Iran Agricultural Research 12:13-28 (1993)

THE EFFECTS OF MALEIC HYDRAZIDE ON GROWTH CONTROL OF PERENNIAL RYEGRASS (*LOLIUM PERENNE* L. CV. YARANDI)

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(Received February 1, 1993)

ABSTRACT

Experiments were conducted in 1990 and 1991 to study the effects of maleic hydrazide (MH) on the vegetative growth reduction and decreased mowing maintenance requirements of perennial ryegrass (*Lolium perenne* cv. Yarandi). Treatments consisted of six rates (0, 1.2, 3.6, 6.0, 8.4 and 10.8 kg ha^{-1}) of Japanese maleic hydrazide (MH), OM-30 (6-hydroxy-3-(2H)-pydridazinone diethanolamine), with 30% active ingredient, and MH synthesized in Iran with the same formulation. Treated grasses were evaluated at ten-day intervals for growth reduction and on selected dates for color maintenance (chlorophyll content), as well as dry matter percentage in shoot fresh weight. Ten days after the first application of the growth retardant, 50% of the treated plots were treated again to evaluate the effects of double application of MH.

No significant differences were found between the Japanese and Iranian MH formulations and consequently Iranian brand of MH may be recommended to replace the Japanese product. The majority of the treatments were effective in reducing vertical growth which lasted for 40 days after the first application. Abnormal yellow coloring of shoots was observed when MH was applied at the rates of 8.4 and 10.8 kg ha^{-1} which ultimately resulted in complete destruction of the plots. The discoloration injury was proportional to growth suppression in terms of average height and increase in dry matter percentage in shoot fresh weight. Use of growth inhibitor from either source up to 6 kg ha^{-1} may be recommended. However, 3.6 kg ha^{-1} MH is preferable because the green appearance of the grass may undesirably be changed.

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تحقیقات کشاورزی ایران
(۱۳۷۲) ۲۸-۱۳:۱۲

استفاده از مالئیک هیدرازید جهت کنترل رشد چمن - رقم یارندی

حسن جمالیان و مرتضی خوشخوی
به ترتیب دانشجوی سابق کارشناسی ارشد و استاد بخش باغبانی دانشکده کشاورزی، دانشگاه شیراز، شیراز، ایران.

چکیده

آزمایش‌هایی در دو سال متوالی ۱۳۶۹ و ۱۳۷۰ انجام شد و اثر مالئیک هیدرازید بر روی کاهش رشد رویشی و کم شدن نیاز به دفعات سرزنی مکانیکی چمن یارندی مطالعه گردید. تیمارها شامل غلظت‌های مختلف ۰، ۱/۲، ۳/۶، ۶/۰، ۸/۴ و ۱۰/۸ کیلوگرم در هکتار از دو نوع مالئیک هیدرازید یعنی OM-30 با ۳۰% ماده مؤثر ساخت ژاپن و نوع مشابه ساخته شده در ایران، در دو زمان مختلف بود. طول شاخساره‌ها از روز دهم، بعد از اولین تیمار، با فاصلهٔ زمانی ده روزه و در پنج نوبت اندازه گیری شد. مقدار کلروفیل و مقدار درصد مادهٔ خشک نسبت به وزن تازه شاخساره هم در زمانهای مورد نظر تعیین گردید. نتایج بدست آمده نشان داد که هیچ تفاوت معنی‌داری بین مالئیک هیدرازید ژاپنی و نوع ساخته شده در ایران وجود ندارد، بنابراین می‌توان از نوع اخیر استفاده کرد. اکثر تیمارها در کاهش رشد مؤثر بودند و این تأثیر تا ۴۰ روز پس از اولین تیمار بر روی گیاه قابل مشاهده بود. استفاده از مالئیک هیدرازید در غلظت‌های ۴/۸ و ۱۰/۸ کیلوگرم در هکتار باعث سوختگی کامل چمن شد. شدت زرد شدن رنگ برگها با کاهش رشد چمن و افزایش درصد ماده خشک آن نسبت به وزن تازه شاخساره رابطه مستقیم داشت. استفاده از هر دو ماده بازدارنده رشد (ایرانی و خارجی) تا میزان ۶ کیلوگرم در هکتار قابل توصیه می‌باشد، ولی با در نظر گرفتن کلیهٔ مسائل بویژه اثر روی رنگ برگها و زرد شدن آنها، بهترین غلظتی که از مالئیک هیدرازید توصیه می‌شود، میزان ۳/۶ کیلوگرم در هکتار می‌باشد.

