

EVALUATION OF PLANT GROWTH REGULATORS FOR MANAGING
FESCUE TURF ALONG HIGHWAY RIGHTS-OF-WAY.

by

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(ABSTRACT)

Plant growth regulators (PGR's) including metsulfuron plus mefluidide at 10 plus 140 g ha⁻¹, chlorsulfuron plus mefluidide at 20 plus 140 g ha⁻¹, imazethapyr plus imazapyr at 67.5 plus 2.5, 96.4 plus 3.6, and 115.7 plus 4.3 g ha⁻¹, ACP 2100 at 60, 120, and 180 g ha⁻¹, and DPX L5300 plus mefluidide at 10 plus 140, 20 plus 140, and 70 plus 140 g ha⁻¹ were applied to 'KY 31' tall fescue (Festuca arundinacea Schreb.). All rates of imazethapyr plus imazapyr, ACP 2100, and chlorsulfuron plus mefluidide afforded a significantly higher turf quality than metsulfuron plus mefluidide. ACP 2100 at 120 and 180 g ha⁻¹, imazethapyr plus imazapyr, DPX L5300 plus mefluidide at 70 plus 140 g ha⁻¹, and metsulfuron plus mefluidide gave the most consistent seedhead suppression. When treating seven month old tall fescue, DPX L5300 plus mefluidide did not adequately suppress seedhead elongation. Metsulfuron plus mefluidide, regardless of timing, caused excessive injury. All rates of imazethapyr plus imazapyr and the upper rates

of ACP 2100 afforded the best turf quality followed by chlorsulfuron plus mefluidide in 1988 to 'Rebel' and both years to 'KY 31'. Red fescue (Festuca rubra L.) quality was best with chlorsulfuron plus mefluidide and the high rate of DPX L5300 plus mefluidide. All other treatments resulted in a poorer quality turf. For all field studies on all turf types, in general, multiple applications were not practical and often caused excessive injury regardless of timing.

Root studies conducted in the greenhouse revealed that with one application, imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide provided root dry weights ranging from 0.5 to 0.7 g, which was greater than metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, and the mowed check which afforded root dry weights of 0.1, 0.3, and 0.2, respectively. With two applications ACP 2100 and DPX L5300 plus mefluidide afforded 350, 1100, 200 and 200% greater root volume than metsulfuron plus mefluidide and chlorsulfuron plus mefluidide and 200, 630, 600 and 600% greater root dry weights. Three applications are not recommended.

In laboratory studies using 'KY 31' tall fescue, mefluidide enhanced the uptake of ^{14}C -DPX L5300 after 48 hours by as much as 11% and the translocation of ^{14}C by 8.4% to the young leaves, 9.3% to the old leaves and 6.1% to the culm. Radioactive material concentrated in the tips of leaves. No significant accumulation of ^{14}C occurred in the crown or roots.

TABLE OF CONTENTS

ABSTRACT.....	ii
TABLE OF CONTENTS.....	iv
LIST OF TABLES.....	vii
LIST OF FIGURES.....	xii
CHAPTER I Literature Review.....	1
Literature Cited.....	13
CHAPTER II EFFECTS OF MULTIPLE APPLICATIONS OF SELECTED PLANT GROWTH REGULATORS ON 'KY 31' TALL FESCUE.....	25
Abstract.....	25
Introduction.....	28
Materials and Methods.....	32
Results and Discussion.....	35
Literature Cited.....	46
Tables.....	51
CHAPTER III EFFECTS OF MULTIPLE APPLICATIONS OF PLANT GROWTH REGULATORS ON RED FESCUE.....	
Abstract.....	56
Introduction.....	58
Materials and Methods.....	61

Results and Discussion.....	64
Literature Cited.....	72
Tables.....	74

CHAPTER IV EFFECTS OF MULTIPLE APPLICATIONS OF PLANT
GROWTH REGULATORS ON NEWLY ESTABLISHED

TALL FESCUE.....	77
Abstract.....	77
Introduction.....	80
Materials and Methods.....	83
Results and Discussion.....	86
Literature Cited.....	98
Tables.....	103

CHAPTER V TALL FESCUE ROOT RESPONSES TO PLANT

GROWTH REGULATORS.....	110
Abstract.....	110
Introduction.....	113
Materials and Methods.....	116
Results and Discussion.....	119
Literature Cited.....	123
Tables.....	126

CHAPTER VI UPTAKE AND TRANSLOCATION OF DPX L5300 BY

TALL FESCUE AS EFFECTED BY MEFLUIDIDE.....	128
Abstract.....	128

Introduction.....	130
Materials and Methods.....	132
Results and Discussion.....	136
Literature Cited.....	140
Tables.....	143
Figure.....	147
CHAPTER VII SUMMARY AND CONCLUSIONS.....	152
APPENDIX TABLES.....	159
VITA.....	213

LIST OF TABLES

Chapter	Table		Page
II	1	Effects of one, two, and three annual applications of PGR's on height of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1987.....	51
	2	Effects of one, two, and three annual applications of PGR's on height of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1988.....	52
	3	Effects of one, two, and three annual applications of PGR's on quality of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1987.....	53
	4	Effects of one, two, and three annual applications of PGR's on quality of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial	

		application in 1988.....54
	5	'Ky 31' tall fescue seedhead suppression for 1987 and 1988. Data from combined means of all application schedules.....55
III	1	Effects of one, two, and three annual applications of PGR's on height of red fescue four weeks after each application and 8 weeks after initial application.....74
	2	Evaluation of one, two, and three annual applications of PGR's for phytotoxicity to red fescue four weeks after each application and 8 weeks after initial application..75
	3	Effects of one, two, and three annual applications of PGR's on quality of red fescue four weeks after each application and 8 weeks after initial application.....76
IV	1	Effects of one, two, and three annual applications of PGR's on height of 'Rebel' tall fescue four weeks after each application

	and 8 weeks after initial application in 1987.....	103
2	Effects of one, two, and three annual applications of PGR's on height of 'Rebel' tall fescue four weeks after each application and 8 weeks after initial application in 1988.....	104
3	Effects of one, two, and three annual applications of PGR's on quality of 'Rebel' tall fescue four weeks after each application and 8 weeks after initial application in 1987.....	105
4	Effects of one, two, and three annual applications of PGR's on quality of 'Rebel' tall fescue four weeks after each application and 8 weeks after initial application in 1988.....	106
5	Effects of one, two, and three annual applications of PGR's on height of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1988.....	107

6	<p>Effects of one, two, and three annual applications of PGR's on quality of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1988.....108</p>
7	<p>'KY 31' and 'Rebel' tall fescue seedhead data for 1987 and 1988. Data from combined means of all application schedules. 'KY 31' data from combined years.....109</p>
V	<p>1 Class comparisons and means for shoot fresh and dry weights, and root volume and dry weights for 1 to 4 annual treatments of ACP 2100, ACP 1911X, and DPX L5300 plus mefluidide on tall fescue contrasted with metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, mowed, and nonmowed treatments.....126</p> <p>2 Regression equations and R² values for the relationship between tall fescue shoot fresh weight, shoot dry weight, root volume,</p>

or root dry weight and rate of
ACP 1911X and ACP 2100.....127

VI	1	Uptake of ^{14}C DPX L5300 by 'KY 31' tall fescue at 2, 12, 48, and 120 hours after treatment alone and in combination with mefluidide.....143
	2	Distribution of absorbed ^{14}C DPX L5300 by 'KY 31' tall fescue at 2, 12, 48, and 120 hours after treatment alone and in combination with mefluidide.....144

LIST OF FIGURES

Chapter	Figure		Page
VI	1	Left autoradiograph, right tall fescue plant at 2 (top) and 12 (bottom) hours after spot treatment with 0.1 uCi ¹⁴ C-DPX L5300. Representative autoradiographs were used as no visible differences occurred between ratios of formulated mefluidide:DPX L5300 (0:1, 1:1, 2:1, and 4:1). Arrow indicates site of ¹⁴ C-DPX L5300 application..	147
	2	Left autoradiograph, right tall fescue plant. Nontreated (top) and a treated (bottom) plant. Treated plant was broadcast treated with 70 g ha ⁻¹ formulated DPX L5300 and spot treated with 0.1 uCi ¹⁴ C-DPX L5300. Arrow indicates site of ¹⁴ C-DPX L5300 application.....	148
	3	Left autoradiograph, right tall fescue plant. Top plant broadcast treated with 70:70 g ha ⁻¹ (1:1) and bottom plant broadcast treated	

- with 140:70 g ha⁻¹ (2:1) ratio of formulated mefluidide:DPX L5300 and spot treated with 0.1 uCi ¹⁴C-DPX L5300. Arrow indicates site of ¹⁴C-DPX L5300 application.....149
- 4 Left autoradiograph, right tall fescue plant. Plant was broadcast treated with 280:70 g ha⁻¹ (4:1) of formulated mefluidide:DPX L5300 and spot treated with 0.1 uCi ¹⁴C-DPX L5300. Arrow indicates site of ¹⁴C-DPX L5300 application.....150
- 5 Autoradiograph of tall fescue foliage, crown and root extract obtained from plants 120 days after foliar application of formulated DPX L5300 plus mefluidide at 70 plus 140 g ha⁻¹ which also included 1.1 uCi of ¹⁴C-DPX L5300. The lanes are designated from left to right: C = Control (DPX L5300 reference), SC = Spiked Control (chloropyll extract plus DPX L5300 reference), LF = Foliar extract from treated foliage, CR = Crown extract, and RT = Root extract.

Origin (O) is at bottom, solvent
front (Fr) is 15 cm above.....151

LIST OF APPENDIX TABLES

1. Effects of one to four applications of PGR's on height of 'KY 31' tall fescue in 1987....159
2. Effects of one to four applications of PGR's on height of 'KY 31' tall fescue in 1987.....160
3. Effects of one to four applications of PGR's on height of 'KY 31' tall fescue in 1988.....161
4. Effects of one to four applications of PGR's on height of 'KY 31' tall fescue in 1988.....162
5. Effects of one to four applications of PGR's on quality of 'KY 31' tall fescue in 1987.....163
6. Effects of one to four applications of PGR's on quality of 'KY 31' tall fescue in 1987.....164
7. Effects of one to four applications of PGR's on quality of 'KY 31' tall fescue in 1987.....165
8. Effects of one to three applications of PGR's on quality of 'KY 31' tall fescue in 1988.....166
9. Effects of one to three applications of PGR's on quality of 'KY 31' tall fescue in 1988.....167
10. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Shawsville, VA in 1987..168
11. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Shawsville, VA in 1987..169
12. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Shawsville, VA in 1987..170

13. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Shawsville, VA in 1988..171
14. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Shawsville, VA in 1988..172
15. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1987...173
16. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1987...174
17. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1987...175
18. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1988...176
19. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1988...177
20. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1987....178
21. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1987....179
22. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1987....180
23. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1988....181
24. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1988....182
25. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1988....183

26.	Effects of one to four applications of PGR's on height of red fescue.....	184
27.	Effects of one to four applications of PGR's on height of red fescue.....	185
28.	Effects of one to four applications of PGR's on quality of red fescue.....	186
29.	Effects of one to four applications of PGR's on quality of red fescue.....	187
30.	Effects of one to four applications of PGR's on quality of red fescue.....	188
31.	Phytotoxicity of one to four applications of PGR's on red fescue.....	189
32.	Phytotoxicity of one to four applications of PGR's on red fescue.....	190
33.	Effects of four applications of PGR's on red fescue.....	191
34.	Effects of one to four applications of PGR's on height of 7 month old 'KY 31' tall fescue.....	192
35.	Effects of one to four applications of PGR's on height of 7 month old 'KY 31' tall fescue.....	193
36.	Effects of one to four applications of PGR's on quality of 7 month old 'KY 31' tall fescue.....	194
37.	Effects of one to four applications of PGR's on quality of 7 month old 'KY 31' tall fescue.....	195
38.	Effects of one to four applications of PGR's on quality of 7 month old 'KY 31' tall fescue.....	196

39. Phytotoxicity of one to four applications of PGR's on 7 month old 'KY 31' tall fescue.....197

40. Phytotoxicity of one to four applications of PGR's on 7 month old 'KY 31' tall fescue.....198

41. Phytotoxicity of one to four applications of PGR's on 7 month old 'KY 31' tall fescue.....199

42. Effects of one to four applications of PGR's on height of 7 month old 'Rebel' tall fescue in 1987.....200

43. Effects of one to four applications of PGR's on quality of 7 month old 'Rebel' tall fescue in 1987.....201

44. Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1987.....202

45. Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1987.....203

46. Effects of one to four applications of PGR's on height of 7 month old 'Rebel' tall fescue in 1988.....204

47. Effects of one to four applications of PGR's on height of 7 month old 'Rebel' tall fescue in 1988.....205

48. Effects of one to four applications of PGR's on height of 7 month old 'Rebel' tall fescue in 1988.....206

49. Effects of one to four applications of PGR's

	on quality of 7 month old 'Rebel' tall fescue in 1988.....	207
50.	Effects of one to four applications of PGR's on quality of 7 month old 'Rebel' tall fescue in 1988.....	208
51.	Effects of one to four applications of PGR's on quality of 7 month old 'Rebel' tall fescue in 1988.....	209
52.	Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1988.....	210
53.	Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1988.....	211
54.	Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1988.....	212

CHAPTER I
LITERATURE REVIEW

Historical aspects of PGR use in turf. Tall fescue (Festuca arundinacea Schreb.) is a cool season, bunch-type species which originated in Europe and is now common to much of the U.S. It is adapted to a wide range of soil and climatic conditions and forms a turf of low shoot density (7, 86). It is a long-lived perennial when grown in the transition zone (7), which encompasses much of Virginia.

