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Kenaf Response to Herbicides in the Rio Grande Valley

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ABSTRACT

Early season weed competition in kenaf can reduce stand establishment and stalk yield. The objective of this study was to evaluate herbicides for phytotoxicity to kenaf and control of early season weeds in kenaf. *Panicum texanum L.* and *Amaranthus palmeri.* L. are two of the most common and troublesome weeds in the Lower Rio Grande Valley of South Texas. Sixteen herbicide treatments including dosage level and timing of application with five different herbicides (trifluralin, pendimethalin, metolachlor, MSMA, and fluazifop-P) were applied to kenaf either preplant incorporated (PPI), preemergence (PRE), or postemergence (POST) and examined over two years. Kenaf stalk yield was greatest with trifluralin applied PRE at 1.1 kg a.i. ha^{-1} as well as PPI and PRE pendimethalin applications at 1.1 and 2.2 kg a.i. ha^{-1}. All other treatments reduced stalk yield. The results of this study indicate that the best weed control, least herbicide phytotoxicity to kenaf, and greatest kenaf stalk weight were achieved with treatments of trifluralin applied PRE at 1.1 kg a.i. ha^{-1}, or pendimethalin applied either PPI or PRE at 1.1 or 2.2 kg a.i. ha^{-1}. Metolachlor applied PPI or PRE, MSMA, and fluazifop-P all injured the young seedling kenaf and decreased stalk yield from 55 to over 90% compared with the untreated weed-free control.

RESUMEN

La competencia con malezas durante las etapas tempranas del cultivo puede reducir el establecimiento del kenaf y el rendimiento del tallo. El objetivo de este estudio fue la evaluación de herbicidas en lo referente a su efecto fitotóxico sobre kenaf y a su eficacia en el control de malezas durante la estación temprana. Dos de las malezas más comunes y más problemáticas en el Bajo Valle del Río Grande en el sur de Texas son *Panicum texanum* L. y *Amaranthus palmeri* L. Se establecieron 16 tratamientos de herbicidas sobre kenaf consistentes en niveles de dosis y tiempo de aplicación de cinco diferentes productos (trifluralín, pendimetalín, metolaclor, MSMA, y fluazifop-P) aplicados por medio de uno de los siguientes métodos: incorporación antes de la siembra (PPI), antes de la emergencia (PRE) o después de la emergencia (POST) y estos fueron examinados por dos años. El mayor rendimiento del tallo en kenaf se presentó cuando se aplicó trifluralín antes de la emergencia a 1.1 kg de i.a. ha^{-1} asi como con las aplicaciones de pendimetalín antes de la siembra y antes de la emergencia a 1.1 y 2.2 Kg i.a ha^{-1}. Todos los otros tratamientos redujeron el rendimiento del tallo. Los resultados de este estudio indican que el mejor control de malezas, la menor fitotoxicidad herbicida al kenaf, y el mayor peso del tallo se obtuvieron con los tratamientos de trifluralín aplicado previamente a la emergencia a 1.1 kg i.a. ha^{-1}, o de Pendimetalín aplicado previamente a la siembra o a la emergencia a 1.1 o 2.2 kg i.a. ha^{-1}. El metolaclor, aplicado antes de la siembra o antes de la emergencia, el MSMA y el fluazifop-P dañaron a las plántulas jóvenes del kenaf y disminuyeron el rendimiento del tallo de un 55% a más del 90% en comparación con el rendimiento del control libre de malezas no tratado.

*Abbreviations used: **PANTE,** Panicum Texanum; **AMAPA**, Palmer Amaranth; **POST,** post-emergence; **PPI**, pre-plant incorporated; **PRE,** pre-emergence; **DAP,** days after planting; **a.i.,** active ingredient.*
*Herbicide Chemical names: **pendimethalin,** (N-(1-ethylpropyl)3,4-dimethyl-2,6-dinitrobenzenamine); **trifluralin**, (2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl) benzenamine); **metolachlor,** (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(w-methyoxy-1-methylethyl)acetamide); **MSMA** (monosodium acid methanearsonate); and **fluazifop-P-butyl**, ((R)-2-[4-[[5-trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid)*

