Bulletin 942

November 1985

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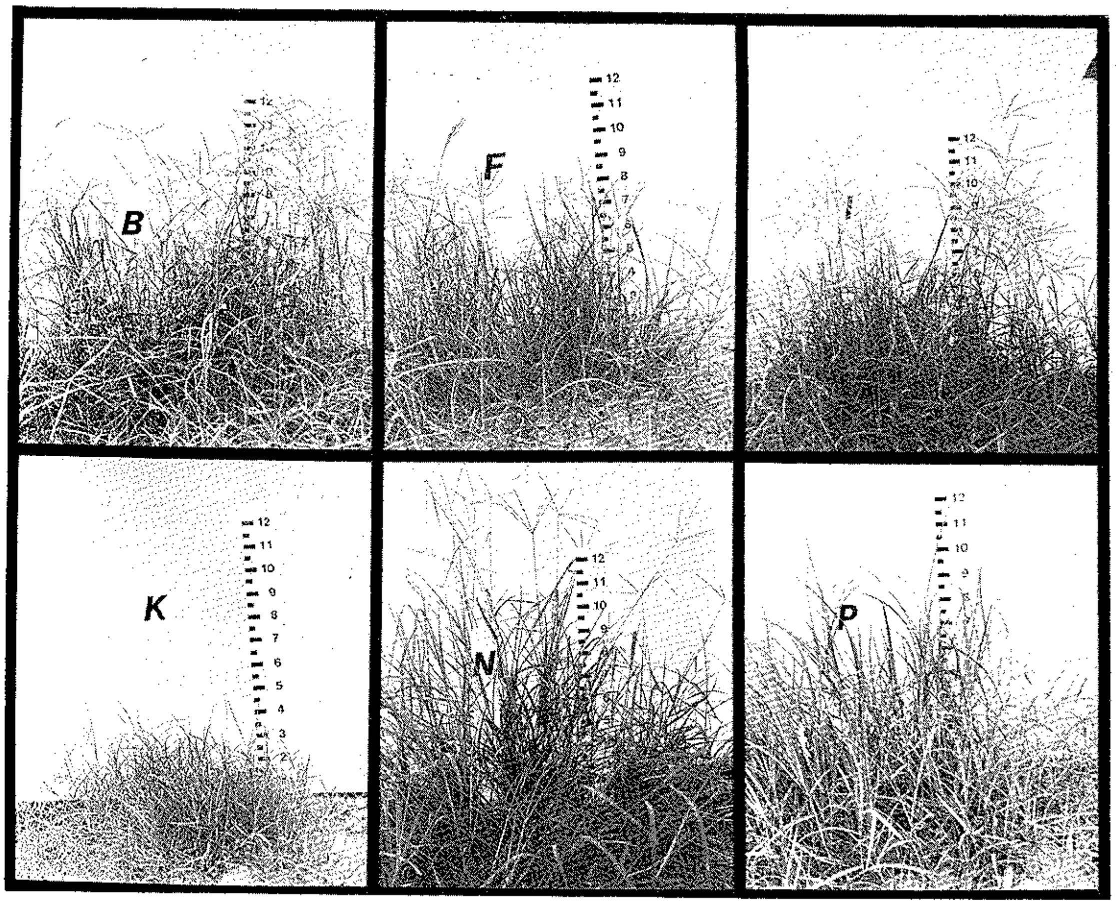

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Cover photograph shows examples of differences in bermudagrass types collected from several locations. Of the 17 biotypes included in this study, many are similar to one another as shown by the top three specimens (B, F, I). Others vary noticeably in length and width of leaves and in length and number of seed heads as the bottom three specimens (K, N, P) pictured. Susceptibility to herbicides also varies among bermudagrass biotypes.

Effectiveness of Grass Herbicides on Different Types of Bermudagrass

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This research was supported in part by the Mississippi Soybean Promotion Board.

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Bermudagrass [*Cynodon dactylon* (L.) Pers.] was reported to be increasing as a problem weed in cultivated fields of Missisippi in 1975 (11). Prior to this time, bermudagrass was controlled by hand-hoeing, frequent cultivations, and by fall plowing with occasional winter harrowing which enhanced kill by freezing temperatures (10).