Active canopy growth of tall fescue begins in April followed by seedhead development by late May with anthesis starting in early June at Blacksburg, VA (86). Flowering and stem elongation occurs only during the spring and all subsequent regrowth is vegetative. The development of flower tillers depends on two conditions: a short day-long night photoperiod with low temperatures for induction of bud primordia during late autumn and winter, followed by a long day-short night photoperiod with cool temperatures during spring. About 45% of the annual dry matter production of well fertilized tall fescue occurs during the first six weeks of spring (86). It comprises the majority of turf grown along Virginia highway rights-of-way, thus tall fescue is the major species for plant growth regulator (PGR's) research. Red fescue (Festuca rubra L.) often occurs in mixed stands with tall fescue and is also treated with

PGR's.

The history of plant growth regulators originates from maleic hydrazide (1,2-dihydro-3,6-pyridazinedione) (MH) which was first discovered in 1894 by a German doctoral candidate in chemistry. No use could be found for the chemical so it remained virtually dormant from literature for over 50 years. The U.S. Rubber Company rediscovered MH in 1947 and observed its growth regulatory effects on tomato (Lycopersicon esculentum Mill.) (37). In 1952, Uniroyal registered MH for tobacco sucker control. It was later discovered that this compound suppressed culm and foliar growth of Kentucky bluegrass (Poa pratensis L.), tall fescue, and several other grass species.

Soon to follow in the PGR market was chlorflurenol (methyl 2-chloro-9-hydroxyfluorene-9-carboxylate). Its marketing claims included keeping turf greener, controlling annual bluegrass (Poa annua L.) and broadleaf weeds, being nonvolatile, and being short lived in soils (37).

A considerable number of growth regulators have been evaluated on roadside vegetation. On roadside turf situations, as few as two mowings or as many as twelve mowings per year are required in maintenance procedures (37, 40). Transportation department personnel in North Carolina, Virginia, Maryland, and New York have stated that MH reduced mowing amount or frequency by 50 to 90% and

reduced maintenance costs by as much as 50% (37). Tall fescue foliar height and dry weight, tiller number, root length, volume and dry weight were reduced by MH along with turf color (39). The number of Kentucky bluegrass rhizomes was also decreased.

MH was evaluated with and without 2,4-D [(2,4-dichlorophenoxy)acetic acid] on a number of roadside turfgrass species in Minnesota (40). When MH was not used, mowing was done two to twelve times annually. Between zero and five mowings per year were saved, depending on the area and MH effectiveness. The 2,4-D was necessary to control broadleaf weeds for a satisfactory appearance. When MH effectively inhibited turf growth annual weeds such as crabgrass (Digitaria spp. Heist.), foxtail (Setaria spp. Beauv.), and ragweed (Ambrosia spp. L.) became abundant in open areas of the turf. These problems have also been reported to occur with mefluidide (N-[2,4-dimethyl-5-[[trifluoromethyl)sulfonyl]amino]phenyl]acetamide), chlorsulfuron {2-chloro-N[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide} plus mefluidide and metsulfuron {2-[[[(4-methoxy-5-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid} plus mefluidide (24, 74).

MH was tested for use on foam carriers to tall fescue and Kentucky bluegrass and was effective in growth

regulation but feasibility studies for roadbank use needed to be conducted (1). MH alone and in combination with chlorflurenol was evaluated over a three year period on roadside turf consisting of Kentucky bluegrass, red fescue, and Colonial bentgrass (Agrostis tenuis Sibth.) in Rhode Island (79). Some discoloration occurred but was not considered objectionable for highway turf. Root growth was significantly retarded by both materials. At Southern Illinois University, these two growth regulators suppressed seedhead development of tall fescue but caused turf discoloration (38).

Need for new PGR's. In 1965, MH accounted for 90% of the total PGR's used in the U.S. By 1975 newer PGR's accounted for more than 50% of the total market (37). Today, PGR's such as mefluidide, metsulfuron and chlorsulfuron make up the majority of PGR's used along highway rights-of-way. New chemistry in growth regulators such as DPX L5300 (methyl 2-[[[[3-(4-methoxy-6-methyl-6-methyl-1,3,5-triazin-2-yl)-N-methyl-amino]carbonyl]amino]sulfonyl]benzoate), imazethapyr ((±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-pyridinecarboxylic acid) plus imazapyr ((±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid), and ACP 2100 alone and in combination with imazaquin {2-[4-,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-

3-quinolinecarboxylic acid) is making greater advancements toward higher quality growth regulated turf by reducing the degree of injury and discoloration.

Growth regulation, unlike mechanical mowing, can be accomplished on areas of excessive slopes or around frequent obstructions or in areas that would impart excessive labor and subject workers to hazardous working conditions using mechanical mowing methods (44). Proper selection of a PGR to maintain turf can reduce labor, fuel, and equipment costs (21, 69). Current areas where such PGR's would be most useful are highway roadbanks, cemeteries, golf course roughs, parks, industrial plants, air fields, orchard swards and grass water ways.

The incorporation of a satisfactory PGR in turfgrass maintenance programs is economically and practically feasible. Reductions in labor, fuel and equipment costs as well as lessened hazards to roadside maintenance crews are among the benefits of PGR use. PGR's are principally used as replacements or substitutions for mowing in situations where mowing is the normal practice and to beautify areas which normally are too difficult to maintain.

The majority of PGR research is conducted on foliar and seedhead suppression with little attention to below ground effects. Studies which have investigated parameters including root, tiller, and rhizome development have shown

that PGR's which effectively reduce vertical topgrowth often reduce root growth as well. Several commercial and experimental PGR's have been shown to reduce roots, tillers, rhizomes and lateral leaf growth (21, 24, 39, 40, 66, 79, 81, 82). Such reductions could have adverse effects on long-term turfgrass stand and thus limit PGR use situations. If a retardant is to be used for grass growth control, long-term effects on subterranean as well as aerial parts must be considered (39). It is essential, therefore, to make accurate evaluations of the effects of PGR's on turfgrass morphology.

In studies concerning root to shoot ratios, Crider (20) found that root growth suppression occurred in both single and repeated percentage-clipping tests when over 40% of the foliage was removed. The Virginia Department of Transportation often removes 50 to 80% of the foliage when mowing occurs. This stops root production of the turf (20). Ideally a PGR would inhibit above ground vertical growth without limiting tillering or subterranean growth and result in a healthier and more vigorous stand of turf than could be maintained under a mowing regime.

PGR's currently available have some use limitations due to phytotoxicity and discoloration, potential to thin or lower density, and potential to cause excess periods of inhibited growth due to unexpected environmental stress

(37). They are not accepted on recreational areas where turfgrass wear is evident. Retarded grass is not able to produce adequate new growth to recover from traffic and is subsequently thinned. An additional problem is that fine turf treated with a PGR will slow down or stop new growth and leaf production, but death of the plant continues at or near normal rate. Without new leaf growth to mask the older dead and dying surface cover, the thatch is more visible and the turf loses its uniform green color, even if phytotoxicity is not a problem (6, 37, 69). Another potential problem is that grasses are more susceptible to growth regulators under low light intensity (37). Street (69) stated that disease incidence has been prevalent on growth regulator-treated turf, likely due to a reduced growth rate and fewer new leaves to mask infection of older leaves. This may play a role in reducing the longevity of growth regulated turf stands. Such problems limit current PGR use to low maintenance sites where slight to moderate leaf chlorosis or thinning of the turf is less objectionable (21).

Currently, mefluidide, chlorsulfuron, and metsulfuron alone or in combination comprise the majority of PGR's used along highway rights-of-way. Often mefluidide is added to chlorsulfuron or metsulfuron to reduce cost and enhance the activity (16, 17).

Mefluidide may have entered the market as a turfgrass retardant because of its usefulness as a herbicide and has been extensively researched for its growth regulatory properties (15, 18, 30, 31, 39, 41, 43, 53, 58, 63, 64). It has proven to be more effective for growth suppression than MH and chlorflurenol (80, 82). Application should be made only to green actively growing turf and no later than two weeks before seedhead emergence for seedhead suppression of cool-season grasses. It may be applied two times per season on Kentucky bluegrass or fescue and an interval of six weeks should elapse prior to the second application (37).

Mefluidide controlled the growth of an orchard sward which was normally mowed ten to fifteen times per year and was concluded to possess the capability to eliminate mowing in this situation (5). Some yellowing has been observed from mefluidide (13, 14, 24, 25, 45, 63, 64), but grass may turn darker green (45, 47). Others attribute the apparent early color loss principally to a lack of grass blade and plant replacement, which results in greater visibility of thatch and brown blade tips (37). It is claimed that mefluidide does not reduce the population density of grass, but will temporarily inhibit the ability of grass to become more dense, which results in a thinned appearance (37, 84). Some studies however, showed reductions in tall fescue, red fescue and Kentucky bluegrass turf density, root, tiller,

and rhizome development (13, 23, 24, 25, 39, 64, 66, 80, 81, 82). Other studies have shown little effect on these parameters and some indicate actual increases in root development with mefluidide (21, 24, 80). Some research has indicated that two applications per year caused adverse effects, limiting its use in this matter (24).

Chlorsulfuron herbicide is used for preemergence and postemergence control of many annual and perennial broadleaf weeds (10, 11, 26) and for the suppression of tall fescue growth and seedhead inhibition (15, 41, 52, 73, 74, 75). Chlorsulfuron has been shown to inhibit root production (76). Chlorsulfuron inhibits the acetolactate synthase enzyme (11). Applications are limited to 26 g ai ha⁻¹ per year to tall fescue for PGR purposes. At 140 g ha⁻¹ it can be used to selectively control tall fescue in Kentucky bluegrass (22, 48, 52).

Metsulfuron is the newest of these three PGR's. Like chlorsulfuron, metsulfuron controls annual and perennial broadleaf weeds (11) and has been reported to have turf growth regulatory properties (15, 41, 51, 58, 61, 73, 74, 75). However, its use has been shown to decrease stand populations of tall fescue (19, 22, 57, 58, 75, 75).

There is a need for a growth regulator which is safe to turf under a wide rate range, provide a wider window of application, and remain cost effective. New growth

regulators which show potential for this type of market include ACP 2100 alone and in combination with imazaquin (ACP 2110) (27, 30, 31, 62, 75, 77, 78), imazethapyr plus imazapyr (12, 28, 29, 51, 57, 59, 75, 83), and DPX L5300 (81). ACP 2100, imazethapyr, and imazapyr are imidazolinone herbicides (68). These herbicides control monocotyledonous and dicotyledonous annual and perennial weeds (63).

Imazethapyr has been under research and development for weed control in soybeans [Glycine max (L.) Merr.] and other leguminous crops since 1982 (70, 71, 72). Imazapyr is a broad spectrum total vegetation control agent that is used for site preparation and conifer release (8, 9, 46, 65) as well as for weed control in railroad and industrial settings (42, 50, 67). Symptoms of the imidazolinones first appear in the meristematic tissue where growth ceases soon after treatment, followed by chlorosis and then necrosis of the tissue (67, 68). The addition of imazapyr to imazethapyr has been observed to synergistically increase weed control (60, 85).

DPX L5300 is a sulfonylurea herbicide currently being tested for broadleaf weed control in small grains (2, 3, 4, 32, 33, 34, 35, 36, 54, 55, 56). It is similar in structure to metsulfuron (11, 61, 75, 76) and chlorsulfuron (11, 75, 76) which afford plant growth regulatory activity on turf and are used for tall fescue growth suppression.

Susceptible species cease growth almost immediately after postemergence treatment with DPX L5300 (4). Similar results have been found for chlorsulfuron (11, 26, 49,) and metsulfuron (11, 49). DPX L5300 has shown a greater safety margin to tall fescue than other sulfonylureas (75, 76).

Street (69) stated that an ideal growth regulator should inhibit leaf expansion with little effect on other meristematic activity. Turf managers would prefer grass with little vertical shoot growth if acceptable color, density and surface uniformity could be maintained. Daniel and Freeborg (21) described the ideal turf regulator as one that would retard vertical leaf growth but permit active root, rhizome, tiller, and horizontal leaf growth. This would permit continued new growth, including new leaves that are essential to maintain a uniformly green, dense turf resistant to wear, disease, and insect damage, and able to overcome hot weather or drought stress. Adequate weed control along with these qualities would all contribute to the ideal growth regulator. It was concluded that in the future there will be effective chemical growth control of turfgrasses even under the most demanding situations (37).

