HERBICIDE EVALUATION FOR THE SELECTIVE CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF

By

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CONTROL OF ANNUAL BLUEGRASS IN
BERMUDAGRASS TURF

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CHAPTER I

INTRODUCTION

Annual bluegrass (Poa annua L.) is a widely distributed weed grass, found in nearly all parts of the world, and it is particularly common in lawns, golf courses, and other turfgrass areas. It is classified as a winter annual and will germinate in Oklahoma from early fall to late spring when the temperatures reach 40-50°F. Generally, it persists until the days become hot, and moisture becomes limiting. However, this is not always the case in Oklahoma, especially on golf course putting greens. Frequent watering appears to encourage annual bluegrass germination and persistence until the temperatures become extremely high.

Annual bluegrass is a prolific seed producer and can produce seed in greens under putting green heights' of clip. It detracts from the beauty and quality of the turf because of its scattered distribution and ragged appearance. Therefore, annual bluegrass is probably the most serious weed in high quality putting green turf.

The purpose of this study is to determine the proper time of application of several pre-emergence herbicides and to evaluate their effectiveness on the control of annual bluegrass in bermudagrass (Cynodon L. Rich.) fairways. Many of the herbicides that are recommended for use on bermudagrass turf are not released for use on bentgrasses (Agrostis spp. L.), which is the major turfgrass used in Oklahoma putting greens. As a result, if annual bluegrass cannot be eradicated from the fairways, it is difficult to keep the greens free from infestation. The infestation is also increased by a constant supply of viable seed from the fairways, which is transported to the greens primarily on the golfers' shoes, clubs, clothing, and carts.

CHAPTER II

LITERATURE REVIEW

Literature concerning the pre-emergence control of annual bluegrass in bermudagrass turf is limited. Daniel (4) reported excellent control of annual bluegrass with lead arsenate in bentgrass turf, especially when soil phosphorus was not high. Yearly applications of lead arsenate greatly reduced the population of annual bluegrass in bentgrass turf; however, toxic levels may accumulate with repeated applications at high rates, according to Sprague (7).

Youngner (8) stated that chemical control of annual bluegrass is seldom completely successful, which may be the result of poor timing of herbicide application. The herbicide must be in the soil at the time of seed germination for adequate control. However, if the germination period is over an extended period of time, retreatments may be required to maintain a toxic herbicide level throughout the germination period. Youngner (9) later indicated that two bensulide applications gave better control of annual bluegrass than one application; however, three applications were not significantly different than two applications. Previous studies by Goss (5) indicated that DCPA at 11.2 kg.a.i. (active ingredient)/ha. gave significant pre-emergence control of annual bluegrass from an October application. Injury to bentgrass was observed by Cornman (3) with DCPA; however, no visible injury was observed with bensulide at 11.2, 22.4, and 33.6 kg.a.i./ha.

Limpel, Schauldt, and Lamont (6) indicated that DAC-893 (dimethyl-2,3,5,6-tetrachloroterephthalate) gave moderate control of annual bluegrass while Chappel and Schmidt (2) obtained only moderate control with DCPA, but 11.2 kg.a.i./ha. gave better control than 22.4 or 33.6 kg.a.i./ha.

Goss (5) found that DCPA at 11.2 kg.a.i./ha., bensulide at 16.8, and diphenamid at 4.5 kg.a.i./ha. all demonstrated highly significant pre-emergence control of annual bluegrass. Bensulide retained good residual activity at the end of twelve weeks, but diphenamid and DCPA indicated considerable breakdown.

Studies by Bingham and Schmidt (1) indicated that the granular formulation of bensulide has a longer residual activity than the emulsifiable concentrate formulation. Large amounts of granular bensulide were found in the soil up to a depth of 12.75 cm. eleven months after the fourth annual application while detectable quantities of the liquid formulation did not persist.

CHAPTER III

METHODS AND MATERIALS

In August, 1968, a study was initiated at the Twin Hills Golf and Country Club in Oklahoma City to evaluate the use of five pre-emergence herbicides on the control of annual bluegrass (_Poa annua_ L.) in common bermudagrass (_Cynodon dactylon_ (L.) Pers.) turf.