Kenaf (*Hibiscus cannabinus* L.) is a drought tolerant annual fiber crop which was selected as the most promising alternative to wood pulp source by a USDA search which included over 500 fiber crops (Anonymous, USDA, 1992). In the past, kenaf has been used for products such as rope, clothing, cooking oil, burlap sacks, and paper (Dempsey, 1968). Weed control strategies need to be identified if kenaf is to become a viable crop in the United States. Burnside and Williams (1968) have shown that early season weed competition in kenaf can reduce yields up to 58 percent when *Amaranthus hybridus* L. and *Seteria viridis* (L.) Beauv. infestations are present. Early season weed control is important for uniform stand establishment and maximum growth of kenaf (Burnside and Williams, 1968). Once kenaf develops a dense foliar canopy, it competes well with most weeds (Dempsey, 1975). Kurtz and Neill (1992) found the herbicides clethodim, fluazifop-P, MSMA, quizalofop, and sethoxydim were not phytotoxic to kenaf when applied postemergence in Mississippi. Preemergence applications of zorial (norflurazon), karmex (diuron), command (clomazone), canopy (chloriumron-ethyl plus metribuzin), aatrex (atrazine), and pursuit (imazethzapyr) all significantly injured kenaf (Kurtz, 1991). The objectives of this study were to evaluate herbicide phytotoxicity to kenaf and control of early season weeds which in this study include *Panicum texanum* L. (PANTE), and *Amaranthus palmeri.* L. (AMAPA) the two most common and troublesome weeds in the Lower Rio Grande Valley of Texas.

MATERIALS AND METHODS

This study used a randomized complete block design with four replications of 16 herbicide treatment over two years. In addition five weedy checks and five handweeded control treatments were included in each block. Kenaf (var. Everglades 41) was planted on 15 March, 1990 and 20 March 1992 in a Willacy fine sandy loam soil (hyperthermic Typic Calciustolls). This soil had an organic matter content of 0.8 % and soil pH of 7.8, with a cation exchange capacity in the Ap horizon of 15.4 me 100 g^{-1}.

Treatments consisted of different application methods, rates and timings of several herbicide products. Field plot size was 2 m (two rows) wide by 7.6 m long. The seedbed was prepared by two tandem disc operations in opposite directions and bed formation was completed with a commercial two-row, rotary tine bed former. Materials evaluated included trifluralin, pendimethalin, metolachlor, MSMA, and fluazifop-P-butyl. Preplant incorporated (PPI) treatments included pendimethalin at 1.1 and 2.2 kg a.i. ha^{-1}, and metolachlor at 1.7 and 3.3 kg a.i. ha^{-1} which were broadcast and incorporated to a 5 cm depth with a PTO powered rotary tiller prior to planting. Preemergence (PRE) treatments of trifluralin and pendimethalin both at 1.1 and 2.2 kg a.i. ha^{-1} and metolachlor at 1.7 and 3.3 kg a.i. ha^{-1} were applied immediately following planting. Postemergence treatments of MSMA at 2.2 or 4.5 kg a.i. ha^{-1} were applied 17 DAP (Days after planting), or at 17 DAP plus 37 DAP. Postemergence treatments of fluazifop-P-butyl were applied at 0.28 and 0.56 kg a.i. ha^{-1} at 17 DAP plus at 30 DAP.

Kenaf was furrow irrigated (approximately 15 cm ha^{-1}) the day after planting to ensure uniform germination and stand establishment. Emergence occurred in two to three days after planting. PRE-applied treatments, although not incorporated, were activated by the post planting irrigation one day after applications were made.

Control of PANTE and AMAPA and crop phytotoxicity were evaluated at 30 and 45 DAP on a 0 to 100 scale where 0 = no weed control and 100 = complete death of the weeds. Crop phytotoxicity was evaluated on a 0 to 100 scale where 0 = no crop phytotoxicity and 100 = complete death of the crop. Phytotoxicity was characterized by yellowing of plant leaves, stunting of plants, or lack of plant vigor. Weed control ratings at 30 DAP was prior to the application of POST treatments; however, PPI and PRE treatments were generally similar to 45 DAP evaluations so only 45 DAP evaluations are presented.

Kenaf plants were harvested at physiological maturity. Relative effects of herbicides on kenaf growth and stalk yield were evaluated by measuring plant height (1992 only), and collecting stalks from 4 m of row, oven drying the stalks and weighing each year.