Objectives. The main objective of this research was to explore the possibility of a vegetation management program to eliminate the need for mowing roadside turf. The particular objectives for each stage of research were as

follows:

Field

To evaluate the PGR activity of multiple applications of ACP 2100, imazethapyr plus imazapyr, and DPX L5300 plus mefluidide against metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, and a nonmowed check for foliar height suppression, seedhead control, and quality of established and fall seeded 'KY 31' tall fescue, fall seeded 'Rebel' tall fescue, and established red fescue.

Greenhouse

To determine the influence of the above PGR's on shoot and root development by measuring above ground biomass, root volume and dry weight of 'KY 31' tall fescue.

Laboratory

To determine the uptake and translocation of DPX L5300 plus mefluidide in 'KY 31' tall fescue as influenced by the rate of mefluidide and time after application.

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CHAPTER II

EFFECTS OF MULTIPLE APPLICATIONS OF SELECTED PLANT GROWTH REGULATORS ON 'KY 31' TALL FESCUE

Abstract. Field experiments were conducted at three locations in 1987 and 1988 to evaluate metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide applied one to four times annually for growth suppression of 'KY 31' tall fescue. Four weeks after one application, a higher turf quality was afforded by imazethapyr plus imazapyr at 67.5 plus 2.5, 96.4 plus 3.6 and 115.7 plus 4.3 g ha⁻¹, ACP 2100 at 60, 120 and 180 g ha⁻¹, and chlorsulfuron plus mefluidide at 20 plus 140 g ha⁻¹ with ratings of 6.3, 6.0, 5.7, 6.5, 6.4, 6.3 and 5.6 in 1987, 8.1, 8.2, 7.4, 7.3, 8.9, 8.1, and 5.8 in 1988 than metsulfuron plus mefluidide which received ratings of 4.1 and 3.3 in 1987 and 1988, respectively. In 1987, the best seedhead suppression of 96% was obtained with ACP 2100 at 180 g ha⁻¹. In 1988 metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, all rates of imazethapyr plus imazapyr, 180 g ha⁻¹ of ACP 2100 and DPX L5300 plus mefluidide at 70 plus 140 g ha⁻¹ resulted in 99 to 100% seedhead suppression. Metsulfuron plus mefluidide afforded the greatest foliar suppression of 40 and 25% in 1987 and 1988 at four weeks with respect to the nonmowed check. The most consistent seedhead

suppression was achieved with the higher rates of ACP 2100, imazethapyr plus imazapyr, the high rate of DPX L5300 plus mefluidide and metsulfuron plus mefluidide. Although turf withstood two treatments per year of imazethapyr plus imazapyr, ACP 2100 and lower rates of DPX L5300 plus mefluidide, no additional benefits occurred from the second application. After three applications, only the lower rates of imazethapyr plus imazapyr elicited an acceptable quality turf with ratings of 6.4 and 6.6 in 1988. No treatments afforded acceptable quality after three treatments in 1987.

Nomenclature: ACP 2100; chlorsulfuron, 2-chloro-N-[[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide; DPX L5300, methyl 2-[[[[3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-N-methyl-amino]carbonyl]amino]sulfonyl]benzoate; imazapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid; imazethapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethylpyridinecarboxylic acid; mefluidide, N-[2,4-dimethyl-5-[[[trifluoromethyl]sulfonyl]amino]phenyl] acetamide; metsulfuron, 2-[[[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid; tall fescue

Festuca arundinacea Schreb. 'KY 31' #¹ FESAR.

Additional index words. ACP 2100, chlorsulfuron, DPX L5300, growth retardant, imazapyr, imazethapyr, imidazolinone, mefluidide, metsulfuron, rights-of-way, sulfonyleurea, turf, vegetation management.

¹Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

INTRODUCTION

Tall fescue is the major turfgrass grown along Virginia highway rights-of-way and has been the main target for growth regulator research in Virginia (26). Active canopy growth of tall fescue begins in April followed by seedhead development by late May with anthesis starting in early June at Blacksburg, VA (30). Flowering and stem elongation occur only during the spring and all subsequent regrowth is vegetative (30). The development of flower tillers depends on two conditions: a short day-long night photoperiod with low temperatures for induction of bud primordia during late autumn and winter, followed by a long day-short night photoperiod with cool temperatures during spring (30). About 45% of the annual dry matter production of well fertilized tall fescue occurs during the first six weeks of spring (30).

Currently available turf growth regulators are expected to control growth for four to eight weeks, depending on environmental conditions, and to afford season long seedhead suppression. The principle advantages cited for using growth retardants in a ground maintenance situation include: low labor, equipment, and fuel costs; better appearance of extensively managed turf by suppressing unsightly seedheads, and less damage and inconvenience in mowing vegetation on

steep or rugged areas (12).

Growth regulators that are currently available have some use limitations such as timing and number of applications due to resulting phytotoxicity and discoloration, potential to thin or lower turf density, and potential to cause excess periods of inhibited growth due to unexpected environmental stress (11). Currently, growth regulators are limited largely to low maintenance sites where slight to moderate leaf chlorosis or thinning of the turf is less objectionable (9).

Mefluidide, chlorsulfuron, and metsulfuron comprise the majority of growth regulators used along Virginia highway rights-of-way either alone or in combination. Mefluidide (4, 6, 13, 14, 17, 20) has been extensively researched for its growth regulatory properties and has been shown to be an enhancing agent for broadleaf herbicides (5). Mefluidide should be applied no later than two weeks prior to seedhead emergence and a minimum interval of six weeks should elapse before the second application. Chlorsulfuron (4, 14, 25) is also used to suppress tall fescue growth. Chlorsulfuron inhibits plant growth by inhibiting the enzyme acetolactate synthase (1). Mefluidide plus chlorsulfuron is the major growth regulator combination used along Virginia highway rights-of-way. Metsulfuron plus mefluidide has proven to elicit growth regulatory properties on tall fescue

as well (4, 14, 20, 25).

The use of metsulfuron plus mefluidide has resulted in injury to tall fescue (7, 19, 20, 26). Chlorsulfuron, at slightly higher rates than recommended for growth retardation, has shown potential for tall fescue control (15, 16).

There is a need for a growth regulator which will allow for rate safety on roadbanks, wider window of application, and cost effective use. New growth regulators which show potential for this use include ACP 2100 (26, 27), ACP 1911X (2, 19, 21, 26, 29), and DPX L5300 (26). ACP 1911X is a prepackaged combination of imazapyr plus imazethapyr. ACP 2100 and imazapyr plus imazethapyr are imidazolinone herbicides (24). These herbicides control monocotyledonous and dicotyledonous annual and perennial weeds (24). Symptoms of imidazolinones first appear in the meristematic tissue where growth ceases soon after treatment, followed by chlorosis and then necrosis of the tissue (23, 24). The addition of imazapyr to imazethapyr has been observed to synergistically increase weed control (22). This phenomenon appears to also hold true for PGR activity. DPX L5300 is a relatively new sulfonyleurea herbicide currently being tested for broadleaf weed control in small grains (10).

The objectives of this research were i) to evaluate ACP 2100, imazethapyr plus imazapyr, and DPX L5300 plus mefluidide applied in the mid to late boot stage of growth

for growth regulation of tall fescue and ii) to evaluate these compounds applied one, two, three, and four times per year at intervals of 52, 14, 10, and six weeks, respectively.

MATERIALS AND METHODS

Field experiments were conducted in 1987 and 1988 at three locations, Staunton, Lexington, and Shawsville, VA., on 'KY 31' tall fescue along Virginia highway rights-of-way. Due to the unknown origin of the soil in the rights-of-way areas, a textural analysis was performed. Staunton soil consisted of 15% sand, 53% silt, 32% clay, and 2.5% organic matter with a pH of 7.5. Lexington soil consisted of 28% sand, 36% silt, 36% clay and 3.8% organic matter with a pH of 7.0. Shawsville soil consisted of 24% sand, 50% silt, 27% clay, and 5.6% organic matter with a pH of 8.0.

Treatments consisted of a nonmowed check, imazethapyr plus imazapyr (a pre-package mix) at 68 + 2.5, 96 + 3.6, and 116 + 4.3 g ha⁻¹, ACP 2100 at 60, 120, and 180 g ha⁻¹, DPX L5300 at 10, 20, and 70 g ha⁻¹, chlorsulfuron at 20 g ha⁻¹, and metsulfuron at 10 g ha⁻¹. Mefluidide at 140 g ha⁻¹ was added to all rates of DPX L5300, chlorsulfuron, and metsulfuron to decrease the rate of the sulfonylurea needed for growth suppression, to increase safety to tall fescue, and to decrease the cost of the treatment (4). This rate of mefluidide alone affords inadequate suppression and was not used in this experiment (3).

All plots measured 1.8 m by 6.1 m. Treatments were applied with a CO₂ backpack sprayer in 280 L water ha⁻¹ with

a 0.25% v/v nonionic surfactant² delivered at 210 kPa utilizing 8003 flat fan tips³. Treatments were applied one, two, three, and four times per year to respective plots. Initial application was made on April 19, 1987, at Lexington and Staunton, and on May 1, 1987, at Shawsville, when tall fescue reached the mid to late boot stage of growth. For plots receiving two, three and four treatments per year, applications were made at 14; 10 and 20; and 6, 12, and 18 weeks, respectively, after the initial treatment. In 1988, initial application was applied on May 1 at Lexington and Staunton, and on May 2 at Shawsville, respectively.

Treatments were compared for foliar height, quality, and seedhead count and culm height. Height measurements were randomly selected from two locations within each plot. Seedhead counts were taken on a random 0.25 m² area. Turf quality was based on a scale from 1 to 9, with 6 representing acceptable quality for highway turf and 9 representing excellent quality. Quality ratings reflected the overall appearance of the turf and took into consideration seedhead number and height, foliar height, density, and color (18). A quality of 1 represent over 75

²X-77. Chevron Chem. Co., San Francisco, CA 94119. Principal functioning agents are alkylaryl polyoxyethylene glycols, free fatty acids, and isopropanol.

³TeeJet 8003 tips. Spraying Systems Co., Wheaton, IL 60287.

seedheads per m² or seedhead height over 60 cm or fescue completely brown or density decrease of 90% or more or combinations thereof. A quality of 9 represents no seedheads, a dark green color, with no density reduction. In 1988, metsulfuron plus mefluidide treatment was applied only in the one application per year interval due to excessive turf thinning in plots treated with multiple applications. In the four application per year interval, the lower rates of ACP 2100 and DPX L5300 plus mefluidide, elicited the greatest margin of turf safety (data not shown). However, these treatments still afforded excessive injury and no treatments were applied in 1988 in this interval. At all locations a split-block design with three replications was used with application schedules representing the main plots and treatments representing the subplots. Statistical evaluations were made by analysis of variance. Locations were combined when the variances proved to be not significantly different (8). Treatment means were derived from combined data of the three locations. When appropriate, a Waller-Duncan K-ratio t-test was used to separate treatment means within levels of individual parameters (28).

RESULTS AND DISCUSSION

Foliar height 1987. All PGR's suppressed turf growth relative to the nonmowed control throughout the first eight weeks (Table 1). Similar results have been found by other researchers (1, 12, 18, 29). In this study growth regulators were applied when tall fescue was in the mid to late boot stage of development after much of the foliar growth occurred. Therefore, large differences in foliar height were not found between treatments. Postponing the PGR treatment well past 100% greenup enabled the tall fescue to develop lush foliar growth and cover open areas with overlapping foliage measuring 30 and 35 cm in 1987 and 1988, respectively. This gave the rights-of-way a full green appearance and the foliar cover may have aided in weed suppression. Fourteen weeks after the initial treatment, turf lodging in the nonmowed plots caused a reduction in foliar height. This resulted in height measurements similar for all PGR's and the nonmowed control with the exception of metsulfuron plus mefluidide and the middle rate of imazethapyr plus imazapyr.

At 14 weeks, four weeks had elapsed since the second treatment of the three applications per year schedule. No differences were found between PGR's except with metsulfuron plus mefluidide and the high rate of DPX L5300 plus

mefluidide. Excessive injury with these latter treatments caused a reduction in foliar height greater than a single application. Metsulfuron plus mefluidide treated turf never fully recovered from this second treatment at 10 weeks and many plants exhibited complete necrosis following the third treatment at 20 weeks in schedule three. This accounts for the low height measurement of six cm for metsulfuron plus mefluidide because the height mean encompassed necrotic plants. Turf did recover by 18 weeks from the high rate of DPX L5300 plus mefluidide applied for the second time at 10 weeks in schedule three.

Metsulfuron plus mefluidide applied for the second time at 14 weeks in schedule two gave similar results as when repeated 10 weeks after initial application. The high rate of ACP 2100 afforded additional foliar height suppression for schedules two and three relative to one application. Turf treated at 14 weeks in schedule two with the high rate of ACP 2100 did recover from injury during the late summer flush but remained suppressed relative to one application.

Anticipating the onset of the fall growth, a third application was made at 20 weeks in schedule three. Four weeks later all treatments of all schedules maintained turf height below that of the nonmowed treatment (Table 1). All rates of imazethapyr plus imazapyr, and the upper rates of ACP 2100 and DPX L5300 plus mefluidide, resulted in greater

suppression of fall growth at 24 weeks relative to one annual application. However, the reduction observed in schedule three was not significantly different from schedule two. With proper timing a second application may be of value under certain turf maintenance programs. Possible carryover of the late applications may enhance the effect of spring treatments the following year.