INTRODUCTION

The objectives of turfgrass management encompass both the establishment and proper maintenance of high quality turf stands over the entire growing season. As more attention is recently paid to turfgrasses in Iran, turf management and lawn culture will be more and more in demand. Today, the turfgrass industry involves the development, production and management of grasses for utility, beautification, and recreational facilities.

Mowing is the most time-consuming aspect of a lawn maintenance program. Good mowing practice is perhaps the single most important factor influencing the appearance and attractiveness of a lawn. Mowing has its own problems and difficulties. For example, when a grass plant is cut, photosynthate production is reduced and a flush of new leaf growth may be stimulated at the expense of stored carbohydrates (9). Supplies to the root diminish and growth may be slowed down or stopped depending on the severity of the clip. Mower maintenance and operator training are management responsibilities that should not be neglected. Mowing is not beneficial to grass since it removes part of the leaf area which is important in photosynthesis. Also, as the leaves are cut out the possibility of grass diseases may be increased.

To solve the problems mentioned above and to reduce the mowing costs on turfgrass, roadsides and recreation areas, chemical control of grass height may be employed. Growth regulators reduce the number of mowings needed during the growing season and provide suppression of seed stalks of perennial grasses. Among plant growth inhibitors, maleic hydrazide (6-hydroxy-3-(2H)-pydridazinone diethanolamine) abbreviated as MH, is one of the most effective growth inhibitors which is widely used, especially in plant height control.

The objective of the present study was to determine and compare the effects of two types of MH (Japanese and Iranian formulations) on the vertical growth, color and percent dry matter of perennial ryegrass (*Lolium*

perenne L. cv. Yarandi), the cultivar which is planted widely in most parts of Iran. This species, as well as other similarly-managed turfgrasses, require intensive management involving frequent mowing throughout the growing season. Management costs could be potentially lowered by using chemical growth inhibitors to reduce mowing frequency. Similarly as seed production in Yarandi cultivar may affect the plant so that it responds as an annual turfgrass, using MH will also prevent seed production by seed stalk suppression. Using MH as a growth inhibitor has been studied by Engel and Ahlgren since 1950 (6). They noted that MH treatments resulted in marked retardation of Kentucky bluegrass (*Poa pratensis* L.), colonial bentgrass (*Agrostis tenuis* Sibth), perennial ryegrass (*Lolium perenne* L.), and red top (*Agrostis alba* L.). However they pointed out that a slight color deterioration accompanied the MH treatments especially in summer-treated turfgrass subjected to drought conditions. Cabler and Horn (2) evaluated chemical growth retardants on several turf species including centipedegrass (*Eremochloa ophiuroides* Munro), bahiagrass (*Paspalum notatum* Flugge) and bermudagrass (*Cynodon dactylon* L.). They noted significantly greater retardation with phosfon (tributyl 2,4-dichlorobenzyl phosphonium chloride) and cycocel (2-chloroethyl-trimethyl ammonium chloride) than with MH. Changes in grass composition of turf have been reported following application of MH over several years (14). Results of an experiment (13) showed that repeated annual applications of MH and 2,4-D (2,4-dichlorophenoxy acetic acid) could modify the plant composition and control the growth of vegetation along roadside verges. Tests carried out on turf areas adjacent to airfield pavements using MH at 4 and 6 lb A^{-1} rates eliminated 5 mowings for the growing season (12). The activity of MH was variable depending on the application time. Anderson (1) reported effective retardation of several turfgrass species. Chemical control of *Poa annua* L. in turfgrass and the effects of various chemicals on seed production were studied by Jagschitz (8). Engel *et al.* (7) evaluated six chemicals for growth retardation effects on "Merion" Kentucky bluegrass, "Penn lawn" red fescue

and "Manhattan" perennial ryegrass. Five greenhouse and four field experiments were conducted by Elkins and Suttner (5) to evaluate commercial and experimental chemical retardants. In greenhouse trials, the most promising results were obtained with Slo-Gro, a MH formulation. Parfitt *et al.* (10) described the growth control of swards growth by chemical means rather than by mowing. Duell *et al.* (3) studied the effects of growth retardants at different times and rates. MH was usually the most effective compound. Sawyer *et al.* (11) carried out an experiment on shoot growth control of a mixture of grasses. Only the MH treatments gave lasting control.

