the untreated check. However, injury did not exceed 15%. The same was the case in the velvetleaf study. However, the velvetleaf study did not include a treatment with diuron applied alone. The 10% crop injury reported for diuron when applied PRE alone indicated that diuron was the primary component causing crop injury in 1987. This is supported further by the fact that when fluometuron or norflurazon were applied alone as PRE, no crop injury resulted. However, injury from diuron in 1988 was not apparent unless it was tank-mixed with norflurazon or fluometuron and applied PRE.

Overall, common cocklebur control was better in 1987 than in 1988 (Table 5). Common cocklebur populations were three times higher in 1988 than in 1987. This, in part, accounts for the reduced control in 1988, since the overall abundance of common cocklebur provided a larger population that was in some way less susceptible to chemical treatment.

In 1987, at 4 weeks after herbicide application, all treatments evaluated provided better than 75% common cocklebur control. The three-way tank-mix of norflurazon, diuron, and fluometuron applied preemergence provided 97% control. However, this was the most injurious treatment evaluated during the 2-year study. Other treatments that compared favorably but were less injurious were: (1) norflurazon applied PPI at 0.75 or 1.5 lb/A followed by fluometuron applied PRE; (2) the norflurazon split at a total rate of 1.5 lb/A with fluometuron included in the preemergence application; and (3) norflurazon at 1.5 lb/A applied as a tank-mix with fluometuron applied PRE. As previously stated, most diuron treatments resulted in crop injury during the course of study. However, in 1987, norflurazon applied PPI at 1.5 lb/A followed by diuron PRE provided 93% control and injury did not exceed 10%. In 1988, this treatment was one of the few diuron treatments that did not adversely affect cotton stand.

At 6 weeks after treatment in 1987, norflurazon applied PPI at 1.5 lb/A followed by fluometuron applied PRE was the superior treatment. The only other treatment that compared favorably to this was the three-way tank-mix combination. However, as previously stated, this treatment reduced stand in 1988 and was more injurious than other treatments in 1987. Norflurazon applied PPI at 1.5 lb/A followed by fluometuron PRE provided 94% control at 8 weeks after treatment. All other treatments other than the three-way tank-mix combination were significantly less than this and control did not exceed 82%. In 1987, norflurazon applied PPI at 1.5 lb/A followed by fluometuron applied PRE was the best treatment for common cocklebur control and did not result in any crop injury or stand reduction.

In 1988, common cocklebur control at 2 weeks after treatment did not exceed 81% for any treatment evaluated (Table 5). The three-way tank-mix was the superior treatment but resulted in excessive injury and significant stand reduction (Table 4). Other treatments that provided better than 70% common cocklebur control were norflurazon applied PP I at 1.5 lb/A followed by fluometuron applied PRE; a norflurazon split, which included diuron in the preemergence half; a diuron plus fluometuron tank-mix applied PRE; or a norflurazon/diuron tank-mix applied PRE. However, the latter two treatments reduced cotton stand below that of the untreated check.

At 4 weeks after treatment in 1988, norflurazon applied PPI at 1.5 lb/A followed by fluometuron applied PRE provided the highest percent common cocklebur control and did not result in any crop injury or stand reduction (Tables 4 and 5). Control for this treatment in 1988 was only 57%, but was 96% in 1987. In 1988, other treatments provided higher control ratings but injury was greater. For the 2 years of evaluation, norflurazon applied PPI at 1.5 lb/A followed by

fluometuron applied PRE resulted in the highest percent common cocklebur contro l with the least amount of crop injury.

Cultivation resulted in a significant improvement in common cocklebur control (Table 5). In the velvetleaf experiment, cultivation improved control only for certain treatments and in general provided improved control only when initial velvetleaf control was less than 50%. For the common cocklebur experiment, uncultivated common cocklebur control at 6 weeks after treatment did not exceed 48%. The addition of cultivation significantly improved control for all treatments. However, it is important to note that cultivation of the untreated check provided 40% common cocklebur control. Although all treatments in the uncultivated plots were less than 50%, the addition of cultivation did not improve control to acceptable levels and in most cases did not exceed that of the untreated control. This reinforces the concept that effective preemergence herbicides are the foundation to sound weed-management programs, and these programs cannot rely solely on cultivation to achieve optimum control. This was particularly true for common cocklebur control.

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Table 5. Preemergence common cocklebur control in cotton.

Treatments			Common Cocklebur Control [1,2]						
Method of Application		Rate	2 weeks	4 weeks			1988[3]		6 weeks
PPI	PRE	lb ai/A	1988	1987	1988	1987	Uncult	Cult	8 weeks 1987
			(%)						
–	Fluometuron	1.5	50 ef	88 c	14 fg	78 d	21 c-f	48 bc	75 b-e
–	Norflurazon	1.5	60 cde	77 d	20 efg	58 ef	12 fg	40 c	35 f
–	Diuron	1.0	39 f	78 d	19 efg	48 g	11 fg	41 c	42 f
Norflurazon	–	1.5	51 ef	88 bc	34 c-f	66 e	18 ef	49 bc	62 e
Norflurazon	Norflurazon	0.75/0.75	56 de	77 d	24 ef	56 fg	16 ef	46 bc	42 f
Norflurazon	Fluometuron	0.75/1.5	58 de	94 abc	30 def	89 b	21 c-f	45 bc	82 bc
Norflurazon	Diuron	0.75/1.0	64 b-e	88 bc	39 b-e	76 d	36 abc	59 a	70 cde
Norflurazon	Fluometuron	1.5/1.5	73 abc	96 a	57 ab	94 a	48 a	60 a	94 a
Norflurazon	Diuron	1.5/1.0	56 de	93 abc	36 b-f	81 cd	35 abc	51 ab	79 bcd
Norflurazon	Norflurazon + Fluometuron +	0.75/0.75 1.5	68 a-d	94 ab	40 b-e	88 b	34 a-d	45 bc	84 b
Norflurazon	Norflurazon + Diuron +	0.75/0.75 1.0	74 ab	92 abc	65 a	75 d	38 ab	46 bc	70 cde
–	Norflurazon + Fluometuron	1.5 + 1.5	66 bcd	92 abc	38 b-e	85 bc	30 b-e	46 bc	82 bc
–	Diuron + Fluometuron	1.0 + 1.5	76 ab	95 ab	56 abc	86 bc	20 def	46 bc	80 bc
–	Norflurazon + Diuron	1.5 + 1.0	70 a-d	92 abc	48 a-d	76 d	26 b-f	49 bc	65 de
–	Norflurazon + Diuron + Fluometuron	1.5 + 1.0 1.5	81 a	97 a	65 a	90 ab	39 ab	54 ab	87 ab
Untreated			0 g	0 e	0 g	0 h	0 g	40 c	0 g

[1]Means within columns followed by the same letter are not significantly different at the 5% level of probability according to DMRT.
[2]Analysis performed on transformed data at 6 and 8 weeks in 1987 only.
[3]LSD (0.05) for comparison of uncultivated (Uncult) vs cultivated (Cult) within each treatment = 9.

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