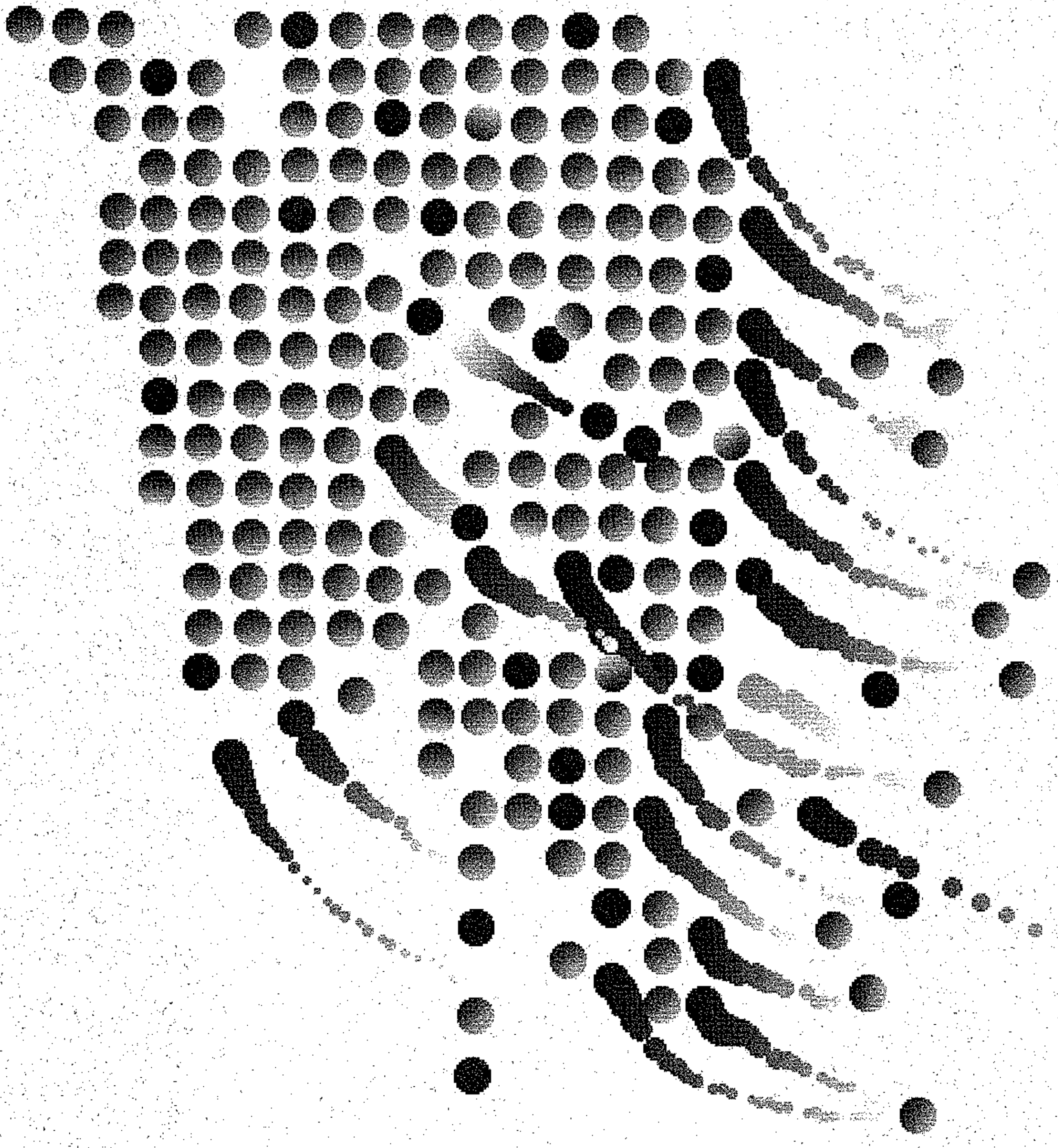
Bulletin 989 December 1992

Cotton Injury from Simulated Quinclorac and Triclopyr Drift



MAFES
MSU
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

Cotton Injury from Simulated Quinclorac and Triclopyr Drift

Joe E. Street
Plant Physiologist
Delta Branch Experiment Station

Charles E. Snipes
Associate Plant Physiologist
Delta Branch Experiment Station

Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine, Mississippi State University. Edited by Keith H. Remy, Publications Coordinator. Cover designed by Mary Frances Dillard, Artist.

Cotton Injury from Simulated Quinclorac and Triclopyr Drift

Introduction

Rice is often grown near cotton fields, so herbicides used on rice may contact cotton either by drift or accidental direct application. Cotton injury from rice herbicides is an important agronomic consideration since most rice herbicides are applied with fixed-wing aircraft. Some currently registered rice herbicides that can injure cotton are propanil, 2,4-D, and acifluorfen (Blazer®) (7). The loss of 2,4,5-T from the market in the early 1980's increased use of 2,4-D in rice. This increased use of 2,4-D, which is more toxic to cotton than 2,4,5-T (13), has partly contributed to increased injury complaints due to drift onto cotton.

Quinclorac (Facet®) has been examined for weed control in rice (5, 14, 17) and is currently being used in rice weed control systems in more than 20 countries (1). Eastin (5) reported that quinclorac controlled a broad spectrum of grass and broadleaf weeds at various application timings in Texas.