The study consisted of two experiments. The first comprised three tests each having a randomized block design with three replications. Each test had fourteen treatments and an untreated check. The plots were 2.74 m. by 2.74 m. (9 ft. by 9 ft.) in size. The difference among the three tests was the application dates, which were: Test 1 - August 21, Test 2 - September 27, and Test 3 - October 30, 1968. The second experiment was a continuation of the first, which consisted of re-treating one-third of each initial plot on two dates. This made a split plot design with a subplot size of 2.51 sq. m. (9 ft. by 3 ft.) having retreatments, respectively, February 4 and 25, 1969, on two of the three subplots. One-third of each plot was not retreated so that a measure of the residual effects from the initial application could be obtained. The herbicides, chemical names, formulations, and the rates expressed as kilograms of active ingredients (a.i.) per hectare and per acre used in this study are shown in Table I. The cost per hectare and per acre for each treatment, based on current retail costs of small lots, is shown in Table II.

TABLE I

HERBICIDES, CHEMICAL NAMES, FORMULATIONS, AND RATES USED FOR THE CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF

Herbicide	Chemical Name	Formulation*	Application Rates kg.a.i./ha.	Application Rates lb.a.i./a.
Bensulide	N-(2-mercaptoethyl) benzenesulfonamide	L, G	14.0, 16.8, 22.4	12.5, 15.0, 20.0
DCPA	Dimethyl 2,3,5,6-tetrachloroterephthalate	WP	11.2, 16.8	10.0, 15.0
Benefin	N-butyl-N-ethyl-α,α,α-trifluro-2,6-dinitro-p-toluidine	G	4.5, 5.6	4.0, 5.0
Diphenamid	N,N-dimethyl-2,2-diphenylacetamide	WP	4.5, 5.6	4.0, 5.0
Sirmate	3,4-dichlorobenzyl methylcarbamate	L	8.9, 11.2	8.0, 10.0

*L - Liquid; WP - Wettable Powder; G - Granular

TABLE II

HERBICIDES, RATES, AND RETAIL COST USED IN THE CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF

Herbicide	Application Rates			
	kg.a.i./ha.	lb.a.i./a.	Cost/ha.	Cost/a.*
Bensulide (L)	14.0	12.5	$234.13	$ 94.79
Bensulide (L)	16.8	15.0	277.88	112.50
Bensulide (L)	22.4	20.0	370.50	150.00
Bensulide (G)	14.0	12.5	234.13	94.79
Bensulide (G)	16.8	15.0	277.88	112.50
Bensulide (G)	22.4	20.0	370.50	150.00
DCPA	11.2	10.0	38.40	15.55
DCPA	16.8	15.0	57.77	23.39
Benefin	4.5	4.0	98.77	39.99
Benefin	5.6	5.0	123.50	50.00
Diphenamid	4.5	4.0	49.17	19.91
Diphenamid	5.6	5.0	61.47	24.89
Sirmate	8.9	8.0	No price available	
Sirmate	11.2	10.0	No price available	

*Cost is based on current retail prices of small lots.

The liquids and wettable powders, which were sprayed uniformly over each plot, were applied with a two-gallon, hand operated, pressure sprayer containing 0.9463 liters (1 quart) total volume. The granular herbicides were applied with a commercial spreader equipped with a speedometer which was calibrated to discharge the desired rate at 2 m.p.h. After each application the test area was watered with the fairway irrigation system to move the herbicides down to the soil surface. Care was exercised not to water to the point of run-off to prevent contamination of adjacent plots. In the second experiment only the retreated plots were watered rather than the entire test area. The liquids and wettable powders were applied in 0.9463 liters (1 quart) of water/2.51 sq. m. (27 sq. ft.), and the granular treated plots were sprayed with 0.9463 liters of water after retreatment. The 0.9463 liters of water per 2.51 sq. m., which is approximately equal to 37.40 hectoliters/ha. (400 gal./acre), was considered sufficient to move the herbicides through the vegetative material to the soil surface.

The plots were scored on a 0 to 10 scale where 0 indicates no control, and 10 represents complete control of annual bluegrass. The plots were evaluated on November 27, 1968, February 5, and April 1, 1969, with each plot being evaluated by at least two on each date.

