Bulletin 997 May 1993

Kenaf

Tolerance to Various Postemergence Herbicides Registered for Other Crops Grown in the Delta of Mississippi

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Published by the Publications Section, Office of Agricultural Communications, Division of Agriculture, Forestry, and Veterinary Medicine, Mississippi State University. Edited by Keith Remy, Publications Coordinator. Cover designed by Beth Carter, Graphic Artist.

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Introduction

A review of the literature was published by Dempsey covering all aspects of kenaf (*Hibiscus cannabinus* L.) production (5). Although kenaf has been grown for food and fiber for centuries in the tropics (17), it has not been commercialized on a large scale in the United States. However, recent increased interest in various end-product uses has spurred renewed agronomic research in kenaf (1, 6, 7, 10, 14, 16). Original thoughts for end use products for kenaf were for paper pulp, but various characteristics of kenaf indicate other possible uses (2, 11, 13, 15).

Moderate to heavy yield reductions in kenaf have been reported from weed competition. Williams (17) showed a 0.43 ton/A yield reduction, while Kurtz and Neill (8) reported an 85% yield reduction with competition from a mixture of johnsongrass [*Sorghum halepense* (L.) Pers.] and common cocklebur [*Xanthium strumarium* (L.)].

Weed control is important in obtaining optimum kenaf yields. Early research conducted to evaluate chemical means of weed control demonstrated the effects of preemergence (PRE) herbicides on kenaf (3, 4, 6, 12). Many of these herbicides caused excessive kenaf injury or are no longer available. However, some research was conducted on herbicides that are presently available. Orsenigo (12) reported 50% kenaf stand reduction with Karmex® (diuron) applied PRE, but no stand reductions from Lorox® (linuron).

Kurtz and Neill (7) found Karmex caused 60% kenaf injury 28 days after emergence (DAE) while Bladex® (cyanazine) caused little or no injury. These trials received 7 inches of rainfall within 24 hours after application and kenaf was replanted into herbicide-treated soil. An experiment conducted in 1989 and 1990 with Bueno-6® (MSMA), Basagran® (bentazon), and Cobra® (lactofen) (10) on cotyledonary and 12- to 14-inch kenaf showed $\leq$ 20% injury with Bueno-6 at 10 and 18 days after treatment (DAT). Injury from Basagran ranged from 16 to 90% on cotyledonary kenaf and from 25 to 43% on 12- to 14-inch kenaf. Lactofen caused $\geq$ 85% injury at both growth stages each year.

Studies in 1991 by Kurtz and Neill (9) showed that herbicides known to injure kenaf could be utilized by making applications postemergence-directed (PDIR). Preliminary studies with Basagran, Bladex, Karmex, Cobra, Lorox, and Goal® (oxyfluorfen) revealed <5% kenaf injury from each herbicide 2 weeks after treatment. Presently, only Bueno-6 (PDIR) and Fusilade 2000® (fluazifop-p) (POST) are registered (24C) for use in kenaf in Mississippi.

The objective of these studies was to evaluate the tolerance of kenaf to selected herbicides applied postemergence over-the-top (POT) or PDIR that are known to severely injure kenaf when applied PRE.

Materials and Methods

Postemergence over-the-top (POT)

Herbicides were applied POT to cotyledonary kenaf in 1989 at Metcalfe, MS, on a Dundee silty clay loam (fine-silty, mixed, thermic, Aeric Orchraqualfs), pH 6.9 and near Charleston, MS, in 1990 on a Cascilla silt loam soil (fine-silty, mixed, thermic, Fluventic Dystrochrepts) with a pH 5.3. Similar trials were conducted on 12- to 14-inch kenaf in 1989 and 1990 near Charleston, MS, on a Cascilla silt loam soil with a pH 5.7. A nonionic surfactant (X-77®) at 0.25% v/v was included in all treatments. Herbicides were applied with a CO_2-charged backpack sprayer calibrated to deliver 24 gpa (1989) and 20 gpa (1990) using flat fan nozzles.

