TURF RETARDATION AND WEED CONTROL IN COMMON KENTUCKY BLUEGRASS BY CGA-17020 AND CGA-24705

BY

SANDRA L. HOWELL

B.S., University of Arkansas at Little Rock, 1967

B.S., University of Arkansas at Little Rock, 1968

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture and Forestry

Kansas State University

Manhattan, Kansas

1976

Approved by:

Charles E. Long

Major professor

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I would like to thank Ciba-Geigy Corporation for furnishing chemicals and contributing to the expense of this research.

To the members of my committee, Dr. Jim Greig, Dr. Stan Ehler, Dr. Ron Campbell, and especially Dr. Charles Long, who served as my major professor, I would like to express my sincere appreciation.

I am especially grateful to my family, Bill, my husband, and my daughters, Hilary and Elizabeth, for their constant support and for their many sacrifices.

LIST OF FIGURES AND TABLES

INTRODUCTION

In Kansas there are approximately 750,000 acres of turfgrass that require periodic mowing. The cost of mowing in terms of labor and energy supply is an important reason for reducing the necessity of this operation. One approach to decreasing the need to mow is the use of turfgrass growth retarding chemicals. Turf retardation can not only reduce the cost of mowing but can also reduce the need for water and fertilizer (14).

Earlier studies in turf growth regulation have shown that proper timing of application is important to the response of the turf (3,7,8, 12). Sachs and Hackett (20) point out that the best time of application will depend on the compound and its immediate and continuing effects on the treated species.

Undesirable side effects from the use of turf retardants have been observed (2,8,9,10,11,12,17,18,19). Some of these effects include discoloration, burning, reduced ability to recover from wear and tear, and increased insect and disease infestation. Thinning of the turf, which may be a phytotoxic reaction to some turf retardants, is not only an undesirable side effect but is related to the invasion of weeds (7,8, 12,19).

Several chemicals have been tested for turf retardation but none have gained widespread use either because of unpredictable results or excessive phytotoxic effects. The search for an acceptable turf retardant continues with research on experimental chemicals. A study of two such chemicals, CGA-17020 and CGA-24705, herbicides with turf retarding potential, was undertaken with the following objectives:

1) to evaluate the effectiveness of CGA-17020 and CGA-24705 as turf retardants when applied at four different dates to previously untreated common Kentucky bluegrass (*Poa pratensis* L.),

2) to assess phytotoxic effects in terms of density reduction,

3) to rate the effect on seedhead production and

4) to determine the effects on weed populations.

MATERIALS AND METHODS

The herbicides, CGA-17020 (chemistry not released) and CGA-24705 [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methyl) acetamide] (Trade name Dual) have demonstrated activity in inhibition of turf growth (5,6). Both chemicals control a number of annual grasses including crabgrass (*Digitaria* spp), goosegrass (*Eleusine* spp), barnyardgrass(*Echinochola* spp), and foxtail (*Setaria* spp) (5,6). Broadleaf weeds controlled include pigweed (*Amaranthus* spp) and knotweed (*Polygonum* spp) (5,6). The combination of herbicidal activity and turf growth regulation could make chemical mowing more feasible.

All experiments were conducted at the Rocky Ford Turf Experiment Field, Manhattan, Kansas, in an established field of common Kentucky bluegrass on Chase silty clay loam. Predominant weeds were dandelion and crabgrass. A higher than average rainfall recorded in the spring was followed by a long dry period during which the plots were not irrigated. Treatment dates and stages of grass growth are presented in Table 1.

Five percent granular formulationa of CGA-17020 and CGA-24705 were applied by a gravity flow spreader at the rates of 0, 2.75, 5.5, and 8.25 kg/ha. A separate application of fertilizer at the rate of 0.4 kg N/100m^2 was made the same day.