CHAPTER IV

RESULTS AND DISCUSSION

The statistical analyses of the data obtained in this study clearly indicates that the effectiveness of these pre-emergence herbicides for the control of annual bluegrass is related to the time of application. Figures 1, 2, and 3 represent the mean control of each treatment for each application date when evaluated on November 27, 1968, February 5, and April 1, 1969, respectively. Data for these figures are presented in Tables V, VI, and VII in the Appendix. The means of Figure 3, which is one-third of the original plot, represent a measure of the residual activity remaining from the initial application.

The combined analysis of variance of the three application dates for both the November 27 and February 5 evaluations resulted in a significant difference among tests, treatments, test x treatment interaction, and evaluation dates. Consequently, each test on each evaluation date was analyzed individually. The analyses of variance are shown in Table III.

Bensulide (L) and bensulide (G) at 22.4 kg.a.i./ha. were signficantly different from all other treatments in the August application, giving 97 and 98% control, respectively. All treatments suppressed at least 92% of annual bluegrass germination except diphenamid and sirmate, whose control ranged from 61 to 73%, as shown in Figure 1. Benefin exhibited control comparable to both bensulide formulations at 22.4

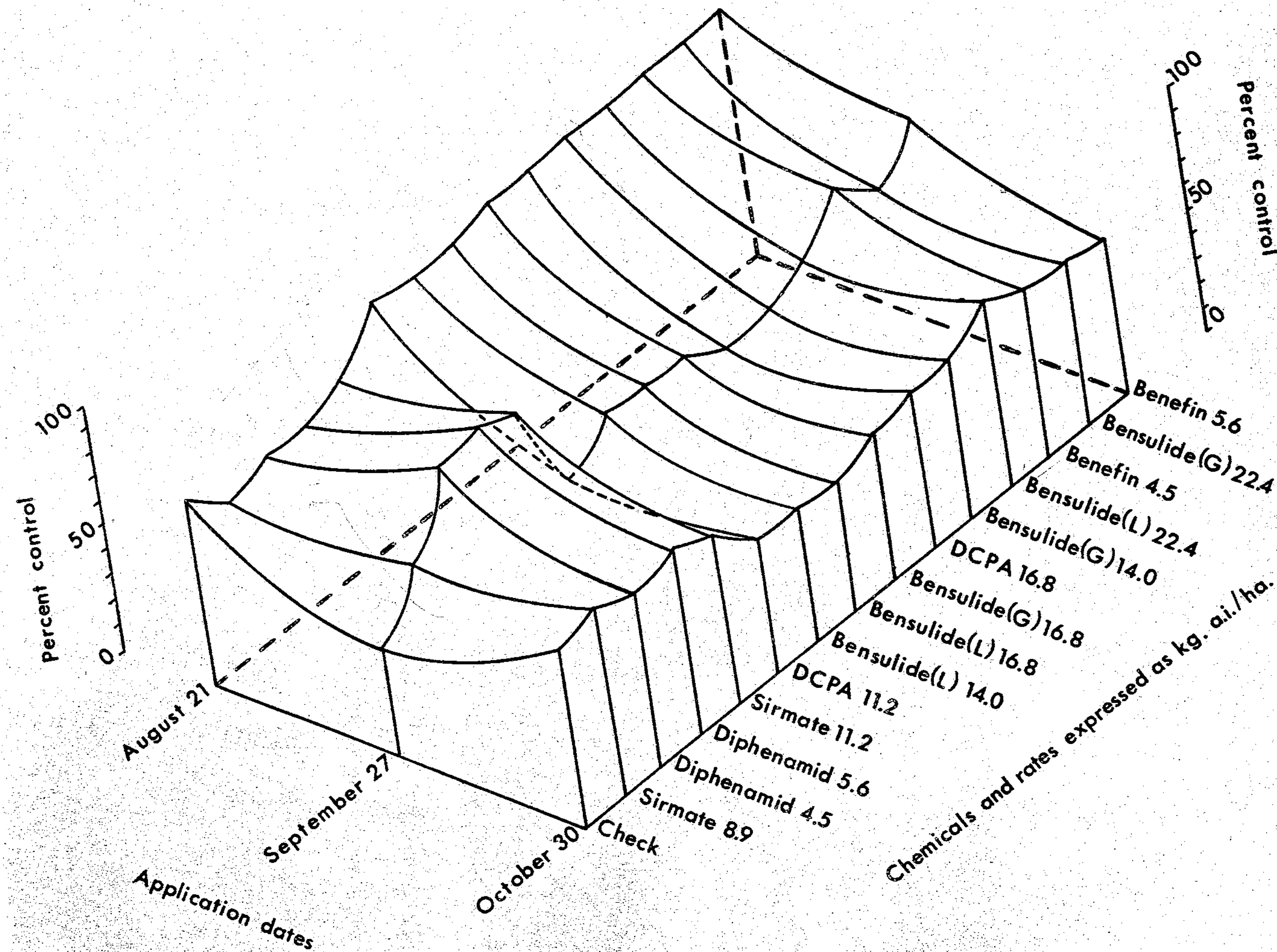

Figure 1. Effect of 14 Herbicides Applied at 3 Different Dates on the Control of Annual Bluegrass (*Poa annua* L.) When Evaluated November 27, 1968