Smith (14) and Street (17) found that quinclorac controlled several major rice weeds. Both researchers pointed out quinclorac applied preplant incorporated, preemergence, or postemergence effectively controlled weeds at application rates from 0.125 to 0.5 pound ai/acre. Water solubility of quinclorac is 62 parts per million at 68°F and vapor pressure is low, which indicates that potential for vapor drift is low. Consequently, the primary mechanism of quinclorac movement to nontarget areas would be by particle drift, contaminated spray equipment, or other misapplication.

Quinclorac applications of 0.05, 0.25, or 1 lb/A caused cotton injury and reduced yield (4). Observed cotton yield decrease was related to time of application, with late applications causing the most cotton injury and yield loss.

Triclopyr (Grandstand®) controls many broadleaf weeds in rice when applied at 0.5 lb/A (2, 15). Its use may be in combinations with other herbicides to extend the weed control spectrum of several herbicides such as fenoxaprop (Whip®), which is effective only on problem grass weeds (16).

Triclopyr is most commonly applied when rice is in the late tillering to panicle initiation stage, which typically corresponds to the early reproductive stages of cotton.

Triclopyr is readily absorbed by plant foliage and roots (1). Once absorbed, it translocates toward meristematic areas. The exact physiological mechanism of action is not known, but appears to be similar to that of the phenoxy herbicides. It apparently is not extremely persistent in the soil environment (9). Triclopyr is microbially degraded in the soil, and can also photodegrade or volatilize, with a half-life of 10 hours in water at 77°F (1).

Triclopyr can injure cotton under greenhouse conditions (3). The application of 0.002, 0.008, 0.03, and 0.125 lb/A triclopyr injured cotton plants 12, 16, 58, and 76%, respectively. These plants were small at the time of triclopyr application, and herbicide efficacy is often greater under greenhouse conditions. Although triclopyr seems safer to cotton than 2,4-D (6), cotton injury due to triclopyr drift is, nevertheless, a potential hazard.

The objectives of this research were: **(1)** to determine the response of cotton at two growth stages to simulated drift rates of triclopyr, and **(2)** to determine injury and yield response to cotton at three growth stages from simulated drift rates of quinclorac.

Materials and Methods

Triclopyr

Experiments were conducted at the Delta Branch Experiment Station near Stoneville, MS in 1987 and 1988. The soil was a Bosket very fine sandy loam. Soil organic matter was 0.8%, and pH was 6.8. Plot size was four 40-inch rows 30 feet long. The experimental design was a randomized complete block design with eight replications and five treatment combinations, an untreated control (UTC), plus a two-by-two factorial arrangement of triclopyr rate (0.03 and 0.06 lb/A) and application time (pin-head square and early bloom). The triclopyr application rates used in these studies correspond to 6% and 12% of the potential application rate of 0.5 lb/A, respectively. This level of simulated drift was derived from research examining drift from fixed-wing aircraft, which showed 6% drift for a distance of 400 feet when herbicide was moved by a 3 mph wind.

A major research concern was the potential for triclopyr application to reduce or delay the reproductive development of the cotton plants. The effect of triclopyr application on cotton flowering was evaluated by counting white blooms per 30 feet of row at approximately 3-day intervals following application. The flowers on cotton plants are initially white and then change to a reddish-pink color after 2 to 3 days before falling from the plant. The number of white flowers would indicate the number of new flowers produced by the plants since the last count. White blooms were determined from 50 to 100 days after emergence, with the two center rows from each plot being counted and averaged.

The effect of triclopyr application on the production of fruiting structures was evaluated by counting the number of total and open bolls per yard of row at 133 and 127 days after emergence in 1987 and 1988, respectively. The total number of open bolls was converted to a percentage of total bolls and used as an indication of plant maturity. These counts were made 7 to 10 days prior to the first mechanical harvesting in each year. Standard production practices for cotton were used in preparing beds, applying fertilizer, and in disease and insect management. The experimental area was kept weed-free with standard herbicides applied preplant incorporated, preemergence, and directed postemergence, plus mechanical cultivation and hand hoeing. 'DES 119' cotton was planted April 28, 1987, and April 26, 1988. Plots were furrow-irrigated twice in 1987 and three times in 1988 after the onset of cotton bloom. The pin-head square and early bloom triclopyr applications were made 34 and 55 days after emergence in 1987 and 40 and 56 days after emergence in 1988. Early bloom was defined as the point when an average of two white blooms per 30 feet of row first occurred. Triclopyr was applied using a backpack sprayer, which delivered 20 gallons per acre of water carrier at a pressure of 24 psi. Cotton was appropriately defoliated prior to mechanical harvest.

The height of 10 randomly selected cotton plants in each plot was measured weekly from 40 to 90 days after emergence. Cotton was mechanically harvested twice. Additional data on the cotton included percent lint, fiber strength, and micronaire. Data were subjected to an analysis of variance. There was a significant year-by-treatment interaction, so the data are presented separately for each year. Means were separated by the Least Significant Difference (LSD) test at the 0.05 significance level.

Quinclorac

Experiments were conducted at the Delta Branch Experiment Station near Stoneville, MS in 1988, 1989, and 1990. The soil type was a Dundee silt loam. Soil organic matter was 1.3% and pH 6.3. Plot size was three 40-inch rows 30 feet long in 1988 and 1989, and four rows 30 feet long in 1990. A randomized complete block design with four replications and a six-by-three factorial treatment arrangement with quinclorac rates (0, 0.125, 0.25, 0.5, 1.0, and 2.0 oz/A) and application times (preemergence, cotyledon, and pin-head square) was used. The quinclorac application rates used in these studies correspond to 0, 3, 6, 12, 25, and 50% of the potential postemergence application rate of 0.25 lb/A, respectively. Since quinclorac application rates are expected to be from 0.125 to 0.50 lb/A, nontarget concentrations of this magnitude could be possible from herbicide application procedures used in rice production.