Foliar height data revealed no additional benefit from higher rates of imazethapyr plus imazapyr, ACP 2100 or DPX L5300 plus mefluidide. Foliar height differences occurred by 18 weeks between rates of DPX L5300 plus mefluidide. By 24 weeks DPX L5300 plus mefluidide at 70 plus 140 g ha⁻¹ in general maintained height suppression to a greater extent than the lower rates. The additional suppression with multiple applications was not substantial enough to justify their use due to increased cost and risk of turf injury on roadside.

Foliar height 1988. Plots treated previously in 1987 were evaluated in mid April 1988, prior to receiving their 1988 application(s). Results indicated that turf treated with metsulfuron plus mefluidide more than once annually was severely injured and thinned. Therefore, due to their poor quality, these plots did not receive treatment in 1988.

With few exceptions, all growth regulators afforded similar foliar suppression after one application per year

(Table 2), similar to results of 1987 (Table 1). At 14 weeks, only the low rate of imazethapyr plus imazapyr, ACP 2100 and DPX L5300 plus mefluidide did not significantly differ from the nonmowed check (Table 2). At this time, four weeks after the second application of 3 treatments per year, there was a reduction in turf height in plots treated with the high rate of imazethapyr plus imazapyr and the higher rates of ACP 2100. This reduction in foliar height was primarily due to injury to the foliage which reduced plant vigor. However, there were no differences in plant heights by 18 weeks. At this time four weeks had elapsed since the second application in schedule two. Although the tall fescue plants seemed tolerant of these second applications in 1988, as observed in 1987, there was no additional benefit from this second application. At 24 weeks, four weeks after the third treatment in schedule three, there was a beneficial effect from the low rate of ACP 2100 and a detrimental effect from the high rate of DPX L5300 plus mefluidide. The low rate of ACP 2100 was the only treatment which provided additional suppression of the turf without detrimental effects when repeated in 1988.

Overall quality 1987. Metsulfuron plus mefluidide reduced quality to well below acceptable and turf maintained this appearance throughout most of the rating period (Table 3). These results agree with that of other researchers (1, 5,

16, 17). All other PGR's caused less turf injury than metsulfuron plus mefluidide. Quality at four weeks fell below acceptable when turf was treated with the high rate of imazethapyr plus imazapyr and DPX L5300 plus mefluidide due to excessive discoloration. Discoloration caused by the high rate of DPX L5300 plus mefluidide lasted beyond the eighth week. Discoloration afforded by the high rate of imazethapyr plus imazapyr may be tolerated for roadside use, but the prolonged period of discoloration caused by the high rate of DPX L5300 plus mefluidide is questionable.

Therefore, the latter treatment received an unacceptable quality rating of 5.3. Culm elongation was delayed somewhat by the low rate of ACP 2100 but by eight weeks seedhead elongation had occurred, thus lowering overall quality.

Additional metsulfuron plus mefluidide treatments proved to be detrimental and sharply reduced turf quality. Chlorsulfuron plus mefluidide appeared to follow a similar trend. Four weeks after the second treatment in schedule two, all treatments reduced quality below acceptable probably due to the additional summer stress. However, turf did recover to an acceptable level for all rates of imazethapyr plus imazapyr, ACP 2100, and the middle rate of DPX L5300 plus mefluidide with the latter treatment being equal to one application. Turf treated twice with the high rate of DPX L5300 plus mefluidide never fully recovered.

Although turf treated with imazethapyr plus imazapyr, and ACP 2100 at 14 weeks in schedule three recovered from this second application, quality, while remaining acceptable, was decreased for the most part and this treatment for roadside use does not appear feasible. Tall fescue did not adequately withstand any PGR after the third treatment in schedule three.

When applied once per year, as time progressed, all rates of imazethapyr plus imazapyr and the upper rates of ACP 2100 and DPX L5300 plus mefluidide provided turf quality similar to or better than chlorsulfuron plus mefluidide. In general, turf quality increased throughout the rating period for treatments in schedule one with the exception of the low rate of DPX L5300 plus mefluidide. The upper rates of imazethapyr plus imazapyr, ACP 2100, and the high rate of DPX L5300 plus mefluidide provided excellent quality turf 24 weeks after initial application. Therefore, no additional benefits occurred where PGR's were applied more than once per year compared to other schedules. The best treatments for 1987, taking all into consideration, were imazethapyr plus imazapyr at 96.4 plus 3.6 and ACP 2100 at 120 g ha⁻¹ applied once. Both treatments afforded little turf discoloration early in the season, afforded above acceptable quality throughout the entire growing season, and gave near excellent quality by the end of the rating period.

Overall quality 1988. Although the quality rating for the lower rates of DPX L5300 plus mefluidide dropped to equal to or below that of metsulfuron plus mefluidide due to seedhead culm elongation, all treatments afforded less foliar injury and a more aesthetically pleasing turf than metsulfuron plus mefluidide (Table 4). The latter result agrees with that of the 1987 study (Table 3).

The middle rate of ACP 2100 and all rates of imazethapyr plus imazapyr afforded less injury and a higher quality turf than chlorsulfuron plus mefluidide for the first 14 weeks with the higher rates of both compounds continuing this response throughout the growing season (Table 4). Four weeks after the second application in schedule three, only the low rate of imazethapyr plus imazapyr, ACP 2100, and both lower rates of DPX L5300 plus mefluidide did not decrease turf quality. However, of these treatments previously mentioned, only the low rate of imazethapyr plus imazapyr afforded an acceptable quality rating prior to the second treatment. With the exception of the low rate of imazethapyr plus imazapyr at 18 weeks and the middle rate of ACP 2100 at 24 weeks, all treatments which afforded an acceptable quality rating prior to a multiple treatment lowered turf quality after a second application.

It is evident that after repeating this study at three

locations for two years that treating tall fescue more than once with these PGR's was often detrimental to the turf and no additional benefits were gained to justify multiple applications for roadside use. However, turf treated twice annually with all rates of imazethapyr plus imazapyr, and the high rates of ACP 2100 withstood this added growth regulation and dropped only slightly in quality shortly after the second treatment both years. Further research is needed on proper timing of this second application to optimize PGR activity on fall growth and minimize turf injury. The latter compounds mentioned show potential for 2 annual applications where fall growth suppression is more desirable than along highway rights-of-way.

The middle rate of imazethapyr plus imazapyr, as reported by Welterlen (29) and the middle rate of ACP 2100 applied once after 100% green-up but prior to seedhead emergence, as in 1987, again provided adequate suppression and excellent quality turf (Table 4). These two treatments were the best overall for feasibility and growth suppression. Lower rates of these compounds did not adequately suppress seedhead elongation which would jeopardize their use for roadside vegetation management. The high rates of these compounds provided good foliar suppression and excellent quality, but the additional amount of chemical did not increase benefits over the middle rate

and therefore would not be as economical.

Seedhead suppression. Seedheads and weeds are the major reasons why the Virginia Department of Transportation mow highway rights-of-way; therefore, stressing the importance of seedhead suppression by a PGR to possibly eliminate mowing where weeds are controlled. Any treatment allowing more than 10 seedheads per m^2 to protrude above the foliar canopy was considered not acceptable. Both years, all PGR's suppressed seedhead height and number relative to the nonmowed check (Table 5). Similar seedhead reduction was also observed by other researchers (12, 29, 25). The higher rates of imazethapyr plus imazapyr, ACP 2100, and the high rate of DPX L5300 plus mefluidide reduced seedhead number equivalent to metsulfuron plus mefluidide while the higher rates of imazethapyr plus imazapyr and ACP 2100 suppressed seedhead development more than chlorsulfuron plus mefluidide in 1987 and the same as this treatment in 1988.

For use along highway rights-of-way 96.4 plus 3.6 and 115.7 plus 4.3 $g\ ha^{-1}$ imazethapyr plus imazapyr, ACP 2100 at 120 and 180 $g\ ha^{-1}$, DPX L5300 plus mefluidide at 70 plus 140 $g\ ha^{-1}$ and metsulfuron plus mefluidide at 10 plus 140 $g\ ha^{-1}$ appeared to be the most consistent PGR's for seedhead suppression for both years at all locations. These treatments were followed closely by chlorsulfuron plus mefluidide at 20 plus 140 $g\ ha^{-1}$ and imazethapyr plus

imazapyr at 67.5 plus 2.5 g ha⁻¹. ACP 2100 at 60 g ha⁻¹ and DPX L5300 plus mefluidide at 10 plus 140 g ha⁻¹ were not satisfactory for seedhead culm elongation suppression. Four applications per year. PGR's were also applied at six week intervals four times during the year of 1987 (Data not shown). Turf was severely thinned by all treatments with the exception of the low rate of ACP 2100 and DPX L5300 plus mefluidide. Similar results have been found for chlorsulfuron by other researchers (13, 14). The lower rates of ACP 2100 and DPX L5300 plus mefluidide, afforded turf quality below acceptable after the second application. Turf was thinned but to a lesser extent than with other treatments. Nonetheless, plots treated with the lower rates of ACP 2100 and DPX L5300 plus mefluidide four times were not repeated in 1988, due to poor quality ratings achieved prior to initial treatment. Four applications at six week intervals would not be acceptable, but it does establish that these lower rates of ACP 2100 and DPX L5300 plus mefluidide show potential and further experimentation is needed to perhaps reduce number of applications and find better timings. Consecutive applications of low rates may prove feasible where higher aesthetics with little to no turf injury and shorter periods of foliar suppression would be acceptable.

Taking into consideration the lack of seedhead

suppression by the low rates, and the lack of additional benefits from the higher rate, 96.4 plus 3.6 g ha⁻¹ imazethapyr plus imazapyr and ACP 2100 at 120 g ha⁻¹ appear to be the most feasible treatments for growth regulation along highway rights-of-way with one application per year. These two PGR treatments, in general, performed better than metsulfuron plus mefluidide and chlorsulfuron plus mefluidide. In some situations where suppression of fall growth is desired, all rates of imazethapyr plus imazapyr and ACP 2100 showed good turf safety following two applications. However, more work is needed to find the optimum timing of this second application.

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Table 1. Effects of one, two and three annual applications of PGR's on foliar height of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1987a.

Treatment	(g/ha)	Foliar Height											
		4(all) 8(all)		14(1) 14(2)		16 dB 14(3)		18(1) 18(2)		18(3) 24(1)		24(2) 24(3)	
		Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application	Weeks After Initial Application
Metsulfuron	10.0	27 f	26 d	24 cA	25 dA	16 dB	26 dA	20 dB	14 eB	29 dA	13 fB	6 eB	
Chlorsulfuron	20.0	28 ef	29 cd	27 abca	27 boda	25 abca	29 boda	24 cda	26 boda	31 cda	28 cda	26 cda	
Imazethapyr & Imazapyr	67.5	29 c-f	30 bod	27 abca	31 abca	26 aba	28 boda	27 bca	29 ba	31 cda	31 bca	26 cdB	
Imazethapyr & Imazapyr	96.4	30 b-e	28 d	25 bca	26 cda	20 boda	28 cda	26 bca	24 dA	32 bca	25 eB	24 dB	
Imazethapyr & Imazapyr	115.7	29 c-f	29 cd	27 abca	30 boda	24 bca	29 boda	26 bca	25 boda	33 boda	28 cda	26 cdB	
ACP 2100	60.0	33 b	33 bc	30 aA	32 aba	25 abca	31 bca	27 bca	29 ba	35 ba	32 ba	30 ba	
ACP 2100	120.0	31 bod	30 bod	27 abca	28 boda	24 boda	31 bca	28 ba	28 bca	35 ba	30 bodB	28 bcB	
ACP 2100	180.0	29 c-f	30 bod	27 abca	27 boda	21 bca	30 boda	24 cdAB	24 cdB	34 bca	27 cdeB	25 cdB	
DPX I5300	10.0	32 bc	34 bc	28 abca	29 boda	24 bca	32 ba	28 ba	28 bca	35 ba	33 ba	29 bca	
DPX I5300	20.0	29 c-f	29 cd	26 abca	26 cda	22 bca	29 boda	29ba	25 boda	35 ba	32 ba	26 cdB	
DPX I5300	70.0	29 c-f	28 d	26 abca	26 cda	20 bodB	27 dA	26 bca	23 dA	30 cda	26 deAB	23 dB	
Normowed	--	45 a	39 a	30 aA	35 aA	29 aA	36 aA	36 aA	36 aA	39 aA	39 aA	39 aA	

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Table 2. Effects of one, two and three annual applications of PGR's on foliar height of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1988^a.