Data were subjected to analysis of variance using a General Linear Models (GLM) procedure (SAS, 1989). Means were separated using a Waller/Duncans K-ration T-test (alpha = 0.05) for each of the variables measured. Contrasts were performed to determine if dosage level of trifluralin, pendimethalin, metolachlor, or MSMA affected weed control, crop phytotoxicity, plant height, plant population, or stalk yield. Contrasts were also used to determine if application timing (PPI, PRE, or POST treatments at 17 DAP, 17+37 DAP) affected weed control, crop phytotoxicity, or crop growth. Orthogonal contrast coefficients were calculated for trifluralin treatments of 1.1 and 2.2 kg a.i. ha^{-1}. Contrast comparison analysis was also made for the following treatments: pendimethalin at 1.1 and 2.2 kg a.i. ha^{-1} applied PPI versus the same treatments applied PRE; pendimethalin applied at 1.1 kg a.i. ha^{-1} (combined PPI and PRE) versus pendimethalin applied at 2.2 kg a.i. ha^{-1}; metolachlor combined (1.7 and 3.3 kg a.i. ha^{-1}) PPI treatments versus the combined PRE treatments; metolachlor combined PPI and PRE treatments of 1.7 kg a.i. ha^{-1} versus 3.3 kg a.i. ha^{-1}; MSMA treatments applied at 17 DAP compared to MSMA treatments applied at both 17 and 37 DAP; MSMA combined treatments (both 17 DAP and 17+37 DAP) at 2.2 kg a.i. ha^{-1} compared to the 4.5 kg a.i. ha^{-1} rate combined application (both 17 DAP and 17+37 DAP). Linear correlation coefficients between kenaf dry stalk weight and other variables were calculated to determine the closeness of relationship between these variables and dry stalk weight.

RESULTS

Excellent control of PANTE and AMAPA was provided by trifluralin, pendimethalin, and metolachlor (applied PPI or PRE). A single treatment of MSMA at either 2.2 or 4.5 kg a.i. ha^{-1} (applied postemergence at 17 DAP) provided inferior control of PANTE and AMAPA when compared to PPI or PRE applied treatments (Table 1). A second application of MSMA applied at 37 DAP in addition to a 17 DAP application, enhanced AMAPA control from 34 to 71 percent for the 2.2 kg a.i. ha^{-1} rate and from 48 to 81 percent control for the 4.5 kg a.i. ha^{-1} dosage level. Fluazifop-P does not affect AMAPA, so control was not evaluated for these treatments. AMAPA was hand removed from the plots at 30 DAP and prior to the application of the 30 DAP herbicide treatment; however, germination of AMAPA continued throughout the season and plots were later re-infested. Control of PANTE with fluazifop-P-butyl was fair (85 and 88% for 0.28 and 0.56 kg a.i. ha^{-1}, respectively) and uniform spray application to the grass leaves may not have been achieved at the 17 DAP treatment due to the broad leaves of AMAPA present at 17 DAP which shaded some of the PANTE plants. Phytotoxicity to kenaf was observed with trifluralin applied at 2.2 kg a.i. ha^{-1} PRE. Metolachlor also produced phytotoxic effects on kenaf with all treatments (6 to 18 percent stunting). All other PPI or PRE treatments did not

Table 1. Percent control of *Panicum texanum*, *Palmeri amaranth*, and herbicide phytotocity to kenaf.