Production practices for cotton were similar to those previously described for triclopyr. The experimental area was kept weed-free with standard herbicides applied preplant incorporated, preemergence, and directed postemergence, plus mechanical cultivation and hand hoeing. 'DES 119' cotton was planted May 17, 1988, May 2, 1989, and May 17, 1990. Plots were furrow-irrigated three times in 1988 and twice in 1990. Plots were not irrigated in 1989.

The preemergence, cotyledon, and pin-head square applications of quinclorac were made 1 to 2, 10 to 20, and 49 to 56 days after planting each year, respectively. Quinclorac was applied with a hand-held CO_2-pressurized backpack sprayer, which delivered 20 gallons per acre of water carrier at a pressure of 24 psi. Cotyledon and pin-head square quinclorac applications also contained a nonionic surfactant at 0.25% v/v to improve plant surface coverage. Cotton was appropriately defoliated prior to harvest.

Data collected included visual evaluations of cotton injury throughout the growing season. Evaluations were made on a scale of 0-100%, where 0 equaled no crop injury and 100 equaled crop kill. For ease of discussion, cotton injury data from 11 to 15 days after the pin-head square application from each year are presented. There was a significant year-by-treatment interaction, so data are presented for each year. Means were separated by the Least Significant Difference (LSD) test at the 0.05 probability level. Seed cotton was mechanically harvested from the center row(s) of each plot in 1988 and 1990. Plots were hand harvested from the center rows in 1989. There was a significant year-by-treatment interaction, with the quinclorac rate effect on seed cotton yield being different each year. The yield data were linearly regressed against quinclorac rate, with the estimated parameters being intercept (cotton yield with no quinclorac application) and slope (unit change in cotton yield per ounce of quinclorac applied).

Results and Discussion

Triclopyr

Cotton height was unaffected by triclopyr applied at early bloom since the plants had already produced most of their height at that time (data not shown); however, higher rates have been shown to reduce plant

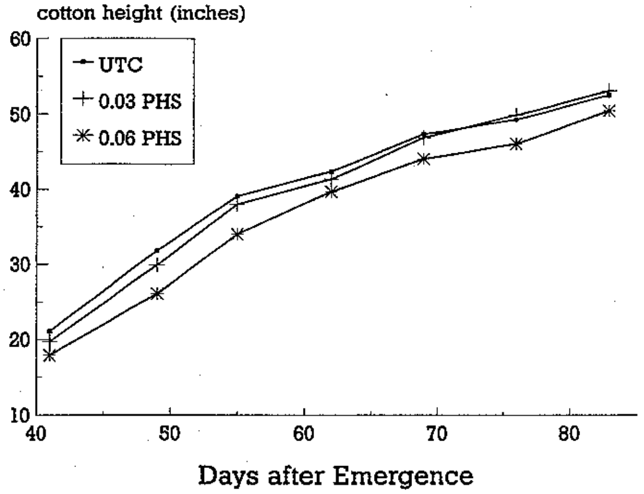


Figure 1. The effect of a pin-head square (PHS) application of triclopyr at 0, 0.03, or 0.06 lb/A on cotton heights in 1987.

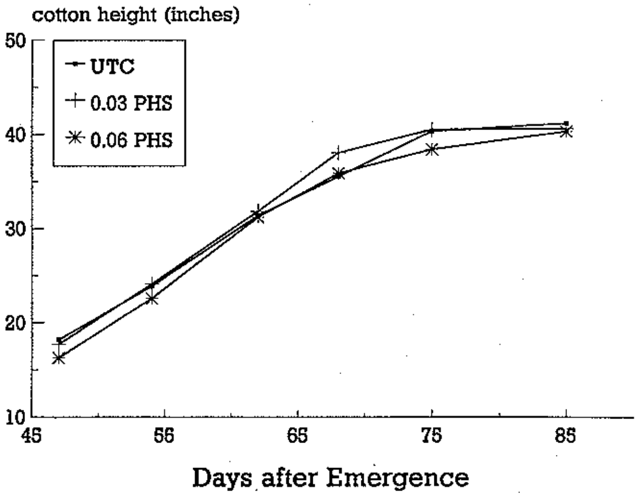


Figure 2. The effect of a pin-head square (PHS) application of triclopyr at 0, 0.03, or 0.06 lb/A on cotton heights in 1988.

height in Texas when applications were made postbloom (8). Triclopyr applied at 0.06 lb/A at pin-head square in 1987 reduced cotton height throughout the measurement interval, although reductions were not greater than 6 inches (20%) (Figure 1). The greatest reduction was in the 50 to 60 days after emergence interval, which was 14 to 24 days after the pin-head square application. Similar results have been previously reported (8). The lag period would be expected with an herbicide that must translocate and then affect plants later.

Cotton height was not affected in 1987 by the pin-head square application of triclopyr at 0.03 lb/A (Figure 1). This indicated that cotton could tolerate a lower level of triclopyr within the plant and not have a detrimental effect on vegetative growth under the conditions of these studies. Cotton height was not affected by triclopyr application in 1988 (Figure 2). Triclopyr did not reduce cotton height in an earlier study since crop height was maximized prior to treatment (8). In this study, the crop continued growth after application, but growth was diminished in 1988 because of drier soil moisture conditions, and any triclopyr effect may have been masked by environmental stress.