Treatment	(g/ha)	Foliar Height									
		4(all) 8(all)		Weeks After Initial Application		Application Schedule ^b					
		14(1)	14(2)	14(3)	18(1)	18(2)	18(3)	24(1)	24(2)	24(3)	
		(cm)									
Metsulfuron	10.0	32 b	32 c	—	—	39 bc	—	43 bc	—	—	—
Chlorsulfuron	20.0	34 b	34 bc	30 bcdA	38 bcdA	36 cA	34 bcdA	44 bcdA	41 bcdA	34 cdeA	34 cdeA
Imazethapyr & Imazapyr	67.5	34 b	35 bc	39 abA	38 a-dA	31 bcdA	40 bcdA	39 bcdA	33 bcdA	45 bcdA	43 bcdA
Imazethapyr & Imazapyr	96.4	35 ab	37 abc	37 bA	35 cdA	28 bcdA	28 bcdA	35 cA	31 bcdA	44 bcdA	37 dA
Imazethapyr & Imazapyr	115.7	34 b	35 bc	35 bA	38 a-dA	27 cdB	35 cA	36 cA	30 cdA	42 cA	38 dA
ACP 2100	60.0	38 ab	40 ab	40 abA	42 abA	33 bA	41 bA	39 bcdA	33 bcdA	47 bcdA	43 bcdAB
ACP 2100	120.0	40 ab	38 abc	38 bA	39 a-dA	30 bcdB	39 bcdA	39 bcdA	32 bcdA	43 bcdA	39 cdA
ACP 2100	180.0	35 ab	31 c	37 bA	36 cdA	26 dB	40 bcdA	38 cA	30 cdA	45 bcdA	39 cdA
DPX I5300	10.0	37 ab	37 abc	42 abA	40 abcdA	32 bcdA	42 bA	43 bA	37 bA	48 bA	45 bA
DPX I5300	20.0	37 ab	35 bc	37 bA	37 bcdA	29 bcdA	39 bcdA	39 bcdA	35 bcdA	47 bcdA	44 bA
DPX I5300	70.0	34 b	33 bc	37 bA	36 cdA	29 bcdA	38 bcdA	36 cA	28 dA	46 bcdA	39 cdAB
Nonmowed	—	43 a	43 a	46 aA	43 aA	44 aA	49 aA	51 aA	51 aA	54 aA	54 aA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = applications at week 0 and 14; 3 = applications at week 0, 10 and 20.

Table 3. Effects of one, two and three annual applications of PGR's on quality of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1987a.

Treatment	Quality												
	4(all) 8(all)		Weeks After Initial Application		(Application Schedule ^b)								
(g/ha)	14(1)	14(2)	14(3)	18(1)	18(2)	18(3)	24(1)	24(2)	24(3)				
Metsulfuron	10.0	4.1 e	4.6 fg	5.5 eFA	4.2 dA	1.7 dB	6.6 deA	3.6 fB	1.4 dC	5.7 dA	1.8 eB	1.0 fB	
Chlorsulfuron	20.0	5.6 b	5.4 c-e	6.0 dA	6.7 aBA	3.7 bcB	6.7 deeA	5.5 abcAB	5.0 abcB	7.6 bA	4.9 dB	2.9 eC	
Imazethapyr & Imazapyr	67.5	2.5	6.3 a	5.9 a-e	6.1 cdeA	5.9 bA	4.8 aA	7.1 b-eA	5.0 cdB	5.7 aB	7.8 bA	6.3 abcB	5.4 abB
Imazethapyr & Imazapyr	96.4	3.6	6.0 ab	6.3abc	6.2 b-eA	6.6 aBA	3.8 bcB	7.6 abcA	5.4 abcB	5.4 abB	8.8 aA	7.1 aB	5.6 aC
Imazethapyr & Imazapyr	115.7	4.3	5.7 bc	6.5 ab	7.0 aBA	6.5 aBA	3.9 bcB	7.8 aBA	5.0 cdB	5.3 abcB	8.9 aA	6.5 bcB	4.4 dC
ACP 2100	60.0	6.5 a	5.7 b-e	5.1 fgA	4.8 dA	4.2 aBA	5.6 fgA	4.6 deA	5.3 abcA	6.8 cA	6.1 bcA	5.2 abcA	
ACP 2100	120.0	6.4 a	6.8 a	6.4 bcdA	5.8 bA	4.1 abB	7.1 b-eA	5.2 bcB	5.7 aB	8.6 aA	7.1 aB	5.7 aC	
ACP 2100	180.0	6.3 a	6.1 a-d	7.3 aA	7.2 aA	3.6 bcB	8.1 aA	5.8 aB	5.0 abcB	8.5 aA	6.5 abB	4.8 bcdC	
DPX I5300	10.0	5.4 cd	4.2 g	4.5 gA	4.5 dA	4.1 aBA	5.3 gA	4.2 eA	4.5 cA	5.0 eA	4.8 dA	4.5 cdA	
DPX I5300	20.0	5.7 bc	5.1 efg	5.7 defA	6.2 bA	4.1 abB	6.8 cdeA	5.2 bcB	4.8 bcB	7.7 bA	6.7 abA	5.1 a-dB	
DPX I5300	70.0	4.9 d	5.3 def	6.4 bcdA	6.1 bA	3.2 cB	7.4 a-dA	5.7 abB	4.9 abcB	8.8 aA	5.6 cdB	3.6 eC	
Nonmowed	--	3.9 e	1.0 h	1.0 hA	1.0 eA	1.0 dA	1.0 hA	1.0 gA	1.0 dA	1.0 fA	1.0 eA	1.0 fA	

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = applications at week 0 and 14; application 3 = applications at week 0, 10, and 20.

Table 4. Effects of one, two and three annual applications of PCR's on quality of 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application in 1988^a.

Treatment	Quality												
	4(all) 8(all)		14(1) 14(2)		14(3) 18(1)		18(2) 18(3)		24(1) 24(2)		24(3)		
Metsulfuron	10.0	3.3 g	4.9 d	5.4 d	---	---	6.2 d	---	---	6.2 d	---		
Chlorsulfuron	20.0	5.8 e	7.3 b	7.6 bA	7.6 bA	2.9 fB	8.0 bA	4.7 fB	4.2 deB	8.0 bA	6.4 cB	2.8 fC	
Imazethapyr & Imazapyr	67.5	2.5	8.1 bc	8.3 ab	8.8 aA	8.7 aA	6.6 aA	8.0 bA	7.6 aA	7.9 aA	8.0 bA	8.7aA	6.4 aB
Imazethapyr & Imazapyr	96.4	3.6	8.2 ab	8.9 a	8.9 aA	8.9 aA	5.4 bcB	9.0 aA	6.8 bc	7.8 ab	9.0 aA	8.3 aB	6.6 aC
Imazethapyr & Imazapyr	115.7	4.3	7.4 cd	8.6 a	9.0 aA	9.0 aA	4.6 dB	9.0 aA	6.1 cB	4.8 cdC	9.0 aA	8.3 aB	3.8 dC
ACP 2100	60.0	7.3 d	5.9 c	6.7 cA	5.8 cAB	5.0 bcdB	7.0 cA	5.2 deB	5.7 bB	7.2 cA	5.8 dB	4.1 cC	
ACP 2100	120.0	8.9 a	8.4 a	8.9 aA	8.8 aA	5.6 bB	9.0 aA	8.0 aB	7.3 ab	9.0 aA	8.7 aA	5.6 bB	
ACP 2100	180.0	8.1 bc	7.4 b	9.0 aA	8.6 aA	3.7 eB	9.0 aA	5.6 dB	4.0 eC	9.0 aA	7.1 bB	3.0 eFC	
DPX L5300	10.0	6.4 e	4.1 e	4.2 eA	4.0 dA	3.8 eA	4.4 eA	3.9 gA	4.1 deA	4.4 eA	4.3 eA	3.1 eB	
DPX L5300	20.0	6.0 e	5.4 cd	5.3 dA	5.4 cA	4.9 cdA	5.0 eA	4.8 eFA	5.2 bcA	5.0 eA	5.6 dA	4.0 cdB	
DPX L5300	70.0	4.3 f	6.0 c	8.3 aA	6.2 cA	2.7 fB	8.8 aA	3.3 hB	2.4 fB	8.8 aA	5.3 dB	1.4 gC	
Notmowed	---	1.0 h	1.0 f	1.0 fA	1.0 eA	1.0 gA	1.0 fA	1.0 iA	1.0 gA	1.0 fA	1.0 fA	1.0 hA	

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication Schedule 1 = one application at week 0; 2 = applications at week 0 and 14; 3 = applications at week 0, 10, and 20.

Table 5. 'KY 31' tall fescue seedhead suppression for 1987 and 1988 eight weeks after initial treatment. Data from combined means of all application schedules^a.

Treatment	(g/ha)	---- 1987 ----		---- 1988 ----	
		-- Seedhead --		-- Seedhead --	
		ht	#	ht	#
		(cm)	(/sq. m)	(cm)	(/sq. m)
Metsulf	10.0	18 f	5 f	0 e	0 d
Chlorsulf	20.0	42 c	14 d	0 e	0 d
Imazeth & Imazapyr	67.5 2.5	40 cd	13 de	5 de	1 d
Imazeth & Imazapyr	96.4 3.6	25 ef	4 f	0 e	0 d
Imazeth & Imazapyr	115.7 4.3	30 de	6 ef	0 e	0 d
ACP 2100	60.0	60 b	34 c	46 b	16 c
ACP 2100	120.0	24 ef	5 f	7 d	3 d
ACP 2100	180.0	14 f	3 f	0 e	0 d
DPX L5300	10.0	70 b	59 b	48 b	39 b
DPX L5300	20.0	59 b	13 de	21 c	15 c
DPX L5300	70.0	40 cd	10 def	0 e	0 d
Nonmowed	--	98 a	81 a	92 a	104 a

^aMetsulfuron, chlorsulfuron, and DPX L5300 all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

CHAPTER III

EFFECTS OF MULTIPLE APPLICATIONS OF PLANT GROWTH REGULATORS ON RED FESCUE

ABSTRACT. Plant growth regulators (PGR's) including metsulfuron plus mefluidide at 10 plus 140 g ha⁻¹, chlorsulfuron plus mefluidide at 20 plus 140 g ha⁻¹, imazethapyr plus imazapyr at 67.5 plus 2.5, 96.4 plus 3.6, and 115.7 plus 4.3 g ha⁻¹, ACP 2100 at 60, 120, and 180 g ha⁻¹, and DPX L5300 plus mefluidide at 10 plus 140, 20 plus 140 and 70 plus 140 g ha⁻¹ applied once per year did not discolor red fescue turf except for slight discoloration with metsulfuron plus mefluidide. Towards the end of the rating period an excellent turf quality of 8.3 was afforded by chlorsulfuron plus mefluidide and the high rate of DPX L5300 plus mefluidide. All other treatments afforded turf quality ranging from 6.4 to 7.7 which was a decrease with respect to the nonmowed check which received a quality of 9. There were no differences in height between PGR treatments and the nonmowed check at eight weeks. Little foliar growth occurred after the application date due to hot dry conditions. Two applications per year caused some phytotoxicity to the turf, but all treatments except 180 g ha⁻¹ of ACP 2100 recovered by the twenty-fourth week. Turf did not recover prior to the first frost from three

applications of any PGR. No differences were observed when plots were rated for spring green-up the following year, except for those treated three or four times. All treatments in schedule three and four resulted in a delay in spring green-up. DPX L5300 plus mefluidide afforded the least injury regardless of application interval.

Nomenclature: ACP 2100; chlorsulfuron, 2-chloro-N-[[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide; DPX L5300, methyl 2-[[[[3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-N-methyl-amino]carbonyl]amino]sulfonyl]benzoate; imazapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid; imazethapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-pyridinecarboxylic acid; mefluidide, N-[2,4-dimethyl-5-[[trifluoromethyl]sulfonyl]amino]phenyl]acetamide; metsulfuron, 2-[[[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid; red fescue, Festuca rubra L. #¹ FESRU.

Additional index words. ACP 2100, chlorsulfuron, DPX L5300, growth retardant, imazapyr, imazethapyr, imidazolinone, mefluidide, metsulfuron, rights-of-way, sulfonylurea, turf.

¹Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

INTRODUCTION

Red fescue is a common turf species growing along Virginia highway rights-of-way. Often in this situation, red fescue occurs in mixed stands with tall fescue (Festuca arundinacea Schreb.). These areas may be treated with plant growth regulators mainly for the suppression of the tall fescue turf. Under such circumstances, it is important to evaluate the influence which these PGR's may have on red fescue.