Each test was designed as a randomized complete block with three replications. Plot size was 1.8 m by 2.1 m. Height of treated plots was compared to the height in the non-treated plots and reported as percent height suppression. Density ratings were visually estimated on a scale of 0 to 10 (0 = no grass growing and 10 = most dense) based on a comparison to the untreated plots. Visual rating of seedhead production as compared to the control was based on a scale of 0 to 10 (0 = no seedheads and 10 = most seedheads). Weed infestation ratings were estimated visually on a scale of 0 for no weed infestation to 10 for complete weed infestation. Weed species were counted in a 625 cm^2 area in each plot. Data for each sampling was analyzed separately and treatment means compared using the Duncan's New Multiple Range Test.

Test I. Chemicals were applied on April 16, 1975, just prior to breaking of spring dormancy. Soil moisture was adequate and weather conditions were sunny and clear with a temperature of 22-25 ^{o}C. Height measurements and density ratings were made at 13, 26, 47, and 66 days after application. A rating of seedhead production was made after 26 days. Forty-eight days after application all plots were mowed to a height of 6 cm and clippings collected for dry weight comparisons. Mowing was repeated at 57 days. Ninety-nine days after application weeds were counted in all plots.

Test II. Plots were cut for the first time to a height of 6 cm just prior to application of materials on May 8, 1975. The grass was fully green, about 10 cm tall, and actively growing. The temperature was approximately 28 ^{o}C and the weather was sunny and clear. Soil moisture was adequate. Height was measured 13, 25, 44, and 69 days after application. Density ratings were made on the same days with a final rating 97 days after treatment. Seedhead production was rated at 25 days and clippings were collected at 26 and 35 days. A weed count was conducted 127 days after treatment.

Test III. After several earlier mowings, test plots were cut to a height of 6 cm and treated on May 27, 1975. The weather was clear with a slight wind and a temperature of about 20°C. Soil moisture was still adequate from earlier spring rains. Height was measured and density ratings taken 31, 50, and 78 days after application. The onset of dry weather reduced growth so that mowing was not necessary. Seedheads were not produced. Weed infestations was rated 78 days after application and a weed count was made at 99 days.

Test IV. Application of the chemicals was made on August 27, 1975. The grass was still in summer dormancy and the weather was sunny and dry. The temperature was 30-32 °C. Height and density were rated 14, 34, 48, and 62 days after application. Weed infestation was rated at 48 days. On October 30, a weed count was taken; however, since most of the crabgrass had been killed by low temperatures, those few that were present were included with "other" species.

Table 1. Dates of application of CGA-17020 and CGA-24705 to previously untreated common Kentucky bluegrass.

TITLE	DATE	STAGE OF GROWTH
TEST I	APRIL 16, 1975	BEFORE NEW GROWTH
TEST II	MAY 8, 1975	AFTER FIRST MOWING
TEST III	MAY 26,1975	AFTER SEVERAL MOWINGS
TEST IV	AUGUST 29, 1975	BEFORE BREAKING SUMMER DORMANCY

RESULTS

Effects on Turf

Test I. CGA-17020 and CGA-24705 effectively retarded vertical growth of Kentucky bluegrass for approximately 7 weeks. Maximum percent height suppression was measured 47 days after treatment. The height of the 8.25 kg/ha rate of CGA-24705 treated grass was 80 % less than the height of the untreated grass. The 5.5 and 8.25 kg/ha rates of CGA-17020 suppressed height 65 %. Clippings were collected when the untreated grass averaged 35 cm and treatments averaged 12.2 cm with a range of 6.8 to 18.3. Clipping dry weights reflected significant growth reduction by all treatments 48 days after application. After the second mowing 57 days after treatment, there were no differences in clipping dry weight. Approximately 8 weeks after treatment turfgrass had fully recovered from significant vertical growth retardation as estimated by height measurements and clipping weights.

Maximum percent reduction of density was recorded at 26 days for CGA-17020 and at 47 days for CGA-24705 (Figure 1). Increasing density ratings were observed after these dates. However, as late as 117 days after application the 5.5 and 8.25 kg/ha rates of CGA-24705 still significantly lessened turf density. This continued activity of CGA-24705 as opposed to CGA-17020 is likely due to slower uptake because of its lower water solubility and greater tendency to be absorbed by organic matter and clay (5). CGA-17020 is more easily leached away from the site of uptake.(6).