Since 1975, bermudagrass has continued to increase as a problem weed in cultivated crops. One factor favoring this increase has been the advanced use of herbicides which are selective for the control of annual weeds but are not effective on perennial weeds, including bermudagrass. The increased use of these herbicides has been accompanied by a great reduction of hand-hoeing and a decrease in the number of mechanical cultivations. These factors, plus the introduction of skip-row planting patterns, have allowed bermudagrass to grow with reduced competition from annual weeds. Bermudagrass grows freely in the unplanted areas (skips) with little competition from crop plants or annual weeds (6,11). More recently, the spread of bermudagrass has been enhanced by an increase in supplemental irrigation and fertilization.

Until the early 1980's, there were no selective herbicides for the control of bermudagrass in cultivated crops. However, since the introduction of the first selective grass herbicide, Poast® (sethoxydim), in 1982, additional selective herbicides have been developed for the control of grasses including bermudagrass in broadleaf crops.

Early evaluation of these chemicals on bermudagrass at different field locations within Mississippi showed variable results (19). One reason for differences in control by individual herbicides could be the presence of different genetic strains or biotypes of bermudagrass within the same geographical areas.

Different biotypes of bermudagrass originate both from naturally occurring genetic mutations in the field and from escapes of strains which were specifically developed for lawn, recreational, pasture, and other uses. Biotypes of bermudagrass are reported to have differential tolerance to herbicides (1, 9, 13, 14, 15, 16, 19).

The first reports of intra-specific differential susceptibility to herbicides in bermudagrass came from sugar-producing areas of the South Pacific by Hilton (9) who reported three tolerant strains. Later, 20 tolerant strains were identified from the Hawaiian Islands (1). Four strains or biotypes (two triploid and two tetraploid) were identified from Mauritius by Rochecouste (13, 14). He found that these biotypes differed in epidermal structure and that the tetraploid biotypes were often more susceptible to TCA (sodium TCA) and Dalapon® (dalapon) than were the triploid biotypes (15, 16).

The objective of this study was to investigate the potential for variability in herbicide control among bermudagrass biotypes within Mississippi and surrounding states of the Lower Mississippi River Valley.

Materials and Methods

Greenhouse preparation. Nine collections of bermudagrass were obtained in October 1979 from cotton fields in the Mississippi Delta Region (5). An additional eight collections were made in 1980 from federal and state tree nurseries in Arkansas, Louisiana, Mississippi, and Tennessee. These collections were designated as biotypes because each is genetically identical through vegetative reproduction. This fits Stebbins' (17) definition of plant biotypes, which is that plants are genetically identical within a population of the same species.

While some of these bermudagrass biotypes differ in physical appearance, most look very similar. Those biotypes differing in appearance range from plants with short leaves and internodes to those with long leaves and internodes. The height and number of seed heads also vary among biotypes. Biotypes collected were coded A through Q (Table 1).

Bermudagrass stolons were cut into 2- to 3-inch sections and transplanted into 4-inch diameter pots. Each pot contained a 2:1:1 (v/v/v) mixture of a Dubbs very fine sandy loam soil (Typic hapludalf), shredded sphagnum, and horticultural-grade vermiculite. Each

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Table 1. Origin of bermudagrass biotypes collected in cotton fields and at federal and state forestry nurseries in the Lower Mississippi Valley Region.

Letter designation	Place of Origin State. County: Location, Source area.
A	MS. Bolivar Co.: Shaw, cotton field.
B	MS. Bolivar Co.: Duncan, cotton field.
C	MS. Tunica Co.: Tunica, cotton field.
D	MS. Coahoma Co.: Int Hwy 61 and 316, cotton field.
E	MS. Leflore Co.: Int Hwy 82 and 49E, cotton field.
F	MS. Quitman Co.: Marks, cotton field.
G	MS. Tallahatchie Co.: Tutwiler, cotton field.
H	MS. Issaquena Co.: Mayersville, cotton field.
I	MS. Humphreys Co.: Silver City, cotton field.
J	MS. Perry Co.: Brooklyn, W. W. Ashe Federal Nursery.
K	MS. Perry Co.: Brooklyn, W. W. Ashe Federal Nursery.
L	MS. Covington Co.: Mt. Olive, Mt. Olive State Nursery.
M	MS. Montgomery Co.: Winona, Winona State Nursery.
N	AR. Pulaski Co.: Little Rock, Baucum State Nursery.
O	LA. Caldwell Parish: Columbia, State Forestry Nursery.
P	TN. Madison Co.: Pinson, Pinson State Nursery.
Q	TN. Madison Co.: Pinson, Pinson State Nursery.

plant was watered daily. The plants were fertilized with a solution of NPK (20-20-20) at 0.2 ounces per gallon and trimmed to 1.5 inches in length every 3 to 4 weeks. The plants were grown in the greenhouse at 75 to 90° F for 18 weeks before being transplanted into the field.