Herbicide treatments to cotyledonary kenaf are given in Table 2. Kenaf was planted July 10, 1989, and treated 10 days after emergence (DAE) (85% RH, 81°F); and May 8, 1990, and treated 8 DAE (40% RH, 83°F).

POT treatments to 12- to 14-inch kenaf are given in Table 3. Kenaf was planted on June 12, 1989, and May 8, 1990; it was treated 29 days after emergence (DAE) (80% RH, 90 °F) in 1989 and 25 DAE in 1990 (65% RH, 81 °F). Soil moisture at time of herbicide application was optimal. No rainfall occurred within 7 days of application either year. Plots consisted of four, 10-foot rows spaced 30 inches apart. Treatments were arranged in a randomized complete block design with four replications in each experiment. The studies were not harvested because of variable stand and limited seed for replanting.

Kenaf phytotoxicity ratings were made 10 DAT in 1989 or 8 DAT in 1990 for the cotyledonary treatments; and 7 and 16 DAT in 1989, and 8 and 34 DAT

in 1990 for the 12- to 14-inch treatments. Ratings were based on visual estimates of treated plants using a scale of 0 to 100 with 0 = no kenaf injury and 100 = all plants dead.

Kenaf height measurements were taken at 26 DAT in 1989 and 49 DAT in 1990 for the cotyledonary treatments, and 16 DAT in 1989 and 34 DAT in 1990 for the 12- to 14-inch treatments. Phytotoxicity was expressed as necrosis by all herbicides except Scepter® (AC 263-222), Pursuit® (imazaquin), and Cadre® (imazethapyr), which initially stunted plants followed by necrosis.

All data were subjected to analysis of variance within and across years. Where a significant F Test was found, mean values were separated using Least Significant Difference (LSD) at P=0.05. Data for each year are presented separately because of significant (P=0.05) year-by-treatment interactions.

Postemergence Directed (PDIR)

Three field studies were conducted in 1991 at the Delta Branch Experiment Station (DBES), Stoneville, MS, on a Dundee silty clay loam (fine-silty, mixed, thermic, Aeric Orchraqualfs) soil. In 1992, two experiments were conducted at the DBES location and one at Vance, MS, on a Forestdale (fine, montmorillonitic, thermic, Typic Orchraqualfs) soil. Herbicides were applied PDIR to the bottom one-third of kenaf stems and kenaf heights are given in Table 1.

A CO_2-charged sprayer with hand-held boom calibrated to deliver 20 gal/A of spray solution was used in each study. Bueno-6 (2.0 lb ai/A) was tank-mixed with the following herbicides with no additional adjuvant added: Basagran (0.75 lb ai/A), Bladex (0.8 lb ai/A), Karmex (0.5 lb ai/A), Cobra (0.2 lb ai/A), Lorox (1.0 lb ai/A), or Goal (0.25 lb ai/A).

Plots consisted of four 20-foot rows spaced 30 or 40 inches apart, with treatments arranged in a randomized complete block design (Table 1). Kenaf phytotoxicity ratings were taken within 4 DAT initially and 14 DAT for the final rating. Ratings were based on visual estimates of plant necrosis using the scale described previously.

Kenaf was grown to maturity and 1/1,000 of an acre was hand-harvested from the center two rows of each plot. Kenaf moisture was determined [((wwt−dwt÷wwt)x100] and yields are converted to zero percent moisture. All data were subjected to analysis of variance. Treatment-by-location and treatment-by-location-by-year interactions occurred for kenaf phytotoxicity ratings, so data are reported by location and year.

When analysis of variance indicated a significant difference (P=0.05) in kenaf phytotoxicity, treatment effects were separated by Waller-Duncan's Bayesian K=500 ratio t-test. No interactions occurred for yield, therefore, data were combined across location and years.