Both chemicals suppressed seedhead production in Test I (Table 2). CGA-17020 not only effectively reduced numbers but also size since the few seedheads that were produced were no taller than average blade height. Seedheads appeared normal in the CGA-24705 treated plots but were also somewhat diminished in height, especially at the 8.25 kg/ha rate.

Test II. Maximum retardation of turfgrass height in Test II was recorded in the 5.5 and 8.25 kg/ha CGA-17020 treatments 13 days after application. This faster response than seen in Test I was probably due to the higher metabolic rate of the actively growing grass. CGA-24705 treatments showed increasing suppression of % height until mowing at 26 and 35 days. After mowing, the 5.5 and 8.25 kg/ha rates of both CGA-17020 and CGA-24705 continued to suppress growth significantly more than the control but less than previously measured. However, since the maximum retardation of growth by CGA-24705 was usually evident later than that of CGA-17020 it is questionable that CGA-24705 had exerted its maximum effect on height suppression before mowing. Approximately 10 weeks after treatment statistical differences in height were not apparent, but dry weights of clippings showed that only CGA-24705 treatments were still effective 7 weeks after application.

Density was not affected by treatments until 25 days after application when maximum effects of CGA-17020 treatments were recorded. Maximum percent density reduction was seen in CGA-24705 treated plots at 44 days (Figure 1). As late as 14 weeks after application the 8.25 rate of CGA-17020 and all rates of CGA- 24705 continued to be less dense than the untreated control plots.

Seedhead formation was suppressed by both treatments (Table 2). CGA-17020 tended to be more effective in the suppression of both formation and size. Seedheads produced in CGA-24705 treatments were approximately

3 to 7 cm taller than blade height but 4 to 10 cm shorter than the seedheads produced in the untreated control.

Test III. Height reduction in treated plots ranged from 28 to 48 % at 31 days when both chemicals demonstrated maximum activity (Figure 1). Differences between check and treatment grass heights decreased until approximately 11 weeks after treatments when no statistical distinction could be made. Clippings were not collected because of the slow growth of the control plots during the test period. Hot weather and drought stress accounted for the slow growth.

There was no seedhead production in Test III during the course of the test.

Reduction in density exceeded height suppression on a percentage basis. More than 11 weeks after application all treatments continued to show significantly reduced density. A temporary recovery in density reduction was noted 50 days after application following a rain. However, renewed drought stress and probable return of the chemicals via capillary moisture (6) is evidenced by the severely reduced density at 78 days. Since the grass was under severe stress at this time, this extreme activity was probably due to treatment and environmental interactions.

Test IV. The response to treatment in Test IV as measured by percent height reduction was greatest 48 days after application when all treatments were statistically different from the control (Figure 1). Nine weeks from the beginning of the test, CGA-24705 at 8.25 kg/ha continued significant vertical growth retardation. Clippings were not collected due to slow growth. Seedheads were not produced during the test.

Maximum density reduction of 90 % was measured in CGA-24705 treated

Table 2. Suppression of seedhead formation of Kentucky bluegrass by CGA-17020 and CGA-24705 as compared to the untreated control.

Treatment	Rate kg/ha	Days after application Test I 26	Test II 25
Control		9.0[x] a[y]	9.7 a
CGA-17020	2.75	1.0 c	5.3 b
	5.5	1.0 c	4.7 b
	8.25	1.0 c	4.0 b
CGA-24705	2.75	2.3 b	6.0 b
	5.5	3.0 b	5.0 b
	8.25	2.3 b	5.0 b

[x] Rating scale 0 to 10 (0 = total suppression and 10 = no suppression).