Land preparation, field establishment, and plot maintenance. Field studies were conducted during 1982 and 1983 on a Dundee very fine sandy loam soil (Aeric Ochraqualfs). Treflan® (trifluralin) was applied over-the-top and double-disk incorporated, followed by preparation of rows 40 inches apart. On May 3 and 4, 1982, all the bermudagrass biotypes were transplanted in a zigzag arrangement 40 inches apart in two-row plots 80 feet long. After the biotypes were transplanted, a four-row roller was used to compress the soil around the bermudagrass. On April 26, 1983, those biotypes which were killed or stunted by one of the herbicide treatments during 1982 were replaced with the respective biotypes. Each replacement was established in the greenhouse by the same method described in the initial field establishment.

Bermudagrass growth prior to and during the experiment was confined within the prescribed area using Paraquat® (paraquat) at 2.5% v/v in water, applied with a hand sprayer at low pressure on days with little or no wind. Weeds in the plots were controlled with Cotoran® (fluometuron) applied broadcast at 1 pound in 20 gallons of water per acre 2 weeks prior to treatment in 1982 and 1983. Basagran® (bentazon) at 1 lb/acre and Blazer® (acifluorfen) at 0.25 lb/acre plus 0.25% v/v of Sterox NJ® (nonoxynol) were applied broadcast in 20 gallons of water per acre on July 20 and 28, 1983, and 2,4-D at 1 lb/acre was applied broadcast in 20 gallons of water per acre on August 1, 1983 for broadleaf and sedge control. These herbicides could have altered the amount of bermudagrass control, but such interactions could not be determined with the experimental design used. In addition, weed control was supplemented by hand-hoeing and spot treatments with a hand-held sponge applicator containing a mixture of water and Roundup® (glyphosate) (3:1, v/v). Each plot was fertilized at the rate of 450 pounds of ammonium nitrate per acre in 1982 and in 1983.

Experimental design and treatment. The experiment was established as a split-split-plot design with herbicides as main plots, rates as subplots, and bermudagrass biotypes (A through Q) as sub-subplots replicated three times. Herbicide rates were chosen from preliminary studies. The rates used were those resulting in a measurable degree of bermudagrass control without killing the most susceptible biotypes. All rates are expressed as pounds of active ingredient (ai) per acre. Herbicide treatments were applied postemergence on June 21, 1982 and 1983, using Poast® at 0.5 and 1 lb/acre, Fusilade® (fluazifop) at 0.25 and 0.5 lb/acre, Verdict® (haloxyfop) at 0.25 and 0.5 lb/acre, Assure® (DPX-Y6202) at 0.25 and 0.5 lb/acre, and Whip® (fenoxaprop) at 0.25 and 0.5 lb/acre. Each was applied with 0.5% v/v Atplus 411F® [polyoxyethylene sorbitan fatty acid ester: mineral oil (17:83% w/w)]. (Atplus 411F® is a product of ICI Americas Inc., Wilmington, Delaware.) Other treatments were Roundup at 1 and 2 lb/acre and Dalapon at 5 and 10 lb/acre, each with 0.5% v/v Sterox NJ. Herbicide treatments were applied in 20 gallons of water per acre with a tractor-mounted air-pressure sprayer equipped with 8003 spray tips with no-drip strainers, at 20 psi pressure.

Control evaluations. Bermudagrass control was determined 2, 4, 7, and 13 weeks after treatment by a visual plant damage rating system on a scale of 0 to 100 where 0=no control, and 100=complete control. The data were subjected to an analysis of variance. Years, herbicide levels, and biotypes were compared by Duncan's multiple range test (DMRT) at the 5% level of significance.