MATERIALS AND METHODS

Experiments to evaluate the effects of maleic hydrazide (MH) on suppression of growth, chlorophyll content, and dry matter percentage in shoot fresh weight of perennial ryegrass (*Lolium perenne* L. cv. Yarandi) were conducted in 1990 and 1991 in the south of Shiraz, Iran. Perennial ryegrass that had been established in the autumn of the previous year was used. MH was applied when the grass was in the early stages of its spring flush.

Grass had been mowed regularly with a mowing machine and was clipped to a uniform height of 6 cm one day prior to application of chemical treatments. Individual plots 2×2.5 m, were laid out in a randomized complete block design with three replications. Japanese MH OM-30 with 30% active ingredient (known as M_1 hereafter), and Iranian made (known as M_2 hereafter) were used. The chemicals were applied at the rates of 0, 1.2, 3.6, 6.0, 8.4 and 10.8 kg active ingredient ha^{-1} for both M_1 and M_2 with a Knapsack sprayer.

Shoot height measurement of undisturbed grass was made at 10-day intervals and continued till 50 days after the first treatment. Height of vertical growth was estimated by measuring four plant specimens in each

plot. To eliminate border effects, 0.50×0.25 m along the length and width of each plot was omitted. Then, the samples were taken randomly from the remaining area to measure chlorophyll content, fresh and dry weight. Ten days after the first application, 50% of the treated plots were treated again. In addition to 4 randomized shoot height samples, the shoot chlorophyll content was measured by a spectrophotometric method using a Bausch and Lomb Spectronic 20. Initially, extraction was done using 80% acetone, following repeated grinding of samples. The extracts were centrifuged at 8000 rpm for 10 min. Dry matter percentage in shoot fresh weight was determined by taking three 50-gram samples per plot.

Treatments, plot size, experimental design, methods of chemical application, measurements and analysis of data were exactly the same in 1990 and 1991. For mean comparison, Duncan's multiple range test (DMRT) was used.

There was no rainfall in any of the experiments for at least 24 hr after treatments.

RESULTS AND DISCUSSION

1. The Effect of a Single Application of MH on Shoot Mean Height

Comparison of chemically treated plots with untreated control plots, 10 days after treatment, revealed significant growth retardation in both years of the experiments. However, there was no significant difference between 8.4 and 10.8 kg of a.i. ha^{-1}. This situation continued up to 30 days after chemical application, but at this time complete loss of plots treated with higher rates (8.4 and 10.8 kg ha^{-1}) of both MH occurred. In both years, there was no significant difference between Japanese and Iranian made MH (Table 1). Therefore, it may be concluded that foreign made MH can be replaced by the Iranian brand of this chemical.

Table 1. The effect of a single application of MH on perennial ryegrass mean height, at selected dates after application. Initial grass height was 6.0 cm at the time of treatment in spring 1990 and 1991.