[y] Means separated by letters are significantly different by the Duncan's New Multiple Range Test at the 0.05 level.

plots at the 8.25 kg/ha rate 34 days after treatment (Figure 1). By 9 weeks the plots had recovered to a 55 % density reduction as compared to the control. Treatments of CGA-17020 caused 37 to 55 % decrease in density at 34 days but by 62 days there was no difference between these treatments and the untreated control. Casual observation of the test area the following spring revealed no noticeable height retardation, but areas treated with the 5.5 and 8.25 kg/ha rates of CGA-24705 were obviously less dense until late spring.

Effects on Weed Populations

CGA-24705 significantly reduced grass weed infestation (95 % crabgrass) at the 5.5 and 8.25 kg/ha rates in Tests I, II, and III. However, increased broadleaf weed infestations (95 % dandelion) negated any overall effect when total weed populations were considered. Counts showed dandelion populations increased when crabgrass populations were controlled. Decreased density and reduced competition from grass weeds probably accounted for the increased dandelion numbers.

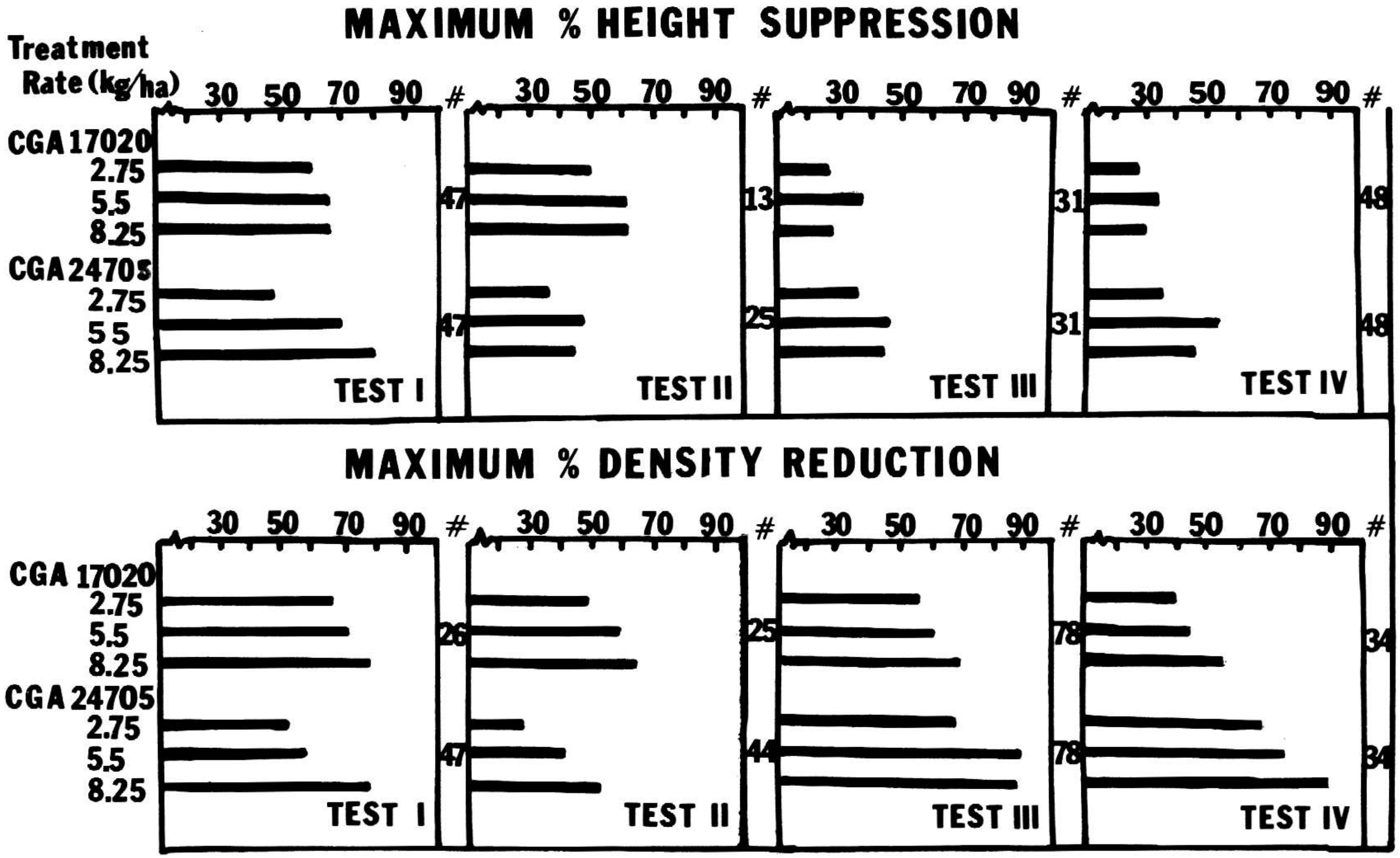
In Test III, all treatments significantly reduced the grass weed infestations, but increased broadleaf infestations were also present. The increased activity of both chemicals, and especially CGA-17020, may be accounted for by the time of application being closer to the actual germination of grass weed seeds. CGA-17020 and CGA-24705 are reported to exert herbicidal effects on germinating seeds (5,6). Lack of activity in Test IV on grass weeds is explained by the application of the materials after germination of the weed seeds had occurred. None of the treatments in Tests I, II, or III significantly affected the total weed numbers as measured by actual count. In Test IV, only the 8.25 kg/ha rate of CGA-