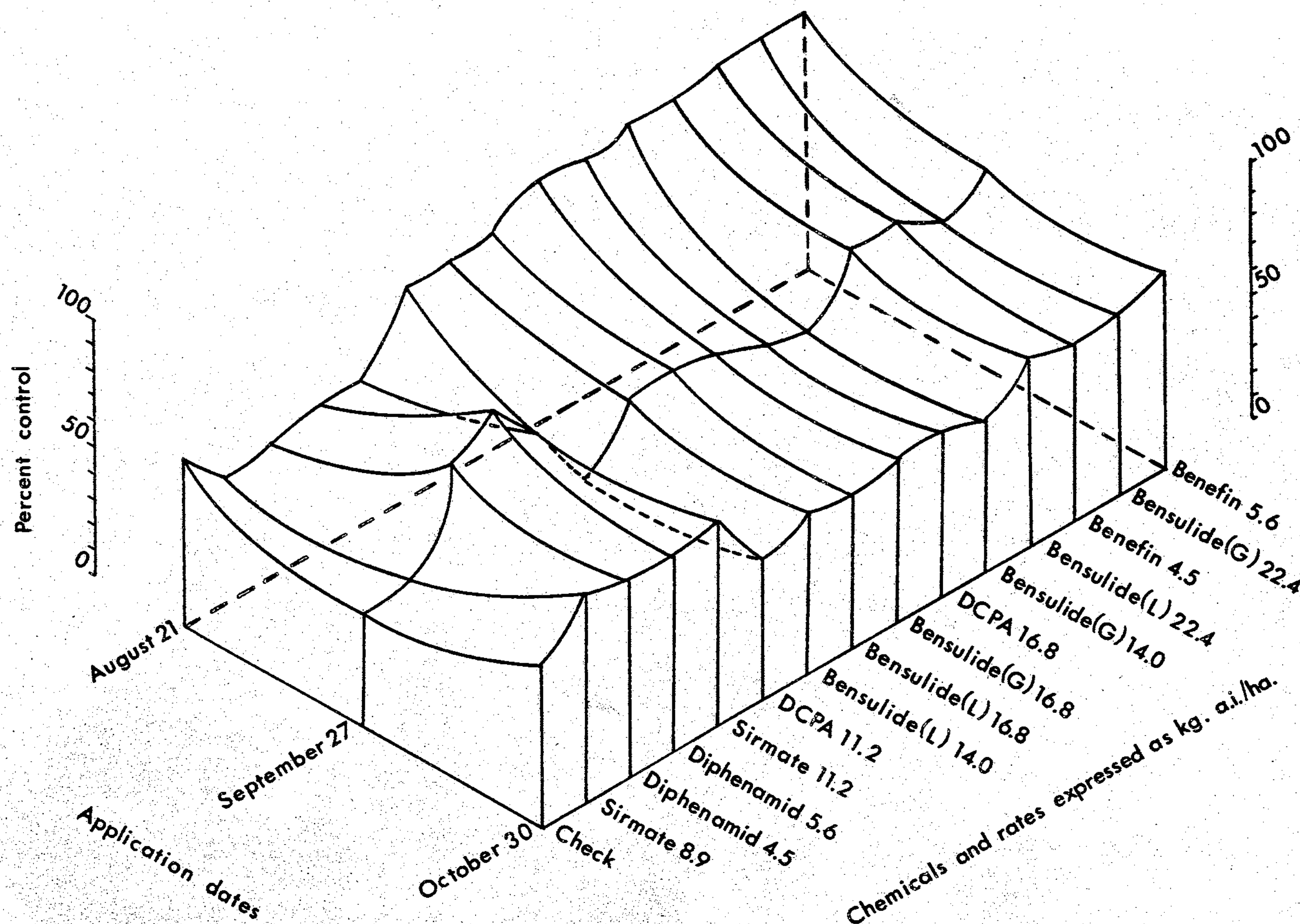

Figure 2. Effect of 14 Herbicides Applied at 3 Different Dates on the Control of Annual Bluegrass (*Poa annua* L.) When Evaluated February 5, 1969