		Mean height (cm)†									
		1990					1991				
		Days after treatment									
Treatment¶	Rate kg a.i. ha^{-1}	10	20	30	40	50	10	20	30	40	50
M_1	0.00	13.76a*	18.44a	21.54a	23.34a	25.35a	14.18a	18.71a	21.76a	23.28a	24.25a
	1.20	12.04b	14.72b	17.12b	16.63c	20.58b	12.39bc	14.93b	17.95b	18.94b	20.48b
	3.60	10.83c	12.81c	14.38c	15.39d	17.40c	11.94cd	13.74c	15.31c	16.11c	18.04c
	6.00	9.84d	11.46d	12.67d	13.62e	15.74d	10.38e	12.13d	13.00d	13.93d	16.47d
	8.40	9.19f	10.43e	§§	-	-	9.52f	10.71e	-	-	-
	10.80	8.92f	10.13e	-	-	-	9.33f	10.54e	-	-	-
M_2	0.00	13.24b	18.23a	21.97a	22.71b	24.98a	13.97a	18.82a	21.86a	21.51a	24.14a
	1.20	11.93c	14.68b	16.96b	18.17c	20.14b	12.54b	15.01b	18.11b	19.03b	20.35b
	3.60	10.63d	12.94c	14.44c	15.45d	17.56c	12.01cd	13.82c	15.13c	15.90c	18.11c
	6.00	9.76e	11.54d	11.90d	13.24e	15.32d	10.42e	12.52d	12.85d	14.00d	16.55d
	8.40	9.25f	10.38e	-	-	-	9.61f	10.59e	-	-	-
	10.80	9.05f	10.32e	-	-	-	9.54f	10.68e	-	-	-

† Each height reported represents an average of four measurements made in each plot for each date.

¶ M_1 and M_2 represent OM-30 (Japanese MH) and MH synthesized in Iran, respectively.

* Treatment means in each column followed by the same letter are not significantly different at the 5% level of probability according to DMRT.

§ Plots lost due to high MH rates.

Evaluation of height reduction showed that the maximum retardation effect was at 30 days after treatment for both formulations of growth regulators, and for single and double applications in both years. The results of height measurements especially at 40 and 50 days after treatment revealed that the duration of effectiveness of both brands of growth regulators in both years was 40 days and, thereafter, growth was restimulated in all treatments (Table 2).

2. The Effect of a Single Application of MH on Shoot Chlorophyll Content

Treatment means at 10 days after chemical application of the first year were significantly different, especially at higher rates. Similar results were obtained in the second year. Reduction of chlorophyll content was directly proportional to increments of chemical concentration (Table 3). Color of grasses treated with higher rates of MH deteriorated markedly between 20 and 30 days, particularly in concentrations of 8.4 and 10.8 kg ha^{-1}. This severe loss of greenness was characteristic of both sources of MH. The injury associated with discoloration was proportional to the growth suppression in terms of average height.

3. The Effect of a Single Application of MH on Shoot Dry Matter

Dry matter percentage in shoot fresh weight increased from 5.0 to 43.5% depending on chemical rate, up to 20 days after the first chemical treatment, in the first year, and from 3.0 to 44.0%, in the second year, for both brands of growth regulator.

Data presented in Table 3 also indicated that treatments with different rates of MH on selected dates not only increased the dry matter but also this enhancement was proportional to the increase in the amount of chemical concentration.

Table 2 The effects of single and double applications of MH on mean height reduction at 10 to 50 days after application in 1990 and 1991.

Mean height reduction (%)

Treatment	Rate kg a.i. ha^{-1}	1990 Days after treatment 10	20	30	40	50	Total reduction	1991 Days after treatment 10	20	30	40	50	Total reduction
T_1	1.20	20.00†	44.00	48.50	16.00	3.50	21.00	29.50	46.50	48.00	21.00	0.00	21.50
	3.60	36.50	55.00	54.50	23.00	6.50	36.50	25.50	61.00	52.00	23.50	0.00	33.50
	6.00	49.00	65.50	84.50	43.00	4.50	47.00	45.50	61.50	75.50	45.00	0.00	42.50
	8.40	56.50	75.00	-¶	-	-	-	55.00	76.50	-	-	-	-
	10.80	59.50	74.00	-	-	-	-	57.00	76.50	-	-	-	-
T_2	1.20	20.00	49.50	56.00	25.00	4.50	33.00	19.50	49.00	51.50	26.00	5.00	24.00
	3.60	36.50	62.50	68.00	32.00	17.00	46.00	25.50	75.50	65.50	47.00	13.00	35.50
	6.00	49.00	65.50	100.00	51.00	16.00	58.50	45.50	66.00	85.50	56.50	14.50	48.00
	8.40	56.50	64.50	-	-	-	-	55.00	80.00	-	-	-	-
	10.80	59.50	79.00	-	-	-	-	57.00	77.50	-	-	-	-

† T_1 represents single application and T_2 represents double application of MH.

¶ Plots lost due to high MH rates.