In 1987, the pin-head square triclopyr applications were made 34 days after emergence. Symptoms of triclopyr were evident as early as 1 day after application. Triclopyr at 0.03 lb/A did not affect flower production when applied at pin-head square (Figure 3). Compared with the untreated controls, the greatest reduction in flowering occurred 20 to 30 days after pin-head square application of triclopyr at 0.06 lb/A (Figure 4). Although no attempt was made to determine the cause of reduced flowering, it could have been due to either reduced square production, reduced square retention, or both. Either of these potential causes of reduced flowering could result indirectly from a reduction in vegetative growth and a corresponding reduction in the cotton plant's ability to support reproductive growth (11).

Following the initial reduction from triclopyr at 0.06 lb/A, flower production on plants treated at the pin-head square stage recovered and was similar to that in the untreated control from 72 to 100 days after emergence in 1987 (Figure 4). The plants did not compensate for the earlier injury by producing more flow-

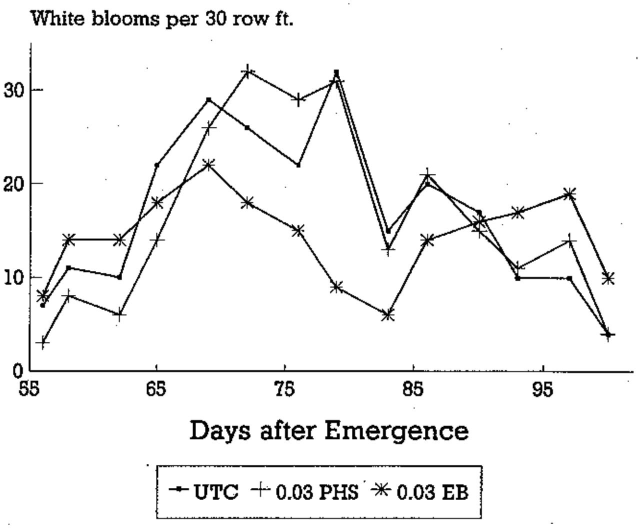


Figure 3. The effect of 0.03 lb/A triclopyr applied at pin-head square (PHS) or early bloom (EB) on white bloom counts in 1987. Comparisons are made to the untreated control (UTC).

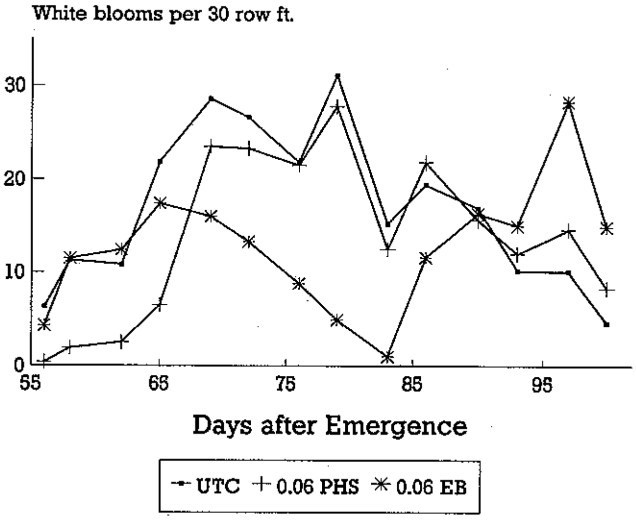


Figure 4. The effect of 0.06 lb/A triclopyr applied at pin-head square (PHS) or early bloom (EB) on white bloom counts in 1987. Comparisons are made to the untreated control (UTC).

ers late in the season. Because of this lack of compensation, fewer bolls were produced (Table 1). Boll production was reduced 27% by 0.06 lb/A of triclopyr applied at the pin-head square stage in 1987. Triclopyr applied at 0.03 lb/A at the pin-head square stage in 1987 did not affect total seed cotton yield (Table 2); however, triclopyr applied at 0.06 lb/A reduced yield 15%. The lack of a direct relationship between number of bolls produced and seed cotton yield would indicate that plants treated at the pin-head square stage with triclopyr produced larger bolls. Larger bolls are often associated with fewer bolls per plant.

Neither rate of triclopyr applied to cotton at the pin-head square stage in 1987 affected crop maturity when measured as percent open bolls (Table 1) or as percent of the total yield in the first picking (Table 2). The lack of an effect on maturity indicates that boll retention was similar for treated and nontreated plants. This observation, along with the observation of reduced flowering early in the reproductive period, suggests that the primary effect of the pin-head square stage application of triclopyr in 1987 was a reduction in early square production or square retention.

Table 1. The effect of triclopyr application on total bolls and percent open bolls 10 days before harvest in 1987 and 1988.

		1987		1988	
Triclopyr rate lb/A	Application time[a]	Total bolls no/3 ft of row	Open bolls %	Total bolls no/3 ft of row	Open bolls %
0	–	105	85	90	68
0.03	PHS	89	85	86	63
0.06	PHS	77	82	93	56
0.03	EB	71	65	85	59
0.06	EB	84	41	93	42
LSD (0.05)[b]		16	12	NS	10

[a] Triclopyr applied at pin-head square (PHS) and early bloom (EB).
[b] For comparison of any two means within a column.

