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Editor's Note

The 3m Company has changed Vistar® to Embark® since this publication was prepared for printing.

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INTRODUCTION

Red rice is a persistent and troublesome weed in rice and soybeans grown in Arkansas, Louisiana, Mississippi, and Texas. Reports (4,12) indicate that red rice was present in cultivated rice as early as 1846, long before rice was cultivated on a commercial scale in these states (3). Red rice generally is classed as strawhull and blackhull biotypes (10).

Numerous herbicides have been evaluated for control of red rice in water-seeded domestic rice, but no herbicide has given better control in field studies than has molinate (Ordram®) (9). Most red rice control programs rely on chemical and cultural control techniques in rotational cropping systems. The three-year rotation includes two years of soybeans followed by rice the third year or one year of grain sorghum and one year of soybeans followed by rice (10). Soybean-rice rotations are common in Mississippi, where strawhull red rice is the principal red rice biotype. During the soybean years of this rotation, alachlor (Lasso®), metolachlor (Dual®), trifluralin (Treflan®), fluchloralin (Basalin®) and pendimethalin (Prowl®) alone or with metribuzin (Sencor® or Lexone®) are used frequently to control red rice. These treatments may be followed by directed postemergence sprays of linuron (Lorox®), paraquat or metribuzin after soybeans are at least 8 inches tall or by bentazon (Basagran®) + mefluidide (Vistar®) when soybeans are in the one-trifoliolate leaf stage (1).

Herbicides that can be applied postemergence to give selective control of red rice irrespective of soybean growth stage are desirable in a rotational program. The new generation of selective grass herbicides may provide this capability. These compounds have been reported to control annual grasses (8), johnsongrass (6, 7), quackgrass (5) and common bermudagrass (2) in soybeans and cotton. The objective of this research was to determine the phytotoxicity (% injury) of five herbicide treatments applied postemergence at two growth stages of strawhull and blackhull red rice, Starbonnet domestic rice and Centennial soybeans. Starbonnet was included as a representative domestic rice cultivar to determine which, if any, of the five herbicides are sufficiently selective to permit use for control of red rice in domestic rice.

MATERIALS AND METHODS

Experiments with herbicides applied during the (a) one- to two-leaf stage of rice and unifoliolate stage of soybeans and (b) five- to six-leaf stage of rice and trifoliolate stage of soybeans were conducted on a Leeper silty clay loam on the plant science farm at Mississippi State, Mississippi in 1981 and were repeated in 1982 on the same soil type, but on a different site in the same field. Strawhull red rice, blackhull red rice, Starbonnet rice or Centennial soybeans each were planted 1 inch deep in rows spaced 24 inches apart.

In the first experiment, sethoxydim (Poast®), DPX Y6202 (Assure®), haloxyfop (Verdict®), fluazifop (Fusilade®) and Vistar + Basagran were applied postemergence to one- to two-leaf rice and unifoliolate soybeans. Rates applied are listed in Table 1.

In the second experiment, the above treatments were applied postemergence to five- to six-leaf rice and three trifoliolate soybeans and repeated. Rates applied are listed in Table 2.

A CO_2-pressurized backpack sprayer was used to apply the herbicides in water at 20 gpa to a 40-inch spray swath. Plot size was four rows eight ft long. Nonoxynol (9 to 10 POE) at 0.25% (v/v) was added to each treatment in 1981 and to Vistar + Basagran in 1982. Except for Vistar + Basagran, 1.25% (v/v) oxysorbic (polyoxyethylene sorbitan fatty acid ester) in mineral oil [(17):83% w/w] was added to each treatment in 1982.

The three rice biotypes, the soybeans, and the five herbicide treatments (along with their respective untreated checks) were arranged factorially as a 3 x 5 experiment in a randomized complete block design with four replications. All plots were hoed and hand-weeded on the day of herbicide application each year. Planting, treatment and rain-

fall data are listed in Table 3.

Injury to rice and soybeans resulting from the herbicide treatments was rated visually on a scale of 0 (no apparent effect) to 100% (death) as compared to their respective untreated check. Ratings were recorded 11 and 7 days after the first application and 17 and 22 days after the second application to one- to two-leaf rice and unifoliate soybeans in 1981 and 1982, respectively. On five- to six-leaf rice and three trifoliolate soybeans, ratings were recorded 7 and 8 days after the first application and 24 and 13 days after the second application in 1981 and 1982, respectively. Specific rating dates are listed in Table 3.