Least squares means were used due to an unequal number of observations and means were separated using the t-test. Actual t-values are not shown because values are different for each comparison, due to unbalanced data sets and least square methods.

Results and Discussion

Postemergence Over-the-top

Of the 15 herbicide treatments applied POT to kenaf in the cotyledon stage of growth, only Bueno-6, Fusilade 2000, Poast® (sethoxydim), Assure® (quizalofop), and Select® (clethadim) did not cause phytotoxicity (Table 2). Phytotoxicity caused from other herbicides was manifested as stunting and/or necrosis both years.

Seven days after treatment in 1989, all the POT herbicide treatments applied to 12- to 14-inch kenaf were phytotoxic when compared to the untreated control (Table 3). By 16 DAT, substantial kenaf phytotoxicity persisted for all treatments except Bueno-6 and Basagran.

In 1990, only the Bueno-6 treatment was noninjurious at the early rating, but at 34 DAT, both Bueno-6

Table 1. Site description for herbicide tolerance trials on established kenaf in 1991 and 1992, Washington (DBES) and Tallahatchie Counties, MS.

Experiment no.	Location	Rep	Application conditions: Planting date	Row spacing	Spray date	Plant height	Temp	Relative humidity	Rainfall following treatment
				inches		inches	F°	%	inches - days
1	DBES	4	4-26-91	40	6-27-91	12-14	72	94	0.66 - 7
2	DBES	4	7-1-91	40	7-31-91	8-12	73	86	0.24 - 7
3	DBES	4	6-26-91	40	7-8-91	8-12	97	50	0.24 - 9
4	DBES	4	5-4-92	40	6-17-92	12-14	86	83	0.5 - 10
5	Vance, MS	4	5-8-92	30	6-18-92	12-14	90	64	1.0 - 2
6	DBES	8	7-14-92	40	8-10-92	12-14	88	82	1.2 - 1

Table 2. Tolerance of cotyledonary kenaf to postemergence over-the-top (POT) herbicides, 1989 at Metcalfe, MS, and 1990 at Charleston, MS.

Treatment	Rate	Phytotoxicitya		Height	
		1989	1990	1989	1990
		10 DAT	8 DAT	26 DAT	49 DAT
	lb ai/A	%		inches	
Untreated control	0	10	0	21	55
Bueno-6	2.0	16	14	17	62
Basagran	0.75	28	90	16	13
Scepter	0.06	50	64	16	0
Pursuit	0.032	80	76	12	13
Cadre	0.032	95	78	2	0
Blazer	0.375	99	99	0	0
Cobra	0.15	99	99	1	0
Reflex	0.25	99	99	0	0
Fusilade 2000	0.20	10	3	23	51
Poast	0.19	8	1	22	57
Assure	0.06	0	1	24	57
Select	0.10	26	1	21	58
Classic	0.008	94	79	7	0
Ally	0.008	99	94	0	0
Oust	0.016	99	95	0	0
LSD (0.05)b		16	15	4	9

aRating dates recorded as days after treatment (DAT).
bFor comparison of any two means within a column.

and Basagran showed no signs of necrosis. All treatments with the exception of Bueno-6 significantly reduced kenaf height both years.

Kenaf exhibited very little tolerance to Basagran applied at the cotyledonary stage, but when applied to 12- to 14-inch kenaf, early injury symptoms of leaf yellowing disappeared by 16 and 34 DAT in 1989 and 1990, respectively. Even though kenaf was recovering from visible Basagran injury symptoms, height was still significantly less than the untreated control at 34 DAT (Table 3).

Height reduction is a very important factor in kenaf production because the goal is biomass rather than seed or lint production. Tall, slender plants have a higher bast fiber percentage than short corpulent plants. Kenaf with a higher bast percentage could be more valuable than higher yielding (total dry matter) plants with a lower bast percentage (12).