24705 increased weed count significantly.

THIS BOOK CONTAINS NUMEROUS PAGES THAT WERE BOUND WITHOUT PAGE NUMBERS.

THIS IS AS RECEIVED FROM CUSTOMER.

Figure 1. Maximum percent height suppression and maximum percent density reduction of common Kentucky bluegrass by CGA-17020 and CGA-24705 when applied at four different dates.



Days after application

DISCUSSION

Significant retardation of vertical height was found in all tests but it was accompanied by significant reduction of density. Each test date reflected differences in effects of the chemicals that may be related to the stage and rate of growth of the grass at the time of application. In Test I both chemicals seemed to delay dormancy when applied before dormancy was broken. The percentage of density reduction was probably not a measure of phytotoxic effect as much as it was a comparison to the amount of green-up seen in the untreated check. Activity of CGA-24705 lasted for a longer time than that of CGA-17020 and this can be explained by the faster uptake and metabolism of the more water soluble CGA-17020 (6). Also CGA-24705 is less likely to leach through the clay loam soils of Kansas quite as rapidly as CGA-17020 (5).

In Test II faster uptake of CGA- 17020 is observed in terms of the lenght of time to reach maximum percent height suppression and density reduction. Since the grass had already experienced green-up, reduction of density is relatively less than seen in Test I. This is in agreement with several studies that concluded turf retardants are best applied in the spring after the turf has initiated rapid growth (1,4,7,11,12,21).

Test III and IV were conducted when the grass was in a state of semi-dormancy. This is reflected by the slow rate of growth seen in the untreated control and the comparatively smaller percent height suppression. Density was more dramatically affected by CGA-24705 in these tests. This suggests that it should not be used as a turf retardant in the late spring or early fall. Turf retardation by maleic hydrazide (1,2-dihydro-3,6-

pyridazinedione)when applied in the fall was found to be extremely variable but best results were obtained when grass was actively growing in the fall (1,4,7,11,12,13).

The effects on grass in Tests III and IV are similar to grass going into a dormant state. CGA-17020 does not seem to affect the grass to the same degree as CGA-24705 or for as long. Eventual recovery suggests these chemicals not only reduce vertical grass growth but also induce a temporary state of dormancy. Under unfavorable environmental conditions as seen in Tests III and IV the semi-dormant state of the grass probably deepened and extended.

Suppression of seedhead production is a desirable effect of turf retardants and can in itself reduce mowings even though turf retardation is neglibible (1). Both chemicals reduced seedhead numbers but superior seedhead suppression was given by CGA-17020 in an early spring application.