Each rating for each experiment in 1981 and 1982 was subjected to analysis of variance. Means were compared by the Waller-Duncan's Bayesian *k*-ratio (*k* = 100 *t* test (11)

RESULTS AND DISCUSSION

Soybean injury by the herbicides evaluated did not exceed 20%, and these symptoms were no longer visible four weeks after treatment evaluation. The most effective single treatment for control of one- to two-leaf rice in soybeans was Vistar + Basagran at 0.125 + 0.75 lb ai/A except for control of Starbonnet with Assure at 0.25 a.i./A in 1981 (Table 1). However, when soybeans and red rice emerge simultaneously, as they did in this study, this herbicide mixture should not be used because the current label specifies application of Vistar + Basagran only after the first full trifoliolate leaf on the soybean plant has expanded (1). The soybeans in these studies had only the unifoliolate leaves at the time of the first application.

Given the current label restriction on Vistar + Basagran and the relatively low level of injury to one-

Table 1. Percent injury to three rice biotypes sprayed at the one- to two-leaf growth stage with five herbicide treatments in 1981.[1/]

Treatment		Rice type and application						Means[4/]	
		Strawhull		Blackhull		Starbonnet			
Herbicide(s)	Rate (lb/A)	1st[2/]	2nd[3/]	1st	2nd	1st	2nd	1st	2nd
		(Percent Injury)							
Poast®	0.50	51 d-g	97	46 d-h	98	61 b-e	96	53 B	97 A
Assure®	0.25	58 c-e	99	61 b-e	98	88 ab	99	69 B	99 A
Verdict®	0.25	40 d-i	96	30 f-d	97	54 c-f	98	41 B	97 A
Fusilade®	0.25	16 i	90	26 g-i	81	35 e-i	82	26 C	84 B
Vistar® + Basagran®	0.125 + 0.75	94 a	96	81 a-c	90	67 a-d	91	81 A	92 AB
Means		52	96	49	93	61	93		

1/ Values within rows and columns for each application across rice types followed by the same lower case letter(s) do not differ according to the Waller-Duncan's Bayesian k-ratio (k = 100) t test. Values not followed by letters do not differ.

2/ Rated 11 days after treatment on August 6, 1981.

3/ Rated 17 days after treatment on August 21, 1981.

4/ Herbicide means within columns for each appliction followed by the same upper case letter(s) do not differ.

Table 2. Percent injury to three rice biotypes sprayed at the five- to six-leaf growth stage with five herbicide treatments in 1981.[1/]

Treatment		Rice type and application							
		Strawhull		Blackhull		Starbonnet		Means[4/]	
Herbicide(s)	Rate (lb/A)	1st[2/]	2nd[3/]	1st	2nd	1st	2nd	1st	2nd
		(Percent Injury)							
Poast®	1.0	92	98 a	82	95 a	83	96 a	86 AB	96 A
Assure®	0.5	93	99 a	91	99 a	94	99 a	93 A	99 A
Verdict®	0.5	80	96 a	81	96 a	74	96 a	78 B	96 A
Fusilade®	0.5	53	90 ab	45	86 ab	49	91 ab	49 C	89 B
Vistar® + Basagran®	0.125 + 0.75	88	94 a	84	76 b	94	98 a	89 A	89 B
Means[4/]		81	95	77	90	79	96		

1/ Values within rows and columns for each application across rice types followed by the same lower case letter(s) do not differ according to the Waller-Duncan's Bayesian k-ratio (k = 100) t test. Means not followed by letters do not differ.

2/ Rated 7 days after treatment on August 21, 1981.

3/ Rated 24 days after treatment on August 28, 1981.

4/ Herbicide means within columns for each application followed by the same upper case letter(s) do not differ.

Table 3. Planting, treatment, rating, and rainfall parameters for Experiments 1 and 2 in 1981 and 1982.

Year	Date planted	Treatment No.	Treatment Date	$\bar{X}$ Plant height at 1st trt[1/] SHR	BHR	SBD	Soybean growth stage Height	Leaves	Injury[2/] (control) ratings No.	Date	Rainfall Quantity	Time after application
				(cm)				(No.)			(cm)	(h)
Experiment 1 (1- to 2-leaf rice)												
1981	July 27	1	Aug. 6	6	11	5	9	1[3/]	1	Aug. 17	1.30	24
		2	Aug. 21						2	Aug. 28	0.76	2
1982	June 8	1	June 18	6	8	5	8	1[3/]	1	June 25	0.00	264
		2	June 25						2	July 8	0.00	72
Experiment 2 (5- to 6-leaf rice)												
1981	July 27	1	Aug. 21	15	18	15	15	3[4/]	1	Aug. 28	0.76	2
		2	Aug. 28						2	Sept. 7	0.00	96
1982	June 8	1	July 8	13	13	13	18	3[4/]	1	July 16	2.30	6
		2	July 16						2	July 23	0.00	72

1/ SHR = Strawhull red rice; BHR = Blackhull red rice; SBD = Starbonnet domestic rice.