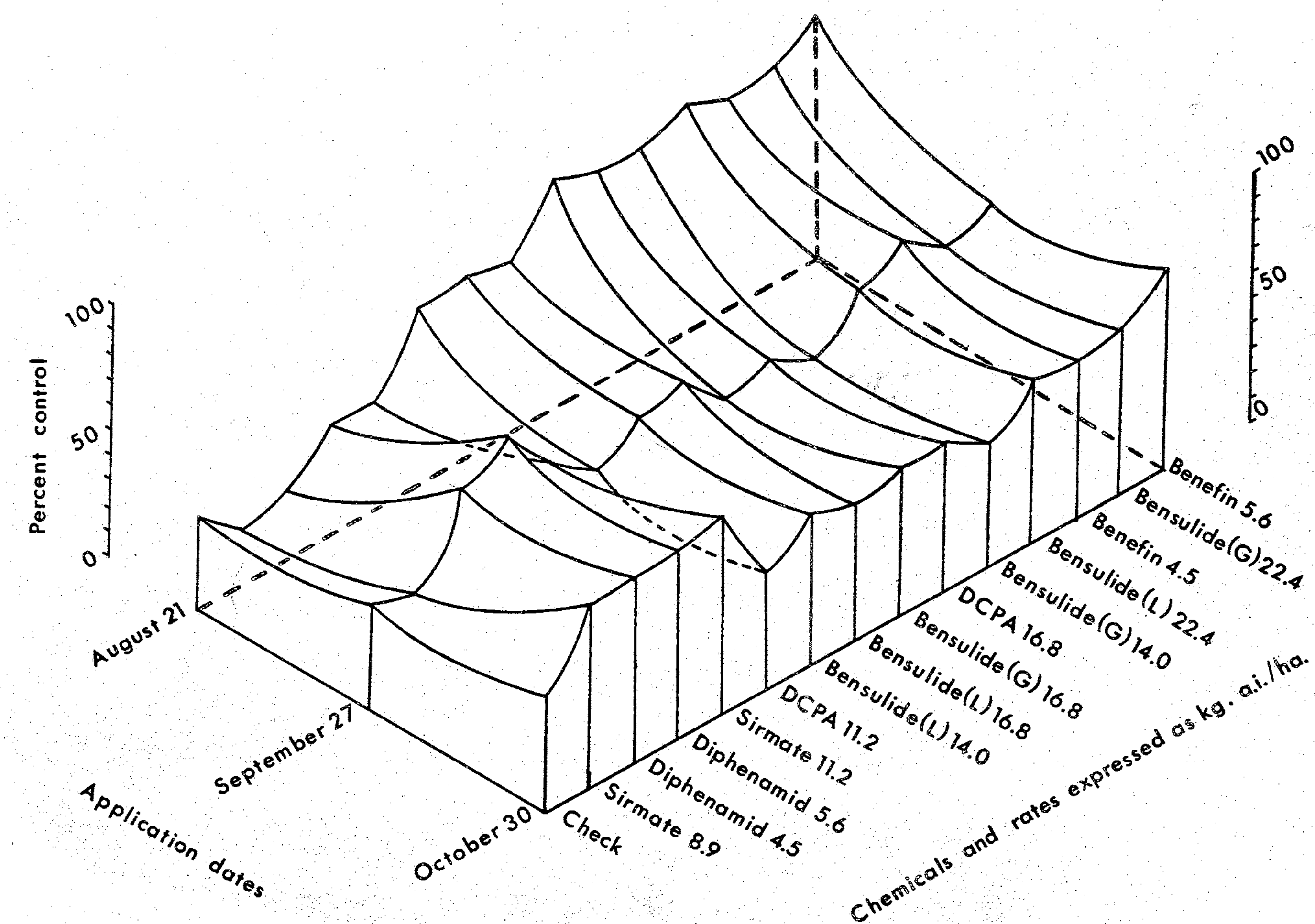

Figure 3. Effect of 14 Herbicides Applied at 3 Different Dates on the Control of Annual Bluegrass (Poa annua L.) When Evaluated April 1, 1969