It is apparent there is a close relationship between turfgrass density and weed infestation. Even in low maintenance turf areas where weed control practices are not normally used, weed infestations are controlled to a degree by the denseness of the turf. Clapham et al (7) noted that maleic hydrazide used in turf retardation reduced turf density and that treated plots were more weedy. He indicated that maleic hydrazide improved conditions for weed growth by thinning the turf. Green (15) suggested the use of 2,4-dichlorophenoxyacetic acid for broadleaf weed control in conjunction with maleic hydrazide. However, researchers found increased numbers of grass weeds in areas treated with this combination. (1,7,12,15, 16).

Since both CGA-17020 and CGA-24705 caused significant decreases in density, increases in weed populations would be expected. In Test I and II there are two reasons why the number of weeds in treated plots might not be significant; 1) recovery from earlier grass thinning as seen in CGA-17020 plots which led to greater competition with weeds and 2) preemergent herbicidal activity which controlled weed seed germination even in plots of lower density. In Test III and IV weed growth as well as grass growth was limited by both chemical treatment and environmental conditions. The effectiveness of CGA-24705 in controlling preemergent weeds as well as in retarding turfgrass could possibly be improved by the use of a broadleaf herbicide.

CONCLUSION

Best results were obtained when CGA-17020 and CGA-24705 were applied after the first mowing in the spring. Both chemicals significantly retarded vertical growth of turfgrass and seedhead production. Control of grass weed by CGA-24705 later in the season was an added benefit. Detrimental effects on density were too excessive for use of these chemicals on fine, closely maintained Kentucky bluegrass. However, use of these chemicals, especially CGA-24705, in combination with a broadleaf hericide, on low maintenance turf or hard to mow areas is feasible. More research is needed to examine consistency of growth suppression under different environmental conditions.

LITERATURE CITED

1. Anderson, C.R. 1963. Inhibitors for economic maintenance. 22nd Short Course on Roadside Development. p. 74-76.

2. Anderson, D.O. 1970. Growth retardant chemicals. 29th Short Course on Roadside Development. p. 93-97.

3. Billot, C. and A. Hentgen. 1974. Effects of growth regulators on certain turfgrasses. 2nd International Turfgrass Conference. p. 463-467.

4. Chamberlin, R.E. 1963. Inhibitors for roadside maintenance. 22nd Short Course on Roadside Development. p. 77.

5. Ciba-Geigy Corporation. December 10, 1974. Experimental herbicide CGA-24705. Technical Release. Ciba-Geigy Corporation. P.O. Box 11422, Greensboro, North Carolina, 27409.

6. Ciba-Geigy Corporation. December 19, 1974. Experimental herbicide CGA-17020. Technical Release. Ciba-Geigy Corporation. P.O. Box 11422, Greensboro, North Carolina, 27409.

7. Clapham, A.J., R.C. Wakefield, and R.S. Bell. 1969. The effect of maleic hydrazide on the growth of turfgrasses. University of Rhode Island Agriculture Experiment Station Bulletin 399:1-22.

8. Dicks, O.W. and A.J. Turgeon. 1972. Chemical growth retardation of turf. 13th Illinois Turfgrass Conference. p. 15-16.

9. Dore, A.T., R.C. Wakefield, and J.A. Jagschitz. 1971. Effect of four growth retardants on Kentucky bluegrass and red fescue used for roadside turf. NEWCC 25:123-130.

10. Engel, R.R., K.J. McVeigh, R.M. Schmit, and R.W. Duell. 1971. The effect of growth regulators on turfgrass species. NEWCC 25:131-139.

11. Foote, L.E., and B.F. Himmelman. 1967. Vegetation control along fence lines with maleic hydrazide. Weeds 15:38-41.

12. ___________. 1971. MH as a roadside grass retardant. Weed Sci. 19:86-90.

13. Fox, D.F. 1968. Plant growth regulators for use on roadsides. 27th Short Course on Roadside Development. p. 104-105.

14. Goodin, J.R. 1970. Growth regulators in non-cropland. Proceedings 22nd Annual California Weed Conference. p. 109-111.