Table 2. The effect of triclopyr application on first-pick, second-pick, and total seed cotton yields in 1987.

Triclopyr rate	Application time[a]	First-pick yield	Second-pick yield	Total yield
lb/A		lb/A		
0	–	3,230	304	3,534
0.03	PHS	2,910	330	3,240
0.06	PHS	2,650	366	3,016
0.03	EB	2,660	570	3,230
0.06	EB	1,804	642	2,446
LSD (0.05)[b]		339	84	304

[a] Application times were at pin-head square (PHS) and early bloom (EB).
[b] For comparison of any two means within a column.

The early bloom triclopyr application was made 55 days after emergence in 1987. Flowering was unaffected for 10 days after triclopyr application and then reduced during the next 22 days by both rates of triclopyr (Figures 3 and 4). Twenty-one days normally elapse between square initiation and flower production (10). More flowers were produced 90 to 100 days after emergence on plants receiving an early bloom application of triclopyr at 0.06 lb/A in 1987 (Figure 4); however, this increase in late-season flowering did not fully compensate for the reduction in flowering earlier in the reproductive period. Boll production was reduced 32% and 20% by triclopyr applied at 0.03 and 0.06 lb/A, respectively (Table 1), while seed cotton yield was reduced 9% and 31% by 0.03 and 0.06 lb/A of triclopyr, respectively (Table 2). Maturity, measured as percent open bolls (Table 1) and as the percent of the total yield in the first harvest (Table 2), was delayed by both rates applied at early bloom. A delay in maturity would be expected if bolls were set late in the season.

The 1988 pin-head square and early bloom triclopyr applications were made 40 and 56 days after emergence, respectively. Except for greater flower production 70 to 80 days after emergence, the flowering pattern for the untreated control was similar to that in 1987. Although a greater number of blooms were produced in 1988, yields were similar in both years. The drier conditions during the reproductive period in 1988 likely resulted in a lower percentage of bolls retained.

Flower production in 1988 was not affected by triclopyr at 0.03 lb/A (data not shown). The effect of the pin-head square application of triclopyr at 0.06 lb/A on flowering in 1988 was similar to that in 1987. Flowering on treated plants was initially reduced, but was similar to that of the UTC after the first 20 days of flowering (Figure 5). Similar to the observations in 1987, there was no compensation for the reduced early flowering. In contrast to 1987, the pin-head square application at either rate did not reduce the total number of bolls produced (Table 1) nor reduce seed cotton yield (Table 3). Only a minor delay in maturity was noted at the higher rate (Table 1).

The effects of the early bloom application of triclopyr at 0.06 lb/A on cotton flowering in 1988 were similar to those in 1987 (Figure 5). There was no effect on the number of flowers produced during the first 10 days after application. Flowering during the next 20 days was reduced. There was a slight increase in the number of flowers produced from 88 to 100 days after emergence. In contrast to 1987, however, the early bloom application of triclopyr did not reduce the total number of bolls produced (Table 1). However, maturity was delayed, especially on cotton receiving the higher rate of triclopyr applied at early bloom (Tables 1 and 3). Boll counts in 1988 were made 127 days after emergence. The increased flowering at 80 to 100 days after emergence would have produced green unopened bolls 30 days later (12). Even though the total number of bolls produced was similar, application of 0.06 lb/A of triclopyr at early bloom reduced seed cotton yield because some of the bolls set late in the season did not mature.

Triclopyr application did not affect the distribution of total cotton yield between lint and seed components (data not shown) nor did it affect fiber strength or micronaire (data not shown), which was similar to previous research (8). In related research, the effects of simulated triclopyr drift were not diminished by the use of cotton growth regulators, such as mepiquat-chloride (Pix®), when applied at labelled rates and application timings (data not shown).

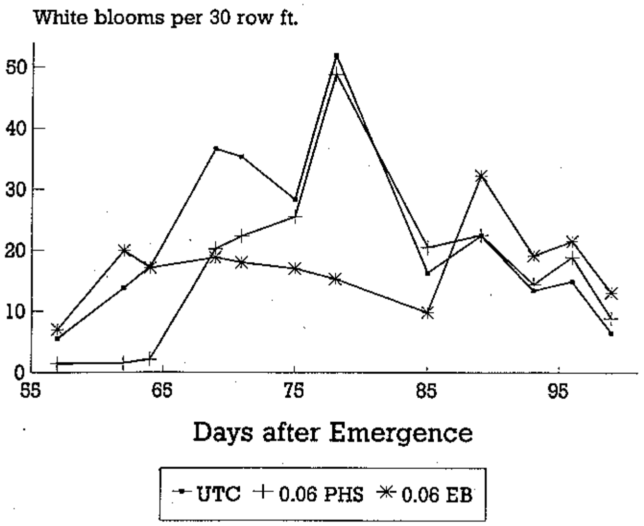


Figure 5. The effect of 0.06 lb/A triclopyr applied at pin-head square (PHS) or early bloom (EB) on white bloom counts in 1988. Comparisons are made to the untreated control (UTC).

Table 3. The effect of triclopyr application on first-pick, second-pick, and total seed cotton yields in 1988.

Triclopyr rate	Application time[a]	First-pick yield	Second-pick yield	Total yield
lb/A		———	lb/A ———	———
0	3,205	500	3,705	
0.03	PHS	2,884	545	3,429
0.06	PHS	2,768	607	3,375
0.03	EB	2,840	625	3,465
0.06	EB	1,910	1,260	3,170
LSD (0.05)[b]		335	160	367

[a] Application times were at pin-head square (PHS) and early bloom (EB).