Bhowmik (2) reported mefluidide caused injury to red fescue. Pennucci and Jagschitz (9) found mefluidide provided 5-6 weeks of foliar height suppression, caused no objectionable turf injury, afforded excellent seedhead control, and caused a darker green color within weeks after treatment. They also concluded imazethapyr provided no turf height suppression, turf injury or seedhead control. Johnston and Faulkner (6) found the combination of paclobutrazol (B-[(4-chlorophenyl)methyl]--(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol) plus mefluidide to be effective in reducing growth of red fescue. Sawyer et al. (11) reported that mefluidide reduced the turf clipping weight and height, suppressed seedheads, caused minimal discoloration, but resulted in less dense red fescue-colonial bentgrass (Agrostis tenuis Sibth.) turf than the

nontreated check. Sawyer and Wakefield (10) examined the effects of mefluidide on colonial bentgrass-red fescue turf and a perennial ryegrass (Lolium perenne L.)-red fescue turf. They observed that mefluidide treatments provided complete seedhead suppression of red fescue with good control of vegetative growth and some turf discoloration. Mefluidide was also tested on a Kentucky bluegrass (Poa pratensis L.)-red fescue turf. The turf exhibited fair to poor color, some loss in turf density, but very good seedhead suppression (1, 4, 5). However, the red fescue was not completely suppressed, resulting in a nonuniform appearance (4). In a study conducted by Kavanagh (7), mefluidide was applied five times in three years to a perennial ryegrass-chewings fescue (Festuca rubra var. commutata Gaud.)-browntop bentgrass (Agrostis castellana) turf and a chewings fescue-browntop bentgrass turf. Results indicated mefluidide caused excellent dwarfing but was less effective in reducing fresh weight. Mefluidide controlled flowering and sometimes caused discoloration in the early season. However, mefluidide treated plots were usually noted for their rich green color later in the season.

The objectives of these studies were to determine the influence of metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, imazethapyr plus mefluidide, ACP 2100 and DPX L5300 plus mefluidide applied one, two, three, and four

times annually with multiple applications at intervals of 14 (Schedule 2), 10 (Schedule 3) and six weeks (Schedule 4), respectively, to red fescue.

MATERIALS AND METHODS

Field experiments were conducted in 1987 at two locations, Staunton and Blacksburg, VA., on red fescue growing along Virginia highway rights-of-way. Due to the unknown origin of the soil in the rights-of-way areas, a textural analysis was performed. Staunton soil consisted of 18.4% sand, 60.5% silt, 21.1% clay, and 3.0% organic matter with a pH of 6.9. Blacksburg soil consisted of 14.4% sand, 53.5% silt, 32% clay and 3.4% organic matter with a pH of 6.9.

Treatments consisted of a nonmowed check, imazethapyr plus imazapyr (a prepackaged mix) at 67.5 + 2.5, 96.4 + 3.6, and 115.7 + 4.3 g ha⁻¹; ACP 2100 at 60, 120, and 180 g ha⁻¹, DPX L5300 at 10, 20, and 70 g ha⁻¹, chlorsulfuron at 20 g ha⁻¹, and metsulfuron at 10 g ha⁻¹. Mefluidide at 140 g ha⁻¹ was added to all rates of DPX L5300, chlorsulfuron, and metsulfuron. The initial application was applied on May 6, at Staunton, and on May 11, at Blacksburg. Plots receiving multiple applications were treated at intervals of 14 (Schedule 2), 10 (Schedule 3), and 6 weeks (Schedule 4), respectively, with one application representing schedule 1.

All plots were 1.8 m by 6.1 m. Treatments were applied with a CO₂ backpack sprayer in 280 L water ha⁻¹ with a 0.25%

v/v nonionic surfactant² delivered at 210 kPa utilizing 8003 flat fan tips³.

Treatments were compared for foliar height, quality, and phytotoxicity. Data were collected bimonthly. Height measurements were made from two random locations within each plot. Turf quality was visually evaluated on a scale from 1 to 9, with 6 representing acceptable quality and 9 excellent (8). Factors affecting quality were turf color, density and appearance. Plots with deep green color, with no density loss, and with a uniform appearance received rating of 9. Plots with yellow-brown color, with density reduction of 90%, with nonuniform appearance, or with combinations of these factors received ratings of 1. Phytotoxicity was visually evaluated on a scale from 0 to 100, where 0 represented no injury.

At both locations, a split-block design with four replications was used with application schedules representing the main plots and PGR treatments representing the subplots. Data were subjected to analysis of variance. Treatment means were derived from combined data of two runs. Runs were combined when the variances proved to be not

²X-77. Chevron Chem. Co., San Francisco, CA 94119. Principal functioning agents are alkylaryl polyoxyethylene glycols, free fatty acids, and isopropanol.

³TeeJet 8003 tips. Spraying Systems Co., Wheaton, IL 60287.

significantly different (3, 12). A Waller-Duncan K-ratio t-test was used when appropriate to separate treatment means within levels of individual parameters (13).

RESULTS AND DISCUSSION

Foliar height. All PGR's suppressed foliar growth of red fescue for the first four weeks as compared to the nonmowed check with little differences found between PGR's (Table 1). These results with imazethapyr plus imazapyr were different from those of Pennucci and Jagschitz (7), who found that imazethapyr alone had no growth regulatory effects on red fescue. By the eighth week, lodging in the nonmowed checks resulted in no significant height differences between treatments after one application. Significant differences reoccurred between plots treated once per year as fall growth began in early September. By week 24, there were no rate differences and all PGR treatments afforded lower foliar heights than in the nonmowed check. However, no turf exceeded 40 cm and would be considered acceptable by The Virginia Department of Transportation⁴.

At 18 weeks, four and eight weeks following the second application in application schedule 2 and 3, respectively, metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, and the high rate of ACP 2100 afforded shorter turf heights than when applied once. The high rate of DPX L5300 plus mefluidide also caused greater suppression of turf when

⁴Personnal communication. Everette Stevens, Environmental Specialist, Virginia Department of Transportation, Bristol Highway Department, Bristol, VA.

treated a second time at 10 weeks, relative to one application. These lower height measurements from the retreatment were due mainly to turf injury resulting in lodging, rather than actual growth suppression.

The third treatment resulted in height differences between intervals for metsulfuron plus mefluidide, the upper rates of ACP 2100, and the low rate of imazethapyr plus imazapyr due to significant turf injury. Despite lower height measurements where PGR's were applied, few significant differences in height between PGR treatments were obtained. Foliar height data revealed that no significant differences were achieved using increased rates of imazethapyr plus imazapyr, ACP 2100, or DPX L5300. Three treatments per year of metsulfuron plus mefluidide, the low rate of imazethapyr plus imazapyr, and the high rates of ACP 2100 produced shorter turf, but at the expense of aesthetic value relative to one application per year. There was no beneficial growth suppression when treatments were used more than once per year.

Phytotoxicity. The greatest level of phytotoxicity to turf was elicited by metsulfuron plus mefluidide and the high rate of DPX L5300 plus mefluidide (Table 2). However, the injury caused by these treatments was well within the acceptable range for roadside turf and this discoloration was outgrown by the sixth week. All other treatments

resulted in acceptable turf color after one application and similar turf color was observed with all treatments six weeks after application.

For two applications per year, the second treatment was applied at 14 weeks after the initial application. There were no significant differences between one and two applications per year or between treatments. With three applications per year, the second application occurring at 10 weeks, there was considerably more injury than with one application. By 14 weeks, all PGR's in schedule three caused significant phytotoxicity to the turf with ACP 2100 at 120 and 180 g ha⁻¹ causing the greatest injury of 36 and 44, respectively. The turf discoloration generally had disappeared two weeks later. The high injury rating for metsulfuron plus mefluidide was due to some plants within each plot exhibiting prolonged chlorosis.

By 24 weeks, four weeks after the third application in schedule three, all rates of imazethapyr plus imazapyr, ACP2100, chlorsulfuron plus mefluidide, and metsulfuron plus mefluidide afforded significant phytotoxicity to red fescue, with the latter treatment causing the greatest injury. All PGR's applied three times, with the exceptions of the low rate of ACP 2100 and all rates of DPX L5300 plus mefluidide, caused significantly more discoloration than the other application schedules. Turf fully recovered only from the

low rate of ACP 2100 and imazethapyr plus imazapyr prior to the first frost (data not shown). No significant discoloration to the turf occurred with any rate of DPX L5300 plus mefluidide with the exception of slight injury resulting at 26 weeks with the high rates. However, at week 28, no injury remained for these treatments (Data not shown).

Metsulfuron plus mefluidide caused excessive injury to red fescue when applied three times per year. All other treatments tested provided considerably less injury. However, injury caused by the high rate of imazethapyr plus imazapyr and ACP 2100 in this application schedule would not be considered acceptable.

Overall quality. Differences in quality began to occur by the fourth week (Table 3). All PGR's except the low rate of ACP 2100 afforded turf quality below that of the nonmowed check. With the exception of the high rate of DPX L5300 plus mefluidide, all rates of imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide afforded a higher quality turf than metsulfuron plus mefluidide or chlorsulfuron plus mefluidide. By week 8 there were no significant differences between treatments.

Turf began its fall regrowth around the eighteenth week. At this time, all PGR's with one exception afforded a higher quality turf than the nontreated check. However, as

fall growth continued, only chlorsulfuron plus mefluidide and the high rate of DPX L5300 plus mefluidide, both applied once, resulted in quality ratings similar to the nonmowed check. In general, red fescue treated with PGR's produced a lower quality turf than when not treated. This could have been in part due to excess plant stress from the compounds and the somewhat slow growth habit of red fescue resulting in slow metabolism and prolonged presence of these compounds within the plants. In these studies, red fescue seedhead production did not occur. This is in contrast to tall fescue, which is a prolific seedhead producer in Virginia. Seedhead suppression of tall fescue is the number one target for growth regulation along highway rights-of-way.

Four weeks after the second application in schedule two the high rates of DPX L5300 plus mefluidide afforded superior turf quality to the nontreated plot. This was due mainly to a darker green turf color in these plots. ACP 2100 at 180 g ha^{-1} caused the greatest injury to red fescue and received the lowest quality of 4.5. Turf did not fully recover from this treatment by 24 weeks and remained below acceptable levels of quality until the first frost. Metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, and the high rates of ACP 2100 applied a second time reduced the quality of the turf at 18 weeks relative to one application.

Following the second application at 10 weeks of the three applications per year schedule, metsulfuron plus mefluidide, imazethapyr plus imazapyr, and ACP 2100 treated turf fell below that of acceptable quality and the nontreated check. Quality of these treatments, with the exception of the middle rate of imazethapyr plus imazapyr, became significantly less than when applied once per year.

By 18 weeks, chlorsulfuron plus mefluidide, metsulfuron plus mefluidide and the low and high rates of ACP 2100 still had not allowed turf recovery to equal that of one application per year. With the exception of chlorsulfuron plus mefluidide, turf treated with a second application, regardless of the timing, did not significantly differ in quality at 18 weeks.

At 24 weeks, four weeks after the third treatment of the three applications per year schedule, quality of all PGR treated turf fell below an acceptable level and below that of the nonmowed check. With the exception of the low rate of DPX L5300 plus mefluidide, turf treated three times per year exhibited lower quality than with one application and also, with the exception of chlorsulfuron plus mefluidide, two applications. No turf treated three times reached acceptable quality prior to the first frost.

Four applications. All PGR treatments elicited lower turf height than the nonmowed check throughout the duration of

the study (data not shown). Except for the low rates of DPX L5300 plus mefluidide, at 10 weeks all treatments afforded excessive phytotoxicity after the second application, with the greatest injury occurring from metsulfuron plus mefluidide and the high rate of ACP 2100. Two weeks after the third application at 12 weeks, again all rates caused excessive phytotoxicity, except for the low rate of DPX L5300 plus mefluidide. The greatest effects were noted by the high rate of ACP 2100 with a rating of 75% injury. Following the fourth and final application of this schedule, all rates of DPX L5300 plus mefluidide and the low rate of ACP 2100 had allowed the turf to recover from the discoloration prior to the first frost. However, quality of these treatments fell far below acceptable with the exception of the low rate of DPX L5300 plus mefluidide which afforded the highest turf quality, 5.8, of all PGR's. Nonetheless, no treatment in this interval fully recovered from the PGR effects and turf thinning was noted from all plots the following spring and increased as rate increased.

With all aspects of growth regulation and feasibility taken into account, one application of any PGR tested would be adequate for spring growth suppression of red fescue without injury to the red fescue stand. There were no additional benefits from multiple applications of these PGR's. However, red fescue turf appears tolerant to all

compounds applied twice per year. Future research is needed to find a proper timing of this second application which may have a use in another turf maintenance program. Both three and four applications per year, at these timings, appeared to be injurious to the red fescue stand and would not be recommended.

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Table 1. Effects of one, two and three annual applications of PGR's on foliar height of red fescue four weeks after each application and 8 weeks after initial application^a.