Kenaf tolerates Fusilade 2000, Poast, Assure, and Select. Basagran, Scepter, Pursuit, Cadre, Blazer® (acifluorfen), Cobra, Reflex® (formesafen), Classic® (chlorimuron), Ally® (metsulfuron), or Oust® (sul-

Table 3. Tolerance of 12- to 14-inch kenaf to postemergence, over-the-top (POT) herbicides, 1989 and 1990, Charleston, MS.

Treatment	Rate	Phytotoxicity[a]				Height	
		1989		1990		1989	1990
		7 DAT	16 DAT	8 DAT	34 DAT	16 DAT	34 DAT
	lb ai/A	%				inches	
Untreated control	0	0	0	0	0	28	44
Bueno-6	2.0	20	0	11	0	27	49
Basagran	0.75	43	0	25	10	22	38
Scepter	0.06	60	84	75	80	13	25
Pursuit	0.032	56	78	74	75	14	28
Cadre	0.032	63	89	78	85	15	22
Blazer	0.375	99	99	94	95	13	7
Cobra	0.15	99	96	86	88	13	24
Reflex	0.25	99	98	88	89	13	27
Classic	0.008	65	95	84	80	14	27
LSD (0.05)[b]		5	5	19	18	2	6

[a]Dates recorded as days after treatment.
[b]For comparison of any two means within a column.

fometuron) applied POT were too injurious to be considered for kenaf. Basagran applied to 12- to 14-inch kenaf showed marginal selectivity. Further experimentation of post-directed applications with these herbicides could possibly offer greater selectivity in kenaf.

Bueno-6 was granted a 24C label in Mississippi in 1991, and Fusilade 2000 received a 24C label in 1992, for weed control in kenaf.

Postemergence Directed (PDIR)

Initial kenaf injury ratings were taken from the bottom one-third of kenaf stems where the actual herbicide spray was directed (Table 4). Kenaf phytotoxicity varied from test to test for a given herbicide treatment and was influenced by how well the herbicides were directed toward the base of kenaf stems.

Bueno-6 was tank-mixed with all herbicides but, for simplicity, only the tank-mix partner will be mentioned in the discussion. Bladex injury ranged from 5 to 16% in 5 out of 6 tests and 76% in test 4 (Table 4). The authors found in an earlier study (8) total stand failure occurred from a PRE Bladex (1.8 lb ai/A) treatment with 7 inches of rainfall within 8 hours. Nine days later when kenaf was replanted into the treated plots, no injury occurred.

Karmex caused 4 to 14% kenaf injury with 70% occurring in test 4 (Table 4). Kurtz and Neill (8) found 60% injury 28 DAE with Karmex in a PRE test. Orsenigo (12) reported a 50% stand reduction with Karmex (1.0 lb ai/A) PRE. Cobra injury ranged from 9 to 39% with 99% in test 4 (Table 4). Kenaf injury from Lorox also was 4 to 20% with 65% in test 4, however Orsenigo (12) reported no stand reduction from Lorox (3.0 lb ai/A) PRE. Goal caused 18 to 40% kenaf injury with 96% in test 4 (Table 4).

Kenaf injury for test 4 was consistently higher for all herbicide treatments because of physical herbicide placement. In this test, it was apparent that the herbicides were applied to the bottom one-half rather than the bottom one-third of the kenaf stem, resulting in a higher percentage of kenaf leaf injury. These lower leaves dropped off rapidly and plant growth resumed.

Whole plant injury ratings were taken by 14 DAT (Table 5). Analysis of variance indicated treatment differences in tests 1, 4, and 6. Even though differences occurred, kenaf injury was not >5% (Bladex and Lorox) in test 1, 19% (Goal) in test 4, and 11% (Goal) in test 6. None of these injury symptoms affected kenaf yield. In tests 5 and 6, interveinal chlorosis in upper leaves was observed from treatments of Bladex, Karmex, or Lorox, however chlorosis stopped occurring in new foliage after 2 weeks. Rainfall (1.5 inches and 1 inch) for test 5 and 6, respectively, occurred within 1 and 2 days following application.