TABLE III

ANALYSES OF VARIANCE MEAN SQUARES FOR THE CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF FOR THREE APPLICATION DATES BASED ON VISUAL OBSERVATIONS IN NOVEMBER, FEBRUARY, AND APRIL

		Application Dates								
		August 21			September 27			October 30		
		Evaluation Dates								
		Nov. 27	Feb. 5	Apr. 1	Nov. 27	Feb. 5	Apr. 1	Nov. 27	Feb. 5	Apr. 1
Source	df	Mean Squares								
Reps	2	3.93	18.46**	26.97*	0.94	23.21**	10.19	25.34**	23.40**	54.21**
Treatments	14	10.54**	19.68**	79.94**	15.85**	11.40**	16.75*	4.45	5.88**	16.82**
Error	28	1.43	2.57	5.13	4.55	3.93	8.22	3.03	2.01	4.63

*, **Significant at the 0.05 and 0.01 levels of probability, respectively

kg.a.i./ha. with benefin at 5.6 kg.a.i./ha. giving the highest control (99%), and benefin at 4.5 kg.a.i./ha. was exceeded only by bensulide (G) at 22.4 kg.a.i./ha. DCPA at 16.8 kg.a.i./ha. gave excellent control (97%) of annual bluegrass while the 11.2 kg.a.i./ha. rate gave only 92% control of annual bluegrass.

The poor results obtained from diphenamid can partially be explained by previous studies which indicates that the effectiveness of diphenamid is greatly reduced by leaching in irrigated land. Golf course fairways are commonly irrigated, and it is possible that the herbicide was leached from the germination zone prior to germination.

Data from the September application of herbicides was quite different from the preceding application. Most of the herbicides that were effective in the August application did not give adequate control when applied in September, as shown in Figure 1. Diphenamid at 4.5 and 5.6 kg.a.i./ha. were the only treatments that gave acceptable control. The 5.6 kg.a.i./ha. rate yielded 98% control while the 4.5 kg.a.i./ha. rate gave 94% control.

One explanation of these results is that diphenamid has shown both pre- and post-emergence properties. At the time of each application, a search was conducted on the test area for annual bluegrass germination. No germination was observed in August, but in September a few plants were found around irrigation heads where moisture is plentiful. Therefore, it is probable that annual bluegrass had already germinated in the test area, and it was overlooked since the plants were small and inconspicuous in the bermudagrass thatch. If this is the case, the control obtained by diphenamid could be a combination of both pre- and post-emergence effects, and this would explain the poor results obtained by the other pre-emergence herbicides that possess no, or only slight post-emergence properties.

All treatments when applied in October gave poor control of annual bluegrass. As stated earlier, annual bluegrass had already germinated at the time of application; therefore, it is obvious that a pre-emergence application would be unsuccessful. However, the post-emergence effects of diphenamid were not observed which could be attributed to unfavorable weather conditions which could prohibit the uptake of the herbicide, or the advanced stage of growth of the *Poa annua* plants which reduced the effectiveness of the post-emergence activity of the herbicide.

The herbicides' phytotoxicity to bermudagrass was also recorded after each application. Sirmate at both rates severely burned the bermudagrass a few hours after both the August and September applications, and the burn persisted for about one week. There was very little phytotoxicity from the October application.

The results obtained from the February 5 evaluation followed the same general pattern as the preceding. Benefin at 4.5 and 5.6 kg.a.i./ha., bensulide (G) at 16.8 and 22.4 kg.a.i./ha., bensulide (L) at 22.4 kg.a.i./ha., and DCPA at 16.8 kg.a.i./ha. still gave excellent control of annual bluegrass from the August application. As shown in Figure 2, the effectiveness of the lower rates of these herbicides is beginning to disappear which indicates that these rates are not sufficient to maintain a toxic level for long term control without a supplemental application.