Treatment	Foliar Height (cm)											
	4(all)			8(all)			Weeks After Initial Application			Application Schedule ^b		
(g/ha)	14(1)	14(2)	14(3)	18(1)	18(2)	18(3)	24(1)	24(2)	24(3)	24(1)	24(2)	24(3)
Metsulfuron	10.0	31 bc	26 a	25 aA	25 aA	19 dA	25 abca	19 dB	21 eB	27 bcdA	22 eB	21 eB
Chlorsulfuron	20.0	30 bc	26 a	28 aA	26 aA	24 abA	29 aA	24 abcB	26 bcB	29 bcA	26 b-eA	27 bA
Imazethapyr & Imazapyr	67.5	32 b	26 a	24 aA	22 aA	21 bcdA	28 abA	24 abca	25 bcdA	28 bcdA	26 b-eAB	25 bcdB
Imazethapyr & Imazapyr	96.4	30 bc	27 a	22 aA	24 aA	22 a-dA	24 bca	24 abca	24 cdeA	25 dA	25 cdeA	24 cdeA
Imazethapyr & Imazapyr	115.7	31 bc	25 a	25 aA	24 aA	22 a-dA	28 abA	25 abA	24 cdeA	27 bcdA	26 b-eA	24 cdeA
ACP 2100	60.0	31 bc	27 a	23 aA	23 aA	26 aA	26 abca	27 aA	28 abA	30 bA	29 abA	26 bca
ACP 2100	120.0	30 bc	24 a	23 aA	23 aA	26 aA	25 abca	25 abA	24 cdeA	29 bcA	28 abca	23 deB
ACP 2100	180.0	30 bc	24 a	27 aA	21 aA	21 bcdA	27 abA	22 cdB	23 cdeB	27 bcdA	23 deAB	22 deB
DPX I5300	10.0	31 bc	27 a	25 aA	22 aA	22 a-dA	23 cA	25 abA	25 bcdA	25 dA	26 b-eA	27 bA
DPX I5300	20.0	30 bc	27 a	24 aA	22 aA	21 bcdA	22 cA	23 bcA	26 bcA	28 bcdA	27 bcdA	26 bca
DPX I5300	70.0	28 c	27 a	25 aA	25 aA	23 abca	24 bca	25 abca	22 deB	26 cda	25 c-eA	25 bcdA
Nonmowed	—	35 a	27 a	29 aA	27 aA	26 aA	24 bca	26 abA	29 aA	38 aA	32 aA	37 aA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1) = one application at week 0; 2) = applications at week 0 and 14; 3) = applications at week 0, 10, and 20.

Table 2. Evaluation of one, two and three annual applications of PGR's for phytotoxicity to red fescue four weeks after each application and 8 weeks after initial application^a.

Treatment	Phytotoxicity												
	4(a11) 8(a11)			14(1) 14(2)			14(3) 18(1) 18(2)			18(3) 24(1) 24(2)			24(3)
(g/ha)	10.0	15 a	0a	0 aB	0 aB	28 cdA	0 aB	0 aB	36 aA	0 aB	0 aB	0 aB	62 aA
Metsulfuron	20.0	11 b	0a	0 aB <td>0 aB <td>25 dA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>22 cdA</td> </td></td></td></td></td></td>	0 aB <td>25 dA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>22 cdA</td> </td></td></td></td></td>	25 dA	0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>22 cdA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>22 cdA</td> </td></td></td>	0 bA	0 aB <td>0 aB <td>0 aB <td>22 cdA</td> </td></td>	0 aB <td>0 aB <td>22 cdA</td> </td>	0 aB <td>22 cdA</td>	22 cdA
Chlorsulfuron	67.5	2.5	0 b	0 aB <td>0 aB <td>35 bcA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>16 dA</td> </td></td></td></td></td></td>	0 aB <td>35 bcA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>16 dA</td> </td></td></td></td></td>	35 bcA	0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>16 dA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>16 dA</td> </td></td></td>	0 bA	0 aB <td>0 aB <td>0 aB <td>16 dA</td> </td></td>	0 aB <td>0 aB <td>16 dA</td> </td>	0 aB <td>16 dA</td>	16 dA
Imazethapyr & Imazapyr	96.4	3.6	0 b	0 aB <td>0 aB <td>31 bcDA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>28 cA</td> </td></td></td></td></td></td>	0 aB <td>31 bcDA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>28 cA</td> </td></td></td></td></td>	31 bcDA	0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>28 cA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>28 cA</td> </td></td></td>	0 bA	0 aB <td>0 aB <td>0 aB <td>28 cA</td> </td></td>	0 aB <td>0 aB <td>28 cA</td> </td>	0 aB <td>28 cA</td>	28 cA
Imazethapyr & Imazapyr	115.7	4.3	5 b	0 aB <td>0 aB <td>35 bcA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>38 bA</td> </td></td></td></td></td></td>	0 aB <td>35 bcA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>38 bA</td> </td></td></td></td></td>	35 bcA	0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>38 bA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>38 bA</td> </td></td></td>	0 bA	0 aB <td>0 aB <td>0 aB <td>38 bA</td> </td></td>	0 aB <td>0 aB <td>38 bA</td> </td>	0 aB <td>38 bA</td>	38 bA
ACP 2100	60.0	0 b	0a	0 aB <td>0 aB <td>34 bcA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>14 dA</td> </td></td></td></td></td></td>	0 aB <td>34 bcA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>14 dA</td> </td></td></td></td></td>	34 bcA	0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>14 dA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>14 dA</td> </td></td></td>	0 bA	0 aA <td>0 aA <td>0 aA <td>14 dA</td> </td></td>	0 aA <td>0 aA <td>14 dA</td> </td>	0 aA <td>14 dA</td>	14 dA
ACP 2100	120.0	0 b	0a	0 aB <td>0 aB <td>36 abA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>31 bcB</td> </td></td></td></td></td></td>	0 aB <td>36 abA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>31 bcB</td> </td></td></td></td></td>	36 abA	0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>31 bcB</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>31 bcB</td> </td></td></td>	0 bA	0 aB <td>0 aB <td>0 aB <td>31 bcB</td> </td></td>	0 aB <td>0 aB <td>31 bcB</td> </td>	0 aB <td>31 bcB</td>	31 bcB
ACP 2100	180.0	1 b	0a	0 aB <td>0 aB <td>44 aA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>40 bA</td> </td></td></td></td></td></td>	0 aB <td>44 aA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>40 bA</td> </td></td></td></td></td>	44 aA	0 aA <td>0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>40 bA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aB <td>0 aB <td>0 aB <td>40 bA</td> </td></td></td>	0 bA	0 aB <td>0 aB <td>0 aB <td>40 bA</td> </td></td>	0 aB <td>0 aB <td>40 bA</td> </td>	0 aB <td>40 bA</td>	40 bA
DPX L5300	10.0	3 b	0a	0 aB <td>0 aB <td>12 eA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td></td></td>	0 aB <td>12 eA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td></td>	12 eA	0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td>	0 bA	0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td>	0 aA <td>0 aA <td>0 eA</td> </td>	0 aA <td>0 eA</td>	0 eA
DPX L5300	20.0	4 b	0a	0 aB <td>0 aB <td>11 eA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>2 eA</td> </td></td></td></td></td></td>	0 aB <td>11 eA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>2 eA</td> </td></td></td></td></td>	11 eA	0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>2 eA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>2 eA</td> </td></td></td>	0 bA	0 aA <td>0 aA <td>0 aA <td>2 eA</td> </td></td>	0 aA <td>0 aA <td>2 eA</td> </td>	0 aA <td>2 eA</td>	2 eA
DPX L5300	70.0	6 bc	0a	0 aB <td>0 aB <td>32 bcDA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td></td></td>	0 aB <td>32 bcDA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td></td>	32 bcDA	0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td>	0 bA	0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td>	0 aA <td>0 aA <td>0 eA</td> </td>	0 aA <td>0 eA</td>	0 eA
Nonmowed	--	0 b	0a	0 aA <td>0 aA <td>0 fA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td></td></td>	0 aA <td>0 fA</td> <td>0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td></td>	0 fA	0 aA <td>0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td></td>	0 aA <td>0 bA</td> <td>0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td></td>	0 bA	0 aA <td>0 aA <td>0 aA <td>0 eA</td> </td></td>	0 aA <td>0 aA <td>0 eA</td> </td>	0 aA <td>0 eA</td>	0 eA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller/Duncan K-ratio t-test.

^bApplication schedule 1) = one application at week 0; 2) = applications at week 0 and 14; 3) = applications at week 0, 10 and 20.

Table 3. Effects of one, two and three annual applications of FGR's on overall quality of red fescue four weeks after each application and 8 weeks after initial application^a.

Treatment	Quality												
	4(all)	8(all)	Weeks After Initial Application			Application Schedule ^b							
(g/ha)	14(1)	14(2)	14(3)	18(1)	18(2)	18(3)	24(1)	24(2)	24(3)				
Metsulfuron	10.0	5.6 d	5.7 a	6.0 aA	5.2 aAB	3.3 eB	7.5 bCA	5.7 dCB	5.1 eB	7.2 bodA	7.0 bodA	1.8 hB	
Chlorsulfuron	20.0	5.9 cd	5.7 a	6.5 aA	6.0 aAB	5.5 abcB	8.5 aA	6.0 bCC	7.3 abcB	8.3 abA	6.1 dB	4.6 odB	
Imazethapyr & Imazapyr	67.5	2.5	6.4 b	6.1 a	5.9 aAB	6.1 aA	5.0 bodB	7.1 cdA	6.6 abCA	7.3 abCA	7.4 bodA	7.1 bodA	4.3 cdeB
Imazethapyr & Imazapyr	96.4	3.6	6.5 b	6.1 a	6.0 aA	5.4 aA	5.1 bodA	6.0 eA	6.6 abCA	6.1 cdeA	6.4 dA	6.5 odA	4.4 cdeB
Imazethapyr & Imazapyr	115.7	4.3	6.5 b	6.0 a	6.0 aAB	5.7 aA	4.8 cdB	7.6 abCA	6.9 abCA	6.3 cdeA	6.9 odA	7.5 a-dA	3.6 defB
ACP 2100	60.0	7.0 a	6.3 a	5.8 aAB	6.1 aA	4.8 cdB	7.8 abCA	7.3 abAB	6.6 bodB	7.5 bodA	7.2 bodA	3.5 efgB	
ACP 2100	120.0	6.5 b	6.1 a	6.0 aA	5.6 aAB	4.8 cdB	7.5 bCA	6.8 abCA	6.9 bodA	6.9 cdA	6.9 bodA	2.9 gfb	
ACP 2100	180.0	6.5 b	6.3 a	5.5 aA	5.5 aA	4.5 dB	7.5 bCA	4.5 dB	5.6 deB	7.1 bodA	4.4 eB	2.6 g-hC	
DPX I5300	10.0	6.4 b	6.1 a	5.8 aA	5.6 aA	5.8 abA	7.8 abCA	7.1 abA	7.8 abA	7.1 bodA	7.1 bodA	5.9 bA	
DPX I5300	20.0	6.4 b	6.3 a	6.0 aA	5.5 aA	5.0 bodA	7.2 cA	7.5 aA	7.0 abCA	7.7 bodA	7.5 a-dA	4.8 cB	
DPX I5300	70.0	6.0 c	6.1 a	6.0 aA	6.0 aA	5.8 abA	8.3 abA	7.8 aA	8.3 aA	8.3 abA	8.2 abA	4.8 cB	
Normowed	—	7.0 a	6.0 a	6.0 aA	6.0 aA	6.0 aA	6.0 eA	6.0 bCA	6.0 cdeA	9.0 aA	9.0 aA	9.0 aA	

^aMetsulfuron, chlorsulfuron, and DPX I5300 all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means between columns of the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller/Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = best.

^bApplication schedule 1) = one application at week 0; 2) = application at week 0 and 14; 3) = application at week 0, 10 and 20.

CHAPTER IV

EFFECTS OF MULTIPLE APPLICATIONS OF GROWTH REGULATORS ON 7 MONTH OLD TALL FESCUE

ABSTRACT. Metsulfuron plus mefluidide at 10 plus 140 g ha⁻¹, chlorsulfuron plus mefluidide at 20 plus 140 g ha⁻¹, imazethapyr plus imazapyr at 68 plus 2.5, 96 plus 3.6, and 116 at 4.3 g ha⁻¹, ACP 2100 at 60, 120 and 180 g ha⁻¹, and DPX L5300 plus mefluidide at 10 plus 140, 20 plus 140, and 70 plus 140 g ha⁻¹ were applied to 'KY 31' and 'Rebel' tall fescue to suppress foliar growth and seedhead culm elongation. Turf was evaluated as a highway rights-of-way. All rates of imazethapyr plus imazapyr and the higher rates of ACP 2100 suppressed foliar growth of 'KY 31' tall fescue by 33% and 'Rebel' tall fescue by 40, 52, 48, 40 and 42% in 1988 relative to the nonmowed check. There was minimum discoloration at four weeks and exceptional quality thereafter with these treatments. Chlorsulfuron plus mefluidide caused objectionable injury by four weeks reducing quality as low as 2.0 and 4.0 for 'Rebel' and 'KY 31' tall fescue, respectively, but turf generally recovered by the eighth week. DPX L5300 plus mefluidide did not uniformly suppress seedheads of either cultivar with the greatest suppression (77%) resulting from the 70 plus 140 g

ha^{-1} rate on 'KY 31' tall fescue. Metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, all rates of imazethapyr plus imazapyr, and the higher rates of ACP 2100 afforded 100% seedhead suppression regardless of cultivar. Metsulfuron plus mefluidide regardless of the timing afforded excessive injury to the stand with multiple applications causing 100% stand reduction. ACP 2100 at 60 and 120 g ha^{-1} , imazethapyr plus imazapyr at 68 plus 2.5 g ha^{-1} and DPX L5300 plus mefluidide at 10 plus 140 g ha^{-1} did not significantly reduce quality when applied twice to 'KY 31' tall fescue and to 'Rebel' tall fescue in 1988. The low rate of ACP 2100 and DPX L5300 plus mefluidide did not decrease quality after three applications regardless of cultivar. Nomenclature: ACP 2100; chlorsulfuron, 2-chloro-N[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide; DPX L5300, methyl 2-[[[[(3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-N-methyl-amino]carbonyl]amino]sulfonyl]benzoate; imazapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid; imazethapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-methyl-pyridinecarboxylic acid; mefluidide, N-[2,4-dimethyl-5-[[(trifluoromethyl)sulfonyl]amino]phenyl] acetamide; metsulfuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid; tall fescue

Festuca arundinacea Schreb. 'KY 31' and 'Rebel' #¹ FESAR.