treatment	application method[a]	dosage	PANTE[b] 1990	PANTE[b] 1992	AMAPA[b] 1990	AMAPA[b] 1992	crop phytotoxicity[b] 1990	crop phytotoxicity[b] 1992
		kg ha-1			%			
trifluralin	PRE[c]	1.1	98 ab	97 ab	98 a	98 a	0 d	0 c
trifluralin	PRE	2.2	98 ab	97 ab	99 a	99 a	0 d	15 a
pendimethalin	PPI[c]	1.1	99 a	95 ab	97 ab	98 a	0 d	2 c
pendimethalin	PPI	2.2	99 a	99 a	97 ab	99 a	0 d	0 c
pendimethalin	PRE	1.1	99 a	97 ab	98 a	98 a	0 d	3 c
pendimethalin	PRE	2.2	99 a	97 ab	98 a	98 a	0 d	3 c
metolachlor	PPI	1.7	93 abc	90 bcd	99 a	99 a	7 c	15 a
metolachlor	PPI	3.3	98 ab	99 a	97 ab	98 a	22 a	16 a
metolachlor	PRE	1.7	91 bc	99 a	99 a	99 a	7 c	6 bc
metolachlor	PRE	3.3	96 ab	99 a	99 a	99 a	16 ab	18 a
MSMA	17 DAP	2.2	80 cd	81 ef	40 fgh	34 gh	0 d	3 c
MSMA	17 DAP	4.5	72 de	74 gh	50 ef	48 fg	0 d	3 c
MSMA	17+37 DAP	2.2+2.2	68 de	69 h	60 cde	71 cd	0 d	3 c
MSMA	17+37 DAP	4.5+4.5	81 cd	79 fg	65 cd	81 b	0 d	5 c
fluazifop-P-butyl	17+30 DAP	0.28+0.28	99 a	85 def	---	---	0 d	13 ab
fluazifop-P-butyl	17+30 DAP	0.56+0.56	99 a	88 cde	---	---	0 d	13 ab
weed-free control	---	---	95	97	95	97	0	0
weedy check	---	---	0	0	0	0	0	0

[a]Percent control values for PANTE and AMAPA control were transformed using an arcsine squareroot transformation prior to means separation. Values shown in the table were back- transformed for the convenience of the reader. Percent control was evaluated on a scale of 0-100 where 0 = no control and 100 = complete death of plants. Crop phytotoxicity was evaluated on a 0-100 scale with 0 = no phytotoxic effects observable and 100 = complete necrosis and death of plant.
[b]Numbers within a column followed by a different letter indicated a significant difference (alpha = 0.05) using a Waller/Duncan K-ratio T-test. Four replications of each treatment were included in the experiment.
[c]Abbreviation PRE = preemergence application of the herbicide, PPI = pieplant incorporated application of the herbicide.

Table 2. Kenaf plant population and dry stalk weight as affected by the various herbicide treatments in 1990 and 1992.

treatment	Application method[a]	dosage	Plant Population[b] 1990	Plant Population[b] 1992	dry stalk weight[b] 1990	dry stalk weight[b] 1992
		kg ha^{-1}	---no. ha^{-1}---		---kg ha^{-1}---	
trifluralin	PRE	1.1	82000 a	85000 a	5300 bc	5300 abc
trifluralin	PRE	2.2	67000 c	77000 a	5200 bc	3300 b-f
pendimethalin	PPI	1.1	54000 d	79000 a	5500 bc	6800 a
pendimethalin	PPI	2.2	72000 bc	75000 ab	6400 b	5500 a-d
pendimethalin	PRE	1.1	45000 ef	67000 b	5700 bc	6100 ab
pendimethalin	PRE	2.2	66000 c	64000 b	6200 b	6000 ab
metolachlor	PPI	1.7	82000 a	85000 a	7900 a	1700 ef
metolachlor	PPI	3.3	74000 abc	75000 a	6000 b	1900 def
metolachlor	PRE	1.7	79000 a	81000 a	7400 a	2700 c-f
metolachlor	PRE	3.3	65000 c	89000 a	7200 a	1700 ef
MSMA	17 DAP	2.2	53000 de	80000 a	2700 e	1200 f
MSMA	17 DAP	4.5	66000 c	78000 a	3300 de	1600 ef
MSMA	17+37 DAP	2.2+2.2	72000 bc	78000 a	2700 e	900 f
MSMA	17+37 DAP	4.5+4.5	84000 a	79000 a	2800 e	800 f
fluazifop-P-butyl	17+30 DAP	0.28+0.28	86000 a	77000 a	2800 de	200 f
fluazifop-P-butyl	17+30 DAP	0.56+0.28	72000 bc	77000 a	2900 de	100 f
weed-free control	---	---	72000	84000	6400	6800
weedy check	---	---	73000	78000	2700	2400

[a]abbreviations: PRE=preemergence applied; PPI=preplant incorporated; DAP=days after planting.
[b]Numbers within a column followed by a different letter indicate a significant difference (alpha = 0.05) using a Waller/Duncan K-ratio T-test. Four replications of each treatment were included in the experiment.