Diphenamid at 5.6 kg.a.i./ha. again proved to be the most effective treatment from the September application, giving 94% control. The

4.5 kg.a.i./ha. rate gave only 83% control, which indicates that this rate is not sufficient to check the continuous germination of annual bluegrass throughout the fall and winter months.

A significant difference among treatments was obtained from the October application. Sirmate at 8.9 and 11.2 kg.a.i./ha. gave the best control; however, a previous study indicated that sirmate had strong post-emergence properties. It is believed that the control is due to post-emergence effects since annual bluegrass had already germinated.

The analysis of variance for the residual activity remaining on April 1 from the initial application showed a significant difference among treatments for all application dates. Benefin at 5.6 kg.a.i./ha., bensulide (G) at 16.8 kg.a.i./ha., and bensulide (L) at 22.4 kg.a.i./ha., which gave 97, 93, and 92% control respectively, were the only treatments that effectively controlled annual bluegrass throughout the test period from the August application, as shown in Figure 3.

These results also indicate that the granular formulation of bensulide has a greater residual activity than the liquid formulation. This is perhaps due to slower breakdown and release into the soil. It appears that comparable control can be obtained with bensulide (G) at 16.8 kg.a.i./ha. as compared to bensulide (L) at 22.4 kg.a.i./ha.

Annual bluegrass was not effectively controlled in either the September or October applications. Diphenamid at 5.6 kg.a.i./ha. gave the best control of 80% in the September application, but the remaining treatments ranged from 37 to 75% control, as shown in Figure 3.

The combined mean control averaged over each replication of each application date was 77, 66, and 77%, respectively. The lower control in the second replication could be due to the design of the fairway irrigation system. For complete coverage the sprinklers must overlap, and in this particular fairway the sprinklers overlapped in the second replication. Therefore, the lower control could be attributed to accelerated leaching of the herbicides from the soil because of the greater quantity of water received.

The second part of the study, which consisted of retreating one-third of each plot on two dates, showed a significant difference among treatments in the split plot analysis. The analyses of variance are shown in Table IV. The statistical difference is the sirmate treatments which were showing definite post-emergence activity. At the time of the February 25 retreatment, the sirmate plots that were retreated on February 4 were showing strong contact effects. No other post-emergence activity was observed. At the April 1 evaluation, all the sirmate plots were severely burnt, but all the annual bluegrass was not dead. The sirmate plots also appeared to green slower than the other plots later in the spring.

These results indicate that the retreatments should have been made sometime between November and February because it was during this period that the effectiveness of the initial application was beginning to disappear. It is also possible that if an earlier retreatment is made, a reduced rate rather than the full rate might be sufficient to provide adequate control.

TABLE IV

ANALYSES OF VARIANCE MEAN SQUARES FOR THE CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF FOR THREE APPLICATION DATES BASED ON VISUAL OBSERVATIONS ON APRIL 1, 1969

Source	df	Application Dates		
		August 21	September 27	October 30
		Mean Squares		
Reps	2	44.33**	20.82	84.19**
Treatments	14	74.09**	30.03*	22.63**
Error (a)	28	5.67	12.74	5.84
Retreatment	2	14.47**	5.87**	.46
T x R	28	2.92**	2.03*	1.42
Error (b)	60	1.16	1.12	.89

*, **Significant at the 0.05 and 0.01 levels of probability, respectively

CHAPTER V

SUMMARY AND CONCLUSIONS

In August, 1968, a study was initiated to determine the proper time of application of several pre-emergence herbicides and to evaluate their effectiveness on the control of annual bluegrass in bermudagrass turf. It is concluded that benefin at 5.6 kg.a.i./ha., bensulide (G) at 16.8 kg.a.i./ha., and bensulide (L) at 22.4 kg.a.i./ha. applied in late August is satisfactory for an 8 month period in the control of annual bluegrass in bermudagrass turf. It is also concluded that DCPA at 16.8 kg.a.i./ha. applied in late August will provide excellent control of *Poa annua* for 3 months without a retreatment. However, the other herbicides should not be eliminated because with proper retreatment they might also provide adequate control.