Results and Discussion

Early season control of the different bermudagrass biotypes using the lower rate of each herbicide is shown at 7 weeks after treatment in 1982 (Table 2) and 1983 (Table 3). Other workers have shown that weed competition during this first 6 to 8 weeks after planting results in the greatest yield reduction of soybeans (2, 18) and cotton (3). Like previous reports of differential susceptibility to herbicides of biotypes of johnsongrass (7, 8, 12), quackgrass (5), and bermudagrass (1, 5, 9, 13, 14, 15, 16, 18), control varied among bermudagrass biotypes in this study.

Results 7 weeks after treatment showed significant variations in the percent control between the most susceptible to the most resistant biotypes. The range of percent control among the different biotypes was greatest (>45%) using Poast and Fusilade and least (12%) using Verdict. The variations in percent control among biotypes were more pronounced using the lower rate than the higher rate of each herbicide.

Season-long control averaged over all bermudagrass biotypes for each of 2 years was greatest with Verdict at 0.5 lb/acre (>95%) and least with Whip at 0.25 lb/acre and Dalapon at 5 lb/acre (<20%) (Figure 1).

When results were averaged over all biotypes for both years, Whip at 0.25 lb/acre gave a maximum control of only 48% 2 weeks after application, with a rapid decline in control to 16% by 13 weeks after treatment. Data are presented by years (Figure 1); averages over both years are not shown. Whip at 0.5 lb/acre resulted in 58% to 55% control at 2 and 4 weeks after treatment, but control rapidly declined to 19% at 13 weeks after treatment. Likewise, Dalapon at 5 and 10 lb/acre, Poast at 0.5 and 1 lb/acre, Roundup at 1 and 2 lb/acre, Fusilade at 0.25 lb/acre, and Assure at 0.25 lb/acre gave maximum control at 4 weeks after application. By 13 weeks after treatment, control had declined greatly with each of these herbicides except for Roundup at 2 lb/acre, which showed only a slight decrease in control from 81% at 4 weeks to 70% at 13 weeks. Seven weeks after treatment, Fusilade at 0.5 lb/acre, Assure at 0.5 lb/acre, and Verdict at 0.25 lb/acre produced a maximum control of 81, 81, and 94%, respectively. Verdict was the only herbicide with which control was slightly higher at 13 than at 7 weeks after treatment in both years.

During 1982 and 1983, control of bermudagrass biotypes from cotton fields was not significantly different (p = 0.05) from biotypes collected in state and federal nurseries (data not shown). For all herbicides and application rates, control of bermudagrass biotypes significantly differed (p = 0.05) between the years 1982 and 1983. At 13 weeks after treatment, differences in control between 1982

Table 2. Comparative percent control of bermudagrass biotypes 7 weeks after treatment in 1982[1].

	Herbicide (lb ai/acre)						
Bermudagrass Biotype	Poast® (0.5)	Fusilade® (0.25)	Verdict® (0.25)	Assure® (0.25)	Roundup® (1.0)	Whip® (0.25)	Dalapon® (5.0)
A	73 a-d	83 a-d	93 a	72 a	82 a	13 c	27 cd
B	75 a-c	75 a-f	87 a	80 a	87 a	20 bc	78 a
C	70 a-d	78 a-e	90 a	82 a	73 a	12 c	77 a
D	45 e	62 d-g	95 a	72 a	62 ab	17 bc	13 cd
E	78 a-c	67 c-g	96 a	78 a	82 a	26 a-c	10 d
F	57 c-e	57 e-g	96 a	85 a	68 ab	13 c	20 cd
G	60 b-e	52 fg	99 a	85 a	70 ab	13 c	17 cd
H	65 a-e	68 b-g	88 a	73 a	38 c	13 c	27 cd
I	88 a	93 ab	99 a	85 a	87 a	45 a	13 cd
J	83 ab	98 a	99 a	80 a	73 a	45 a	37 bc
K	73 a-d	47 g	99 a	68 a	82 a	35 a-c	32 b-d
L	60 b-e	70 b-g	98 a	72 a	77 a	23 a-c	33 b-d
M	87 a	88 a-c	96 a	78 a	77 a	40 ab	52 b
N	50 de	90 a-c	96 a	80 a	48 bc	33 a-c	22 cd
O	57 c-e	95 a	98 a	83 a	82 a	40 ab	51 b
P	70 a-d	77 a-e	98 a	85 a	84 a	40 ab	32 b-d
Q	43 e	62 d-g	94 a	70 a	83 a	13 c	13 cd
Mean	66	74	95	78	74	26	33
Range	88-43	95-47	99-87	85-68	87-38	45-12	78-10