Kenaf yield was not affected by any herbicide treatment, Table 5. Yield ranged from 4.44 tons/A for the Goal treatment to 4.83 for the Basagran treatment.

Table 4. First phytotoxicity ratings recorded from the bottom one-third of kenaf stem as affected by postemergence-directed (PDIR) herbicide applications at six locations, Washington and Tallahatchie Counties, MS, 1991-1992.[a]

Herbicide		Kenaf Phytotoxicity (bottom one-third of stem)					
		1991			1992		
		Location					
Treatment[b]	Rate	#1	#2	#3	#4	#5	#6
	lb ai/A	(%)					
Basagran	0.75	11 b	18 b	11 b	48 c	4 b	13 b
Bladex	0.8	5 cd	16 b	8 cd	76 ab	9 bc	6 c
Karmex	0.5	4 cd	14 b	5 d	70 bc	10 bc	4 cd
Cobra	0.2	9 bc	39 a	9 bc	99 a	38 a	16 b
Lorox	1.0	4 cd	20 b	6 cd	65 bc	8 bc	4 cd
Goal	0.25	18 a	40 a	18 a	96 a	24 ab	21 a
untreated	–	0 d	0 c	0 e	0 d	0 c	0 d

[a]Means within columns followed by the same letter are not significantly different at the P=0.05 level according to Waller-Duncan's Bayesian K=500 ratio t-test.

[b]Bueno-6 (2.0 lb ai/A) was tank-mixed with each herbicide treatment, and no additional adjuvant was added.

Table 5. Effects of postemergence-directed (PDIR) herbicide applications on kenaf tolerance and yield at six locations in Washington and Tallahatchie counties, MS, 1991-1992.

Herbicide		Kenaf Phytotoxicity (whole plant) 14 DAT[a]						
		1992		1991				
		Location						
Treatment[c]	Rate	#1	#2	#3	#4	#5	#6	Yield[b]
	lb ai/A	(%)						ton/A
Basagran	0.75	0 b	0	0	4 b	0	0 c	4.83 a
Bladex	0.8	5 a	4	3	9 b	3	2 bc	4.79 a
Karmex	0.5	0 b	0	0	8 b	0	0 c	4.48 b
Cobra	0.2	0 b	0	0	8 b	0	5 b	4.69 ab
Lorox	1.0	5 a	3	3	6 b	3	0 c	4.60 ab
Goal	0.25	0 b	13	0	19 a	5	11 a	4.44 b
untreated	0	0 b	0	0	0 b	0	0 c	4.58 ab

[a]Means within columns, followed by the same letter are not significantly different at the P=0.05 level according to Waller Duncan's Bayesian K#500 ratio t-test.

[b]Means within column, followed by the same letter are not significantly different as determined by the t-test. Means are Least Square Means due to unequal observations.

[c]Bueno-6 (2.0 lb ai/A) was tank-mixed with each herbicide treatment, and no additional adjuvant was added.

The data indicate that Basagran, Bladex, Karmex, Cobra, Lorox, or Goal can be safely tank-mixed with Bueno-6 and applied PDIR to 8- to 14-inch kenaf without reducing kenaf yield. These treatments will not be legal until registration is granted for use in kenaf.

Acknowledgments

This research was funded through a cooperative agreement with USDA-ARS, Jamie Whitten Delta States Research Center, Stoneville, MS. The authors wish to thank the following companies for supplying the herbicides: American Cyanamid, BASF, E.I. DuPont, Isk Biotech, Rohm and Haas, Valent, and Zeneca. The authors appreciate the expert technical assistance provided by Daniel M. Robertshaw, Sr., Willie Earl Clark, Jody Simcox, F. Roland Sabbatini, Gordon R. Tupper, H. C. (Lyle) Pringle, and R. Manning.

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