The results indicate also that early spring is not the proper time for effective retreatment of DCPA at either rate and the lower rates of the other herbicides. The residual effects of these herbicides is not long enough to suppress the continuous germination throughout the winter months from a late August application.

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APPENDIX

TABLE V

THE PERCENT CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF FOR EACH APPLICATION DATE AS DETERMINED ON NOVEMBER 27, 1968

Herbicide	Rate of Application		Application Dates		
	kg.a.i./ha.	lb.a.i./a.	Aug. 21	Sept. 27	Oct. 30
Bensulide (L)	14.0	12.5	92.6	65.8	55.0
Bensulide (L)	16.8	15.0	93.0	62.5	52.5
Bensulide (L)	22.4	20.0	97.3	63.3	78.3
Bensulide (G)	14.0	12.5	97.8	58.3	65.0
Bensulide (G)	16.8	15.0	96.3	62.5	60.0
Bensulide (G)	22.4	20.0	98.5	67.5	67.5
DCPA	11.2	10.0	92.3	50.0	54.1
DCPA	16.8	15.0	97.3	51.6	65.8
Benefin	4.5	4.0	97.8	80.8	69.1
Benefin	5.6	5.0	99.0	82.8	63.3
Diphenamid	4.5	4.0	69.1	93.5	70.8
Diphenamid	5.6	5.0	69.1	98.6	77.8
Sirmate	8.9	8.0	61.6	68.3	79.1
Sirmate	11.2	10.0	73.3	89.1	70.0
Check	-	-	77.5	45.0	72.5

TABLE VI

THE PERCENT CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF FOR EACH APPLICATION DATE AS DETERMINED ON FEBRUARY 5, 1969

Herbicide	Rate of Application		Application Dates		
	kg.a.i./ha.	lb.a.i./a.	Aug. 21	Sept. 27	Oct. 30
Bensulide (L)	14.0	12.5	82.3	69.1	64.1
Bensulide (L)	16.8	15.0	83.8	70.0	60.8
Bensulide (L)	22.4	20.0	94.1	77.1	75.3
Bensulide (G)	14.0	12.5	94.3	55.8	60.8
Bensulide (G)	16.8	15.0	95.3	65.0	65.8
Bensulide (G)	22.4	20.0	96.5	68.3	72.8
DCPA	11.2	10.0	81.6	48.3	55.0
DCPA	16.8	15.0	91.1	60.8	65.0
Benefin	4.5	4.0	96.0	78.3	70.8
Benefin	5.6	5.0	97.5	77.5	78.3
Diphenamid	4.5	4.0	51.6	83.3	80.1
Diphenamid	5.6	5.0	57.5	94.1	81.0
Sirmate	8.9	8.0	49.1	49.1	82.3
Sirmate	11.2	10.0	57.5	75.0	83.3
Check	-	-	65.8	46.6	64.1

TABLE VII

THE PERCENT CONTROL OF ANNUAL BLUEGRASS IN BERMUDAGRASS TURF FOR EACH APPLICATION DATE AS DETERMINED ON APRIL 1, 1969

Herbicide	Rate of Application		Application Dates		
	kg.a.i./ha.	lb.a.i./a.	Aug. 21	Sept. 27	Oct. 30
Bensulide (L)	14.0	12.5	74.1	59.1	63.3
Bensulide (L)	16.8	15.0	70.8	62.5	55.0
Bensulide (L)	22.4	20.0	92.0	59.1	64.1
Bensulide (G)	14.0	12.5	84.8	43.3	50.8
Bensulide (G)	16.8	15.0	93.0	45.8	60.0
Bensulide (G)	22.4	20.0	88.8	58.3	65.0
DCPA	11.2	10.0	71.6	47.5	47.5
DCPA	16.8	15.0	85.6	52.5	60.8
Benefin	4.5	4.0	84.1	70.0	63.3
Benefin	5.6	5.0	97.0	65.0	80.8
Diphenamid	4.5	4.0	27.5	69.1	75.0
Diphenamid	5.6	5.0	44.1	80.0	75.0
Sirmate	8.9	8.0	21.6	37.5	73.3
Sirmate	11.2	10.0	42.5	60.0	87.5
Check	-	-	37.5	43.3	48.3

VITA

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