[b] For comparison of any two means within a column.

Triclopyr affected seed cotton yields, but the effect was more dependent upon stage of application than on herbicide rate. Total seed cotton yield was reduced both years when 0.06 lb/A was applied to cotton in the early bloom stage. However, other rates and timings responded differently over the 2 years. The 0.03 lb/A rate applied at pin-head square had no effect on yield either year, but 0.06 lb/A reduced yields when applied at pin-head square in 1 of 2 years.

Crop maturity was delayed each year by all triclopyr treatments. The impact of delayed maturity was difficult to quantify since cotton yields were not always reduced. For example, in 1988, 0.06 lb/A triclopyr reduced percent open bolls when applied at pin-head square (Table 1), but this treatment did not reduce total yield (Table 3). However, an overriding factor was the ability of the cotton plant to recover from delayed maturity. Following fruit abortion, subsequent boll retention depends upon the type of fruit aborted (10). If squares are shed, losses can be offset. If young bolls are shed, losses are more difficult to offset. In either case, a time-delay is necessary to allow for adequate development of later bolls (12).

For pin-head square treatments, any fruit abortion was offset, especially for triclopyr at 0.03 lb/A. However, triclopyr at 0.06 lb/A applied to early cotton at early bloom resulted in fruit abortion at a time when subsequent boll retention was less (10). In 1987 and 1988, cotton plants did not have time to recover from triclopyr injury at early bloom to offset yield losses from higher rates of triclopyr. Management practices designed to maximize crop earliness (i.e. insect management, fertility, defoliation) may enhance this recovery; however, environmental factors largely dictate the response these practices have on cotton.

Quinclorac

Cotton injury was primarily characterized as a reduction in crop height when quinclorac was applied prior to cotton emergence. Cotyledon and pin-head square applications of quinclorac caused leaf strapping. Excessive elongated bracts and malformed blooms and squares were also evident following the pinhead square application. Visual evaluations of quinclorac injury to cotton were similar in all 3 years (Table 4). The order of quinclorac damage to cotton by application time was pin-head square > cotyledon > preemergence and as expected, an increase in quinclorac rate was coincident with greater cotton injury. These results are in agreement with previous results (4), with postemergence applications causing more damage than preemergence applications.

Visual evaluations of cotton injury indicate two major points. First, the potential damage to cotton is greatest from later quinclorac applications (pin-head square), although quinclorac at 2 oz/A applied prior to cotton emergence caused visual injury on emerging cotton in 2 of 3 years (Table 4). Later in the season, quinclorac concentration in spray drift would be increased since rice producers would need to increase the quinclorac application rate to obtain acceptable control of larger weeds. Second, visual evaluation data indicated that very low rates of quinclorac applications (3% of the proposed application rate) consistently caused visual damage each year when applied at pinhead square.

Table 4. Cotton injury to simulated drift rates of quinclorac.

Application Rate	Application Time[a]	1988	1989	1990
oz/A			%	
0		0	0	0
0.125	PRE	0	3	0
0.25	PRE	0	0	0
0.5	PRE	0	5	0
1.0	PRE	0	6	0
2.0	PRE	0	33	10
0.125	COT	0	0	0
0.25	COT	0	5	3
0.5	COT	0	10	6
1.0	COT	0	28	13
2.0	COT	13	55	36
0.125	PHS	15	15	19
0.25	PHS	26	31	24
0.5	PHS	35	33	29
1.0	PHS	36	48	39
2.0	PHS	50	59	41
LSD (0.05)		4	10	8

[a] Quinclorac applications made prior to cotton emergence (PRE), at the cotyledon (COT) or pin-head square (PHS) stage.

Table 5. Linear regression parameters examining the effect of quinclorac application on seed cotton yield in 1988, 1989, and 1990.

Appl. time[a]	Year	Intercept	Slope	r^2	Prob >|T|[b]
		lb/A	lb/oz ai		
PRE	1988	2,146	-140.45	0.03	0.394
	1989	1,492	46.21	0.01	0.613
	1990	2,412	-120.18	0.02	0.509
COT	1988	1,892	-175.41	0.08	0.184
	1989	1,454	-148.98	0.20	0.027
	1990	2,641	-273.66	0.22	0.021
PHS	1988	1,832	-770.65	0.57	0.0001
	1989	1,478	-620.99	0.76	0.0001
	1990	2,688	-291.66	0.20	0.030

[a] Quinclorac applications applied preemergence (PRE), at the cotyledon (COT) or pin-head square (PHS) stage.

[b] Probability that slope is significantly different from zero, with a nonsignificant slope indicating no effect of quinclorac rate on cotton yield.

Seed cotton yield for each year was linearly regressed against quinclorac rate for each application timing (Table 5). The addition of a quadratic term to the regression model did not improve the fit of the model (analyses not shown). Regression analyses indicated that the only slopes different from zero, thus indicating a significant rate effect at the 0.05 probability level, were in the cotyledon and pin-head square applications (Table 5).