Table 3 The effects of different concentrations of MH on chlorophyll content and dry matter of perennial ryegrass in spring 1990 and 1991.

Treatment	Rate kg i.a. ha^{-1}	Chlorophyll content (mg g^{-1})				Dry matter (%)			
		1990		1991		1990		1991	
		Days after treatment							
		10	20	10	20	10	20	10	20
M_1¶	0.00	2.70a†	2.51a	2.64a	2.68a	19.90e	22.60f	20.40e	23.00e
	1.20	2.50bc	2.37a	2.51a	2.41b	21.30d	24.10e	21.20d	23.90d
	3.60	2.43c	2.23b	2.44b	2.28b	22.00cd	25.30d	23.00c	25.80c
	6.00	2.06e	1.98c	2.14c	2.00d	23.50b	27.00c	24.40b	27.30b
	8.40	1.74f	1.01d	1.70d	1.11e	25.70a	39.50b	25.90a	41.00a
	10.80	1.65fg	0.92d	1.54de	0.88f	25.40a	40.30a	26.30a	41.00a
M_2	0.00	2.76a	2.48a	2.54a	2.56a	20.10e	21.90f	20.50de	22.70e
	1.20	2.52b	2.40a	2.49ab	2.44b	21.00de	23.80e	21.30d	24.20d
	3.60	2.26d	2.12b	2.38b	2.16c	22.60bc	25.90d	22.70c	25.80c
	6.00	2.17de	1.95c	2.09c	1.94d	23.40b	26.80c	24.80b	26.90b
	8.40	1.54g	0.97d	1.64d	0.95f	24.90a	41.10b	26.50a	40.90a
	10.80	1.53g	0.99d	1.48e	1.00e	25.50a	40.40a	26.00a	41.30a

† Treatment means in each column followed by the same letter are not significantly different at the 5% level of probability according to DMRT.

¶ M_1 and M_2 represent OM-30 (Japanese MH) and MH synthesized in Iran, respectively.

4. The Effect of a Double Application of MH on Shoot Mean Height

Retardation of shoot vertical height on chemically retreated plots compared to untreated control plots revealed significant differences on selected dates in the first and second years of the experiments. This was true for both brands of growth regulator (Table 4). Double application of MH was mostly effective at 30 days after the treatment, in both years. However, this effect decreased thenafter. At 50 days, this difference was negligible, compared to a single application of MH. A double application of MH did not affect the duration of MH effectiveness.

5. The Effect of a Double Application of MH on Shoot Chlorophyll Content

There was a significant difference between the plots retreated with MH compared to nontreated control plots in both years of the experiment. Chlorophyll content of shoots had a diminishing trend proportional to the concentrations and frequency of MH used. Chlorophyll reduction percentage ranged from 13.5 to 79.0% in the first year. This reduction was from 9.5 to 18.5% more than the single application of MH depending on the chemical concentrations. In the second year of this experiment, chlorophyll content ranged from 11.0 to 87.0% and showed a 4.0 to 23.5% increase compared to a single application (Table 5).

6. The Effect of a Double Application of MH on Shoot Dry Matter

Dry matter weight significantly increased as a result of the double application of both brands of MH in the first and second year of experiments (Table 5).

Table 4. The effect of double application of MH on mean height of perennial ryegrass at 10 to 50 days after application in spring 1990 and 1991.