[1]Numbers within columns followed by the same letter are not significantly different according to Duncan's multiple range test at the 0.05 level. The LSD for comparing numbers within columns is 20; the C.V.% is 18.

and 1983 averaged over the two herbicide rates varied 38, 30, 22, 12, 12, and 4% with Poast, Whip, Roundup, Fusilade, Dalapon, and Assure, respectively (data not shown). In 1982, control with Verdict was about the same as in 1983 (93-94%). Verdict and Assure were least affected by season-long environmental differences in 1982 and 1983 (Figure 1).

Season-long control using Poast at 1 lb/acre and Dalapon at 5 and 10 lb/acre was unacceptable under non-competitive growing conditions (Figure 1). Similar results were reported by Chandler (5). Likewise, Whip at 0.25 and 0.5 lb/acre provided unacceptable control over all bermudagrass biotypes. Fusilade at 0.25 lb/acre and Roundup at 1 lb/acre gave only fair control and resulted in a wide range of susceptibility among biotypes.

This collection of bermudagrass biotypes does not represent all of the possible genetic variability nor the full range of potential differences in herbicidal susceptibility within this geographical area. However, our data demonstrate that within any given year, there are differences in the comparative herbicidal susceptibility in bermudagrass biotypes from a wide area within the lower Mississippi River Valley region. While no one biotype was significantly more susceptible or tolerant to all herbicides, Verdict provided consistent acceptable control (>80%) of all bermudagrass biotypes over both years. These data are helpful in making recommendations for the control of a wide range of bermudagrass biotypes.