The fit to the regression equation was especially low in the preemergence quinclorac application treatments, indicating little effect on seed cotton yield from preemergence quinclorac applications of less than 2 oz/A (Figure 6). This was consistent with the visual evaluations of cotton injury, which showed that only the 2 oz/A application in 1989 and 1990 caused cotton injury (Table 4). A major advantage of quinclorac use in rice is that it can be used preemergence. These data indicated that accidental exposure of cotton to quinclorac prior to emergence posed little danger of yield reduction. This is in agreement with Crawford et al. (4), who reported that 0.8 oz/A of quinclorac applied preemergence did not reduce cotton yield.

The yield data for quinclorac applications at the cotyledon stage were variable, with $r^2 < 0.25$ in each year (Figure 7). Quinclorac application to cotton in the cotyledon stage caused yield losses in 1989 and 1990, with the slopes of -149 and -274 being significant at the 0.05 level (Table 5). The yield data and visual evaluations of quinclorac phytotoxicity to cotton at the cotyledon stage were consistent. No injury was ob-

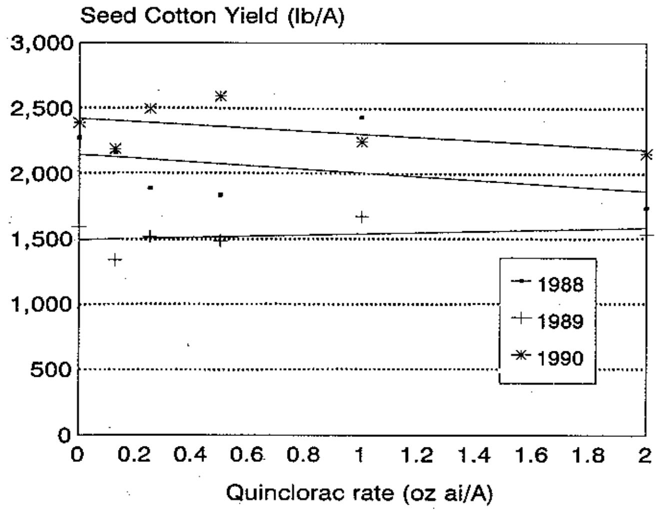


Figure 6. The effect of a preemergence application of quinclorac at 0, 0.125 0.25, 0.5, 1.0, and 2.0 oz/A on cotton yields in 1988, 1989, and 1990. The lines represent regression equations of the form y = intercept + (slope x rate). Regression parameters presented in Table 5.

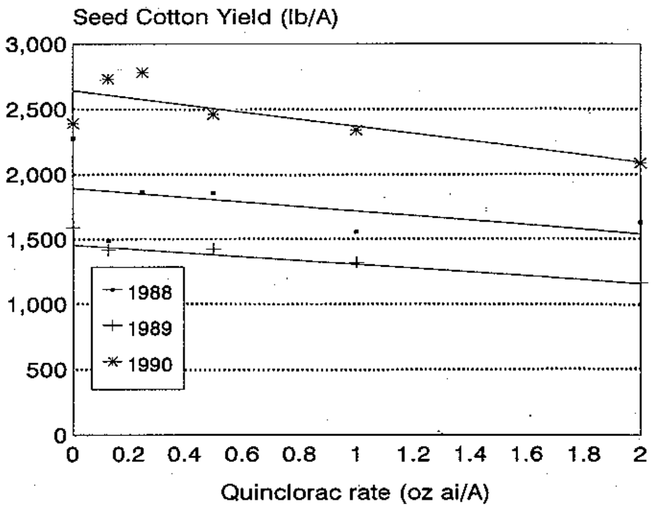


Figure 7. The effect of a cotyledon application of quinclorac at 0, 0.125, 0.25, 1.0, and 2.0 oz/A on cotton yields in 1988, 1989, and 1990. The lines represent regression equations of the form y = intercept + (slope x rate). Regression parameters presented in Table 5.

served in 1988 except at the 2 oz/A rate, and quinclorac applications ≥1 oz/A caused cotton injury in 1989 and 1990. These data indicate that quinclorac drift from rice fields onto fields of small cotton would have to be ≥1 oz/A to decrease cotton yield substantially. Quinclorac at these rates, applied to cotton in the cotyledonary stage, did not reduce yields consistently enough to create severe problems with incidental contact.

The greatest effect of quinclorac to cotton was observed when applied at the pin-head square stage (Figure 8). Slope parameters were significant at the 0.05 level in all years (Table 5). As much as 76% of the variability could be accounted for with quinclorac applications made at the pin-head square stage. This indicated a predictable cotton yield response to quinclorac misapplication at this growth stage. Yield losses ranged from 292 to 771 lb/A for each ounce of quinclorac applied. An approximate average yield loss of 530 lb/A of seed cotton could be expected with each ounce of quinclorac applied when cotton was at the pin-head square stage. Both visual evaluation data and yield data indicate that cotton at the pin-head square growth stage was sensitive to quinclorac application. These yield data are in partial agreement with previous research, where 0.8 oz/A of quinclorac reduced cotton yield 13 and 42%, when applied preemergence and postemergence, respectively (4). However, based on our data, preemergence application did not adversely affect seed cotton yield.