Treatment¶	Rate kg a.i. ha^{-1}	Mean height (cm)† 1990 — Days after treatment: 10	20	30	40	50	1991 — Days after treatment: 10	20	30	40	50
M_1	0.00	13.76a*	18.01a	21.66a	23.00a	24.86a	14.18a	18.35a	22.04a	23.50a	23.98a
	1.20	12.04b	13.85b	15.85b	16.86b	18.61b	12.39bc	14.06b	16.06b	17.82b	19.61b
	3.60	10.83c	12.10c	13.52c	14.42c	15.92c	11.94cd	12.98c	14.24c	14.90c	17.52c
	6.00	9.84d	11.04d	11.02d	12.02d	13.57d	10.38e	11.72d	12.33d	12.87d	15.10d
	8.40	9.19f	10.48de	-§	-	-	9.52f	10.48e	-	-	-
	10.80	8.92f	9.60e	-	-	-	9.33f	10.43e	-	-	-
M_2	0.00	13.24b	16.67a	22.10a	23.27a	25.18a	13.97a	18.26a	22.12a	23.34a	24.00a
	1.20	11.93c	13.90b	16.91b	15.67b	18.74d	12.59b	14.23b	15.97b	18.00b	19.70b
	3.60	10.63d	12.14c	13.46c	14.75c	16.36c	12.01cd	13.02c	14.31c	15.03c	17.43c
	6.00	9.76e	11.10d	10.10d	12.11d	14.24d	10.42e	11.91d	12.40d	13.00d	15.37d
	8.40	9.25f	10.61d	-	-	-	9.61f	10.26e	-	-	-
	10.80	9.06f	9.92e	-	-	-	9.54f	10.31e	-	-	-

† Each height reported represents an average of four measurements made in each plot for each date.

¶ M_1 and M_2 represent OM-30 (Japanese MH) and MH synthesized in Iran, respectively.

* Treatment means in each column followed by the same letter are not significantly different at the 5% level of probability according to DMRT.

§ Plots lost due to high MH rates.

Table 5. The effect of single and double applications of MH on chlorophyll reduction and dry matter increase of perennial ryegrass.

Treatment	Rate kg i.a. ha^{-1}	Chlorophyll reduction (%)				Dry matter (%)			
		1990		1991		1990		1991	
		Days after treatment							
		10	20	10	20	10	20	10	20
T_1†	1.20	7.50	4.00	2.50	7.00	5.00	6.50	3.00	4.50
	3.60	9.00	12.00	6.50	14.50	10.00	12.50	10.00	11.00
	6.00	22.00	21.00	18.00	24.50	14.50	17.00	16.50	15.50
	8.40	39.50	59.50	35.00	60.00	20.50	44.00	21.50	43.50
	10.80	41.00	61.50	41.00	63.50	21.00	43.50	21.50	44.00
T_2	1.20	7.50	13.50	2.50	11.00	5.00	16.50	3.00	15.50
	3.60	9.00	21.50	6.50	21.50	10.00	26.50	10.00	25.50
	6.00	22.00	30.50	18.00	28.50	14.50	32.00	16.50	28.50
	8.40	39.50	78.00	35.00	76.50	20.50	57.50	21.50	57.50
	10.80	41.00	79.00	41.00	87.00	21.00	57.50	21.50	57.50

† T_1 and T_2 reperesent single application and double applications of MH, respectively.

Table 6. A three-month report of temperature and relative humidity of the years 1990 and 1991 by Shiraz Office of Meteorology.

Year	Month	Monthly temperature (C°)			Monthly relative humidity (%)		
		Monthly Max.	Monthly Min.	Monthly Mean	6.00 AM	12.00	18.30 PM
1990	April	24.90	9.80	12.40	58.00	29.00	31.00
	May	33.20	12.50	22.90	44.90	18.00	19.00
	June	27.40	18.40	27.90	35.00	14.00	15.00
1991	April	25.50	10.70	18.10	60.00	29.00	33.00
	May	31.60	14.50	23.10	44.00	19.00	23.00
	June	36.40	18.10	27.30	39.00	17.00	20.00

CONCLUSION

The results obtained in this study confirmed the previous findings by Engel *et al.* (7), Duell *et al.* (3), Elkins and Suttner (5) and Elkins (4) who showed MH caused reduced vertical growth which dissipated differentially with time. The present results were also in agreement with those obtained in the experiments of Elkins (4), in which MH at the rates of 2.24 and 4.50 kg ha^{-1} affected growth reduction up to 45 days.

As the monthly mean temperature and relative humidity of the growing season were higher in 1991 than 1990 (Table 6), the slight differences that existed between the results of the two years of the present study may be attributed to these factors. Overall, by MH treatment, the number of mowings during the growing season can be reduced. Use of either brand of growth inhibitor at the rate of 6 kg ha^{-1} can be recommended. However, as the grass appearance may be undesirable at higher rates, the 3.6 kg ha^{-1} MH is preferable. Reapplication of MH after 40 days may be recommended.

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