2/ Rating 1 = control (injury) after treatment; Rating 2 after treatment 2.

3/ Unifoliolate.

4/ Trifoliolate.

to two-leaf red rice from one application of the other herbicides, control of rice at an average level of 90% or more required two applications of Poast at 0.50 lb/A or Assure and Verdict at 0.25 lb/A (Tables 1 and 4).

Assure was the only treatment that resulted in an average of 90% (actually more than 90%) red rice injury 7 and 8 DAT in 1981 and 1982 when applied once to five- to six-leaf red rice seedlings (Tables 2 and 5). Mosier et al (8) reported that four-to six-leaf red rice was not controlled ($\geq$ 75%) by a single application of Fusilade at rates up to 0.60 lb/A while Verdict at 0.50 lb/A and Poast at 0.60 lb/A were effective. Again, the time between treatment application and injury evaluation may have been too short in these studies. A single application of Assure was not significantly more injurious to rice than were Poast or Vistar + Basagran in 1981.

Averaged across rice biotypes and years, all treatments except Fusilade resulted in 85 to 99% rice injury when applied twice to five- to six-leaf rice. Fusilade resulted in an average injury level of 73%, which was nearly the same average injury level (75%) resulting from two applications to one- to two-leaf rice. Soybean growth stage probably would not be a limiting factor in applying Vistar + Basagran to five- to six-leaf red rice as the soybean plants had three trifoliolate leaves when applied in these studies.

Mean injury to rice biotypes averaged over herbicides differed in 1982 after one application. The herbicides resulted in significantly less injury to 5- to 6-leaf Starbonnet than to strawhull red rice but not to blackhull (Table 5), but, at the one- to two-leaf stage, strawhull red rice was injured less than blackhull or Starbonnet (Table 4).

A significant herbicide by rice biotype interaction occurred in 1981 after two herbicide applications to five- to six-leaf red rice (Table 2) and after one application to one- to two-leaf rice in 1981 (Table 1). No logical explanation is offered for these responses, other than some unmeasured environmental effect peculiar to 1981, as neither interaction repeated itself in 1982. It is clear, however, that none of the treatments were safe enough to Starbonnet to permit their use to control red rice in Starbonnet plantings.

Table 4. Percent injury to three rice biotypes sprayed at the one- to two-leaf growth stage with five herbicide treatments in 1982.1/

Treatment		Rice type and application						Means	
		Strawhull		Blackhull		Starbonnet			
Herbicide(s)	Rate (lb/A)	1st2/	2nd3/	1st	2nd	1st	2nd	1st	2nd
		(Percent Injury)							
Poast®	0.50	24	96	31	95	35	77	30 C	89 A
Assure®	0.25	50	99	63	99	68	99	60 B	99 A
Verdict®	0.25	49	99	53	99	63	97	55 B	98 A
Fusilade®	0.25	36	56	40	73	55	73	44 B	62 B
Vistar® + Basagran®	0.125 + 0.75	89	99	88	98	85	97	87 A	98 A
Means		50 B	90	58 A	93	63 A	89		

1/ Herbicide means within columns and rice type means within rows for each application followed by the same upper case letter(s) do not differ according to the Waller-Duncan's Bayesian k-ratio (k = 100) t test. Means not followed by letters do not differ.

2/ Rated 7 days after treatment on June 18, 1982.

3/ Rated 22 days after treatment on June 25, 1982.

Table 5. Percent injury to three rice biotypes sprayed at the five- to six-leaf growth stage with five herbicide treatments in 1982.1/

Treatment		Rice type and application							
		Strawhull		Blackhull		Starbonnet		Means	
Herbicide(s)	Rate (lb/A)	1st2/	2nd3/	1st	2nd	1st	2nd	1st	2nd
		(Percent Injury)							
Poast®	1.0	56	76	51	73	46	73	51 B	74 C
Assure®	0.5	97	99	92	99	93	99	94 A	99 A
Verdict®	0.5	76	92	66	99	54	85	65 B	92 AB
Fusilade®	0.5	39	63	35	53	30	55	35 C	57 D
Vistar® + Basagran®	0.125 + 0.75	71	91	53	86	49	80	58 B	86 BC
Means		68 A	84	59 AB	82	54 B	78		

1/ Herbicide means within columns and rice type means within rows for each application followed by the same upper case letter(s) do not differ according to the Waller-Duncan's Bayesian k-ratio (k = 100) t test. Means not followed by letters do not differ.

2/ Rated 8 days after treatment on July 8, 1982.

3/ Rated 13 days after treatment on July 16, 1982.

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