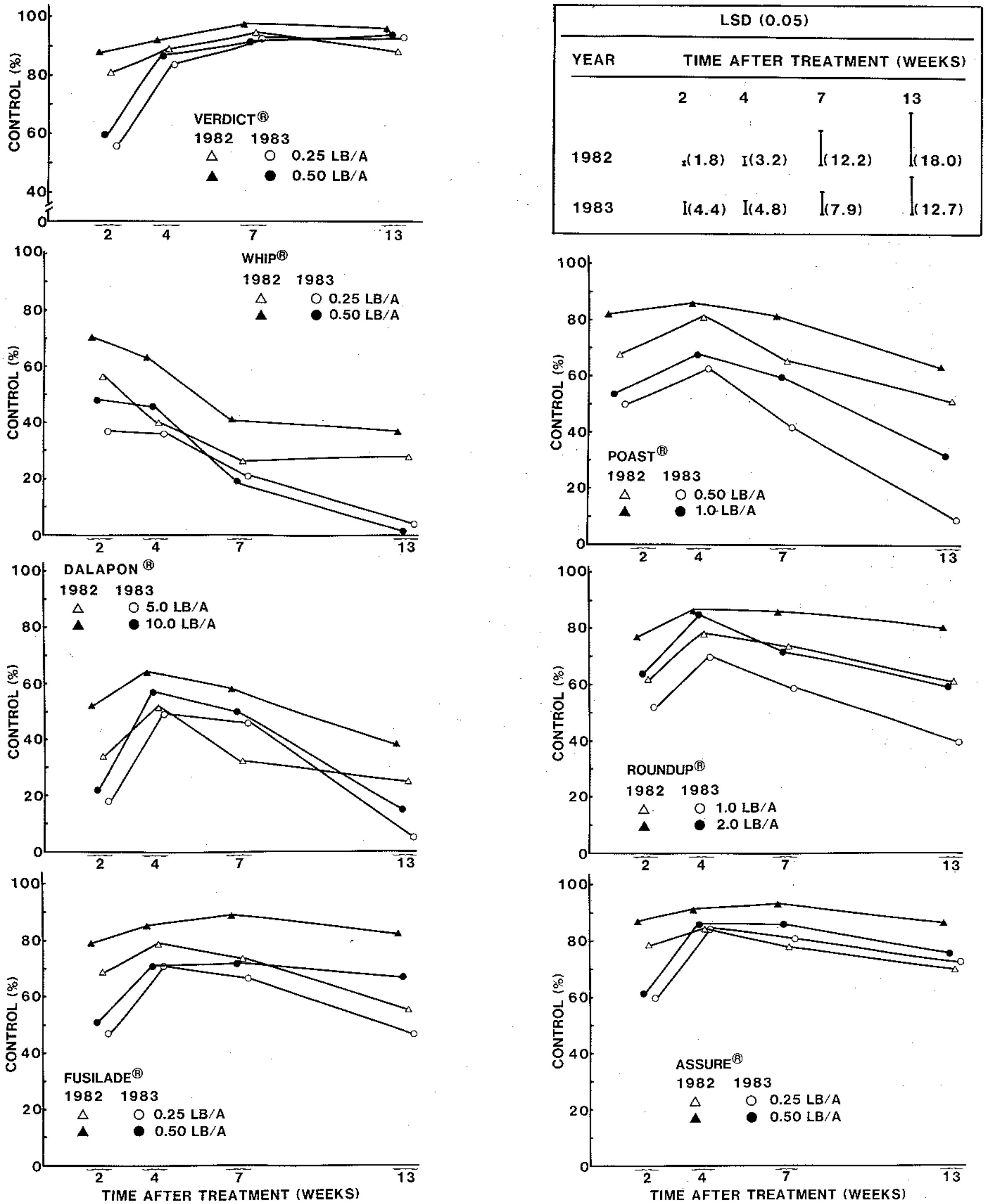
Acknowledgments

Appreciation is extended to J. M. Chandler, Agronomist, for the collection of these bermudagrass biotypes, to Terry E. Newton, Research Technician, for the excellent assistance and sincere interest in this study; to Debbie Boykin, Statistician, who added valuable assistance in data analysis; and to Lisa Kent, Research Technician, for graphics preparation.

Table 3. Comparative percent control of bermudagrass biotypes 7 weeks after treatment in 1983[1].

	Herbicide (lb ai/acre)						
Bermudagrass Biotype	**Poast® (0.5)**	**Fusilade® (0.25)**	**Verdict® (0.25)**	**Assure® (0.25)**	**Roundup® (1.0)**	**Whip® (0.25)**	**Dalapon® (5.0)**
A	53 a-c	78 a	93 a-c	89 a-b	47 b	22 a-c	37 c-e
B	33 de	68 ab	93 a-c	62 c	40 b	15 bc	45 a-d
C	43 b-d	87 a	92 a-c	62 c	68 a	28 ab	50 a-c
D	33 de	62 ab	95 a-c	91 a	70 a	28 ab	38 b-e
E	65 a	88 a	93 a-c	88 ab	73 a	30 ab	35 de
F	52 a-c	60 ab	87 c	94 a	47 b	23 a-c	33 de
G	48 bc	57 ab	94 a-c	88 ab	65 a	27 a-c	30 e
H	40 cd	60 ab	88 bc	78 a-c	52 b	15 bc	45 a-d
I	40 cd	88 a	99 a	88 ab	63 a	35 a	37 c-e
J	57 ab	68 ab	96 ab	93 a	70 a	20 a-c	38 b-e
K	43 b-d	32 d	96 ab	57 c	47 b	13 bc	37 c-e
L	18 f	60 a-c	91 a-c	73 bc	50 b	17 a-c	55 a
M	52 a-c	86 a	94 a-c	75 a-c	63 a	18 a-c	53 a
N	53 a-c	70 ab	94 a-c	92 a	55 a	13 bc	53 a
O	33 de	68 ab	92 a-c	94 a	73 a	28 ab	47 a-d
P	22 ef	60 a-c	96 ab	98 a	63 a	12 bc	52 ab
Q	25 ef	45 c	92 a-c	62 c	63 a	8 c	47 a-d
Mean	42	67	93	81	59	21	46
Range	65-18	88-32	99-87	98-57	73-40	38-8	55-30

[1]Numbers within columns followed by the same letter are not significantly different according to Duncan's multiple range test at the 0.05 level. The LSD for comparing numbers within columns is 19; the C.V.% is 19.



LSD (0.05)

YEAR	TIME AFTER TREATMENT (WEEKS)			
	2	4	7	13
1982	(1.8)	(3.2)	(12.2)	(18.0)
1983	(4.4)	(4.8)	(7.9)	(12.7)

Figure 1. Effects of herbicides on bermudagrass at 2, 4, 7, and 13 weeks after treatment. Data are mean percent control averaged across 17 biotypes. LSD values for each year are over seven herbicides at both rates.

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