Table 3. Kenaf plant height at maturity in 1992 as affected by the various herbicide rates and application methods.

treatment	application method[a]	dosage	height
		kg a.i. ha^{-1}	cm
trifluralin	PRE[a]	1.1	110 b-e
trifluralin	PRE	2.2	106 b-e
pendimethalin	PPI[a]	1.1	154 a
pendimethalin	PPI	2.2	151 a
pendimethalin	PRE	1.1	156 a
pendimethalin	PRE	2.2	154 a
metolachlor	PPI	1.7	71 de
metolachlor	PPI	3.3	83 cd
metolachlor	PRE	1.7	98 cd
metolachlor	PRE	3.3	69 de
MSMA	17 DAP[a]	2.2	117 b-e
MSMA	17 DAP	4.5	129 bcd
MSMA	17+37 DAP	2.2+2.2	115 b-e
MSMA	17+37 DAP	4.5+4.5	124 bcd
fluazifop-P-butyl	17+30 DAP	0.28+0.28	88 cd
fluazifop-P-butyl	17+30 DAP	0.56+0.56	63 e
weed-free control	---	---	134
weedy check	---	---	126

[a]PRE=preemergence applied; PPI= preplant incorporated; DAP=days after planting.
[b]Numbers within a column followed by a different letter indicate a significant difference (∞ = (.05) using a Waller/Duncan K-ratio T-test. Four replications of each treatment were included in the experiment.

Table 4. Simple linear correlation coefficients between kenaf dry stalk weight and selected and selected variables.

	Probability > |R|	
	1990	1992
Texas panicum	0.24	0.21
Palmer amaranth	0.18	0.15
herbicide phytotoxicity	- 0.28	- 0.23
kenaf plant height[a]	-----	0.65
kenaf plant population	0.28	0.24

[a]Plant height at plant maturity was measured only in 1992

exhibit crop phytotoxic effects as compared to the handweeded (weed-free) treatment (Table 1). Kenaf phytotoxicity was 13 percent from fluazifop-P treatments, which is in agreement with work done by Kurtz and Neill (1992) where kenaf injury by fluazifop-P was found to be 10 percent at 8 days after treatment although in the Mississippi study the kenaf recovered to produce yields not different from the control.

Kenaf plant height was reduced by 27 to 49 percent in 1992 with metolachlor treatments (Table 3). Plant height also was reduced in fluazifop-P treatments. Much of this late season crop height reduction was probably due to competition from PANTE.

Dosage of trifluralin, pendimethalin, metolachlor, or MSMA had no effect (non-significant P-values in contrast comparisons) on control of PANTE, AMAPA, kenaf height, kenaf plant population, or stalk dry weight. Kenaf phytotoxicity was increased when the trifluralin dosage was increased from 1.1 to 2.2 kg a.i. ha^{-1} (Table 2). Applying pendimethalin or metolachlor either PPI or PRE had no differences in weed control, growth, or yield of kenaf (Tables 1 - 2). A single application of MSMA at 17 DAP was not different from two applications (17+37 DAP) (Table 1) on weed control and neither method provided satisfactory control of AMAPA or PANTE.

Correlation coefficients between kenaf dry stalk weight and PANTE control, AMAPA control, herbicide control, kenaf plant height, and kenaf plant population indicated that only plant height was highly correlated with dry stalk yield in 1992 (Table 4).

Stalk yields were greatest with trifluralin applied (PRE at 1.1 kg a.i. ha^{-1}) and all of the pendimethalin treatments (either PPI or PRE). (Table 2) Pendimethalin treatments also produced the greatest plant height and relatively high correlations between plant height and stalk yield were found (Table 4). Stalk yields varied between years but MSMA and fluazifop-P at all dosage levels and application timings reduced stalk yields from 50% to over 80% when compared with the weed-free control. Much of the reduction in yield was likely due to competition from non-controlled weeds competing for moisture and light rather than continued crop injury from the herbicide application. Metolachlor reduced stalk yield in 1992 but did not reduce stalk yields in 1990 with 1.7 kg a.i. ha^{-1} applied PPI or PRE or with 3.3 kg a.i. ha^{-1} applied PRE. This study indicates that the greatest weed control, least herbicide phytotoxicity to kenaf, and greatest kenaf stalk weight were achieved consistently with treatments of trifluralin applied at 1.1 kg a.i. h a^{-1}, or pendimethalin applied either PPI or PRE at 1.1 or 2.2 a.i. kg ha^{-1}.

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