15. Green, W.C. 1955. The progress of weed control on Connecticut state highways. NEWCC 11:429-432.

16. Grimm, D.G. 1963. Inhibitors for economic maintenance. 22nd Short course on Roadside Development. p. 78.

17. Madison, J.H., J.M. Johnson, W.B. Davis and R.M. Sachs. 1969. Compounds for chemical mowing of turfgrass. California Agriculture. 23:9-10.

18. Naylor, A.W. and E.A. Davis. 1950. Maleic hydrazide as a plant growth inhibitor. Bot. Gaz. 112:112-126.

19. Radko, A.M. 1953. What about maleic hydrazide? USGA Journal and Turf Management. June. p. 30-32.

20. Sachs, R.M. and W.P. Hackett. 1972. Chemical inhibition of height. Hort. Sci. 7:440-447.

21. Zukel, J.W. 1953. Report on use of maleic hydrazide for temporary inhibition of grass. Abstract in A Literature Summary on Maleic Hydrazide by J.W. Zukel for Uniroyal. p. 163-164.

APPENDIX

TABLES 1 THROUGH 5 REFER TO TEST I.

Table 1. Growth suppression of common Kentucky bluegrass in Test 1 (April 16,1975) as measured by plant height.

Treatment	Rate (kg/ha)	% Height reduction days after application 13	26	47[y]	66
Control	0	0 a[x]	0 a	0 a	0 a
CGA-17020	2.75	45 c	52 b	62 bc	0 a
	5.5	34 bc	52 b	65 bc	0 a
	8.25	41 c	52 b	65 bc	2 a
CGA-24705	2.75	21 b	40 b	48 b	0 a
	5.5	28 bc	40 b	70 c	0 a
	8.25	38 bc	40 b	80 d	23 a

[y] Grass mowed at 48 and 57 days

[x] Means separated by letters are significantly different by the Duncan's New Multiple Range Test at the 0.05 level.

Table 2. Growth suppression of common Kentucky bluegrass in Test I (April 16, 1975) as measured by density estimation.

Treatment	Rate (kg/ha)	Average density rating days after application 13	26	47	72	117
Control	0	10.0 a[x]	10.0 a	10.0 a	10.0 a	10.0 a
CGA-17020	2.75	3.3 b	3.7 b	8.3 a	8.3 ab	9.3 a
	5.5	3.3 b	3.0 b	7.0 ab	8.3 ab	9.5 a
	8.25	3.7 b	2.7 b	4.3 bc	7.0 ab	9.2 a
CGA-24705	2.75	4.0 b	3.3 b	5.0 bc	7.0 ab	8.3 ab
	5.5	4.7 b	4.3 b	4.3 bc	6.0 b	7.8 b
	8.25	5.0 b	3.3 b	2.3 c	5.7 b	7.5 b

[x] Means separated by letters are significantly different by the Duncan's New Multiple Range Test at the 0.05 level.

Table 3. Dry weights of clippings collected from Test I (April 16, 1975).

Treatment	Rate (kg/ha)	Clipping dry weights (gms) collected Days after application 48	 57
Control	0	465.9 a[x]	200.9 a
CGA-17020	2.75	175.7 b	199.7 a
	5.5	93.8 c	202.1 a
	8.25	72.2 c	181.2 a
CGA-24705	2.75	101.5 c	200.7 a
	5.5	64.5 c	165.5 a
	8.25	36.6 c	104.5 a

[x] Means separated by letters are significantly different by the Duncan's New Multiple Range Test at the 0.05 level.

Table 4. Weed infestation in Test I (April 16, 1975) 91 days after application.

Treatment	Rate (kg/ha)	Grass weeds	Broadleaf weeds
Control	0	5.7 bc[x]	3.7 a
CGA-17020	2.75	6.7 c	3.7 a
	5.5	8.3 c	4.3 a
	8.25	7.0 c	4.7 ab
CGA-24705	2.75	6.3 c	5.7 abc
	5.5	3.0 ab	6.7 bc
	8.25	2.3 a	7.0 c

[x] Means separated by letters are significantly different by the Duncan's New Multiple Range Test at the 0.05 level.