Earlier research has shown that propanil, acifluorfen (Blazer®), oxadiazon (Ronstar®), and bifenox (Modown®) applied to cotyledonary cotton at simulated drift rates significantly reduced cotton yield (7). Applications of these materials at later stages, which would correspond to pin-head square stage in this study, did not affect cotton yields. The opposite was true in the present study. Quinclorac was more injurious at the later stages of cotton development. Triclopyr applications made on cotton in early-to- late reproductive stages of growth resulted in yield

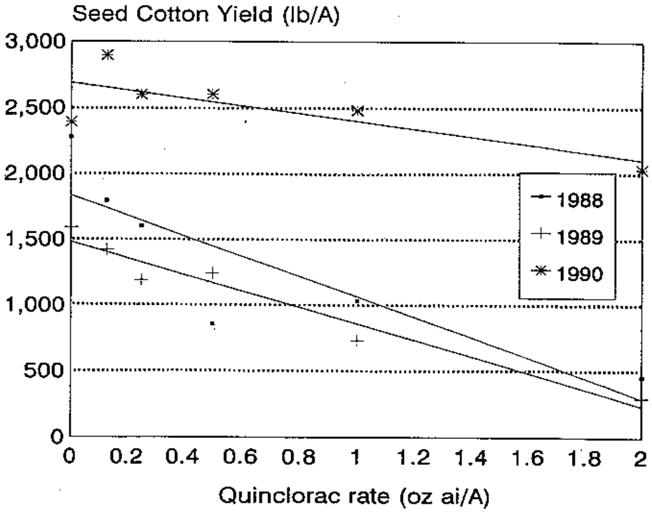


Figure 8. The effect of a pin-head square application of quinclorac at 0, 0.125, 0.25, 0.5, 1.0, and 2.0 oz/A on cotton yields in 1988, 1989, and 1990. The lines represent regression equations of the form y = intercept + (slope x rate). Regression parameters presented in Table 5.

decreases in most cases (7), and were similar to yield reductions for quinclorac with respect to developmental stage. Seed cotton yields were drastically reduced by 2,4-D when applications were made during similar developmental stages (13).

In general, simulated drift rates of contact herbicides, such as propanil or acifluorfen, seem to be more injurious to young cotton than systemic herbicides, such as triclopyr, 2,4-D, or quinclorac. Conversely, when cotton is in the reproductive phase of growth, these systemic herbicides have a more profound effect on cotton yield than contact herbicides. Based on this and previous research, the order of systemic herbicide damage to cotton would be 2,4-D > quinclorac > triclopyr. However, 2,4-D was not included in the present studies and developmental stage at time of application could alter this response significantly.

Literature Cited

1. Anonymous. 1988. Herbicide Handbook. pages 249-250. Weed Science Society of America. Champaign, IL.
2. Black, H. L., R. J. Smith, Jr., and K. Khodayari. 1986. Triclopyr for weed control in rice. Proc. South. Weed Sci. Soc. 39:69.
3. Bovey, R. W., and R. E. Meyer. 1981. Effects of 2,4,5-T, triclopyr, and 3,6-dichloropicolinic acid on crop seedlings. Weed Sci. 29:256-260.
4. Crawford, S. H., P. R. Vidrine, and R. K. Collins. 1990. Phytotoxicity of quinclorac to cotton. Proc. South. Weed Sci. Soc. 43:117.
5. Eastin, E. F. 1989. Quinclorac activity in rice as influenced by time of application. Proc. South. Weed Sci. Soc. 42:70.
6. Fratesi, K. T., M. W. Wray, and D. H. Paroonagian. 1988. Cotton and soybean tolerance to triclopyr amine, 2,4-D amine, and bromoxynil. Proc. South. Weed Sci. Soc. 41:355.
7. Hurst, H. R. 1982. Cotton (*Gossypium hirsutum*) response to simulated drift from selected herbicides. Weed Sci. 30:311-315.
8. Jacoby, P. W., C. W. Meadors, and L. E. Clark. 1990. Effects of triclopyr, clopyralid, and picloram on growth and production of cotton. J. Prod. Agric. 3:297-301.
9. Jotcham, J. R., D. W. Smith, and G. R. Stephenson. 1989. Comparative persistence and mobility of pyridine and phenoxy herbicides in soil. Weed Technol. 3:155-161.
10. Kerby, T. A., and D. R. Buxton. 1981. Competition between adjacent fruiting forms in cotton. Agron. J. 73:867-871.
11. Mauney, J. R. 1986. Vegetative growth and development of fruiting sites. p. 11-28 *In* J. R. Mauney and J. McD. Stewart (ed.). Cotton Physiology. The Cotton Foundation, Memphis, TN.
12. McD. Stewart, James. 1986. Integrated events in the flower and fruit. p. 261-300 *In* J. R. Mauney, and J. McD. Stewart (ed.). Cotton Physiology. The Cotton Foundation, Memphis, TN.
13. Miller, J. H., H. M. Kempen, J. A. Wilkerson, and C. L. Foy. 1963. Response of cotton to 2,4-D and related phenoxy herbicides. USDA Tech. Bull. No. 1289, 28 p.
14. Smith, R. J., Jr. 1990. Quinclorac and combinations for weed control in rice. Proc. South. Weed Sci. Soc. 43:116.
15. Smith, R. J., Jr. 1988. Tolerance of rice (*Oryza sativa*) to acifluorfen and triclopyr applied alone or in mixtures with propanil. Weed Sci. 36:379-383.
16. Snipes, C. E., and J. E. Street. 1987. Fenoxaprop for postemergence barnyardgrass (*Echinochloa crus-galli*) control in rice (*Oryza sativa*). Weed Sci. 35:224-227.
17. Street, J. E., and J. L. Baldwin. 1990. Comparison of PPI, PRE, and early POST applications of BAS 51400H. Proc. Rice Tech. Work. Group 3:131.

Printed on Recycled Paper

53927/0.9M