Additional index words. ACP 2100, chlorsulfuron, DPX L5300, growth retardant, imazapyr, imazethapyr, imidazolinone, mefluidide, metsulfuron, rights-of-way, seedling turf, sulfonylurea.

¹Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

INTRODUCTION

Tall fescue is a cool season, bunch-type species that originated in Europe, is adapted to a wide range of soil and climatic conditions, and is grown along Virginia highway rights-of-way (3, 32). The majority of the growth occurs in the spring but tall fescue can grow throughout the year (32). Flowering and stem elongation occurs only during the spring and all subsequent regrowth is vegetative. Growth regulators are primarily used to suppress seedheads and decrease maintenance costs (15). Depending on environmental conditions four to eight weeks of foliar suppression and season long seedhead inhibition can be expected from growth retardants.

Current growth regulators have some use limitations regarding age of turf to be treated and have potential to thin or lower turf density (14). These detrimental aspects of growth regulators may be magnified when applied to recently seeded areas.

In Virginia mefluidide, chlorsulfuron, and metsulfuron are the most used plant growth regulators along highway rights-of-way (6, 27). Mefluidide has been shown to enhance the effect of broadleaf herbicides and is often used in combination with chlorsulfuron and metsulfuron. (5, 6, 7, 16, 18, 20, 27). Both metsulfuron and chlorsulfuron are not

recommended to be applied to tall fescue stands less than one year old (27). Metsulfuron plus mefluidide has injured established tall fescue (28). Chlorsulfuron has been shown to selectively control tall fescue from Kentucky bluegrass (Poa pratensis L.) (17, 19).

Currently, growth regulators with greater safety margins are being developed for use on tall fescue. These growth regulators include ACP 2100 (28), imazethapyr plus imazapyr (9, 10, 28, 30), and DPX L5300 plus mefluidide (28). ACP 2100, imazethapyr, and imazapyr are imidazolinone herbicides which control both monocotyledonous and dicotyledonous annual and perennial weeds (25). Meristematic growth has been shown to cease soon after treatment of imidazolinones (24, 25). Imazapyr is a broad spectrum total vegetation control agent that is used for site preparation and release of conifers (4) as well as for weed control in railroad and industrial settings (24). Imazethapyr has been under research and development for weed control in soybeans [Glycine max (L.) Merr.] and other leguminous crops since 1982 (26). Research has shown that the addition of imazapyr to imazethapyr significantly enhances weed control (23, 31). This appears to hold true for PGR activity as imazethapyr in combination with imazapyr, produced similar or superior foliar and seedhead suppression of 'Rebel' tall fescue compared to mefluidide

(30). DPX L5300 is currently being tested for broadleaf weed control in small grains (1, 2, 11, 12, 13, 21).

With tall fescue comprising the major turf species along Virginia highways, it was chosen for this study. Longevity of stands is often shortened due to excessive rates of chemicals or because of construction (27). Under such circumstances, the Virginia Department of Transportation often reseeds these areas to establish stands of tall fescue. These newly seeded areas can sometimes, be treated the following year with PGR's.

The objectives of this research were to evaluate one to four applications per year of metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide for growth regulation and tolerance of 7-month old 'Rebel' and 'KY 31' tall fescue.

MATERIALS AND METHODS

Field experiments were conducted in 1987 and 1988 on 'KY 31' and 'Rebel' tall fescue seeded in the fall. 'KY 31' tall fescue experiments and the 1988 'Rebel' tall fescue experiment were conducted at the Virginia Tech Airport Research Station, Blacksburg, VA. Plots were seeded on September 20, 1986, and September 1, 1987, respectively. Prior to seeding, 98 kg N ha⁻¹ in the form of 10-10-10 fertilizer was applied to the soil surface. Seventy-three kg N ha⁻¹ in the form of 10-10-10 fertilizer was applied on October 28 and again on March 2 for the 1987 experiment and on October 25 and March 3 for the 1988 experiments. Bromoxynil (3,5-dibromo-4-hydroxybenzotrile) at 0.56 kg ha⁻¹ was applied on September 15, 1987, and 2,4-D (2,4-dichlorophenoxy acetic acid) plus dicamba (3,6-dichloro-2-methoxybenzoic acid) at 0.56 plus 0.28 kg ha⁻¹ respectively, was applied on April 6, 1988, for broadleaf weed control in the 1988 experiments. Soil type was a Groseclose loam (Clayey, mixed, mesic Typic Hapludults) with 3.1% organic matter and a pH of 5.8. Turf was irrigated as needed.

The 1987 'Rebel' tall fescue experiment was conducted in Mecklenburg County, VA, on an Appling sandy loam (Typic Kanhapludult Clayey Kaolinitic Thermic) with pH of 6.7 and organic matter content of 1.9%. Plots were seeded on

September 15, 1986, and supplied with 49 kg N ha⁻¹ per month for a six month period in the form of 20-20-20 fertilizer.

Treatments consisted of a nonmowed check, imazethapyr plus imazapyr (a pre-packaged mix) at 68 + 2.5, 96 + 3.6, and 116 + 4.3 g ha⁻¹, ACP 2100 at 60, 120, and 180 g ha⁻¹, DPX L5300 at 10, 20, and 70 g ha⁻¹, chlorsulfuron at 20 g ha⁻¹, and metsulfuron at 10 g ha⁻¹. Mefluidide at 140 g ha⁻¹ was added to all rates of DPX L5300, chlorsulfuron, and metsulfuron to simulate the Virginia Department of Transportations treatments and to increase seedhead suppression. This rate of mefluidide alone does not afford complete seedhead suppression (6).

Foliar and culm height measurements were randomly selected from two locations within a plot. Seedhead count was taken on a random 0.25 m². Quality was based on a scale from 1 to 9, with 6 representing acceptable quality, 9 representing excellent quality with no seedheads, no density reduction, deep green color and foliar height less than 40 cm, and 1 having more than 75 seedheads per m², being over 60 cm in height or a 90% reduction in density or turf being brown or combinations of the above (22).

Treatments were applied with a CO₂ backpack sprayer in 280 L water ha⁻¹ with a 0.25% v/v nonionic surfactant¹

¹X-77. Chevron Chem. Co., San Francisco, CA 94119. Principal functioning agents are alkylaryl polyoxyethylene glycols, free fatty acids, and isopropanol.

delivered at 210 kPa utilizing 8003 flat fan tips³ to plots measuring 1.8 m by 2.4 m. Treatments were applied one to four times per year to respective plots with initial application occurring on May 14, 1987, and April 19, 1988, for 'KY 31' and on May 10, 1987, and April 19, 1988, for 'Rebel' tall fescue. Tall fescue had developed beyond 100% green-up. All PGR plots were mowed at 12 weeks after initial application to remove weeds. Plots receiving more than one application were treated as follows: schedule two = applications at 0 and 14 weeks; schedule three = applications at 0, 10, and 20 weeks; schedule four = applications at 0, 6, 12, and 18 weeks.

Treatments were arranged in a split-block design with three replications. Application schedule represented the main plots and treatments represented the subplots. An analysis of variance was conducted. Runs were combined when the two variances proved to be not significantly different (8). Treatment means were derived from combined runs for 'KY 31' tall fescue. A Waller-Duncan K-ratio t-test was used when appropriate to separate treatments within levels of individual parameters (29).

³TeeJet 8003 tips. Spraying Systems Co., Wheaton, IL 60287.

RESULTS AND DISCUSSION

REBEL 1987

Foliar height. No differences occurred between treatments in schedule one until after the fall flush of growth at week 24 (Table 1). All PGR's suppressed foliar height relative to the nonmowed check with the greatest reduction occurring from ACP 2100 at 180 g ha⁻¹ and chlorsulfuron plus mefluidide at 20 plus 140 g ha⁻¹. All PGR plots were mowed to 11 cm at 12 weeks to remove weeds and seedheads. Four weeks after the second application, regardless of the schedule, no differences in height between treatments were noted. However at 18 weeks, eight weeks after the second application of schedule three, metsulfuron plus mefluidide and the high rate of imazethapyr plus imazapyr caused complete necrosis of the turf. Chlorsulfuron plus mefluidide and the high rate of ACP 2100 severely decreased turf height due to excessive injury resulting in complete necrosis of many plants. In schedule three, metsulfuron plus mefluidide, chlorsulfuron plus mefluidide and the high rate of imazethapyr plus imazapyr caused excessive turf injury and differed significantly from schedule one and two.

For all schedules at 24 weeks, all PGR's resulted in lower height measurements than the nonmowed check. A second application of metsulfuron plus mefluidide, regardless of

the schedule was detrimental to the turf. Four weeks after the final application of schedule three, chlorsulfuron plus mefluidide and the high rate of imazethapyr plus imazapyr and ACP 2100 resulted in turf necrosis. In schedule three the high rate of imazethapyr plus imazapyr, the high rate of ACP 2100, chlorsulfuron plus mefluidide and metsulfuron plus mefluidide caused complete necrosis. The best growth regulation in schedule two without desiccation of the turf occurred with the high rate of imazethapyr plus imazapyr and for schedule three the middle rate of ACP 2100 and the high rate of DPX L5300 plus mefluidide. Two applications of the high rate of DPX L5300 plus mefluidide also reduced height relative to one application.

Foliar height 1988. All PGR's reduced height throughout the first four weeks (Table 2). Few differences occurred between PGR's with the low rate of ACP 2100 and the lower rates of DPX L5300 plus mefluidide affording the least amount of suppression. By the eighth week metsulfuron plus mefluidide, all rates of imazethapyr plus imazapyr, and the upper rates of ACP 2100 maintained growth regulation.

At 12 weeks, all PGR plots were mowed to 22 cm to remove weeds and seedheads resulting in a significant difference between PGR's and the nonmowed control. Four weeks had elapsed since the second application in schedule three. Metsulfuron plus mefluidide, the upper rates of

imazethapyr plus imazapyr and ACP 2100, and the high rate of DPX L5300 plus mefluidide suppressed growth relative to one application with metsulfuron plus mefluidide and the high rate of ACP 2100 causing the greatest effect.

At 18 weeks, four and eight weeks following the second application in schedule two and three respectively, all rates of imazethapyr plus imazapyr in schedule two reduced turf growth relative to one application. In schedule three, metsulfuron plus mefluidide treatment caused complete necrosis and was the only PGR treatment to reduce foliar height relative to one application. Four weeks following the third application in schedule three at 24 weeks no differences were noted between schedules with the exception of metsulfuron plus mefluidide which afforded complete control of tall fescue. At this time metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, and the upper rates of imazethapyr plus imazapyr afforded the greatest suppression of fall growth by PGR's applied once.

As in 1987, metsulfuron plus mefluidide applied twice regardless of the schedule, proved detrimental to the turf. Quality 1987. No significant differences occurred in quality by four weeks (Table 3). However, at eight weeks metsulfuron plus mefluidide and the high rate of ACP 2100 afforded the poorest quality of the PGR's but remained better than the nonmowed check. No differences occurred

between treatments by the fourteenth week. At this time, four weeks after the second application in schedule three, metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, the upper rates of imazethapyr plus imazapyr, and the high rate of ACP 2100 and DPX L5300 plus mefluidide severely injured the turf, reducing quality below that of the nonmowed and relative to one application. No PGR treatment was acceptable and turf never recovered.

At 18 weeks, four weeks after the second application in schedule two, there was no significant difference between treatments or between schedules one and two. However, in schedule three, multiple applications of metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, the upper rates of imazethapyr plus imazapyr, all rates of ACP 2100 and the high rate of DPX L5300 plus mefluidide afforded lower quality turf than when applied once. Regardless of application schedule, no treatment afforded an acceptable quality turf except the low rate of ACP 2100 at 24 weeks in schedule one after fall growth had begun.

All PGR's afforded higher quality than metsulfuron plus mefluidide and the nonmowed control in schedule one. Metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, the higher rates of imazethapyr plus imazapyr, and the higher rates of ACP 2100 reduced quality of turf when applied two or three times per year relative to one

application. Three applications of the high rate of DPX L5300 plus mefluidide resulted in a lower quality turf than one or two applications. The middle rate of DPX L5300 plus mefluidide was the only multiple application treatment to afford an acceptable quality.

In general, seedling turf was unable to develop and fill in while growth was suppressed during the cooler spring months. Turf entered the summer droughty conditions in poor quality and often became thinned from the additional stress. Although the low rate of ACP 2100 and the middle rate of DPX L5300 plus mefluidide afforded acceptable quality by the end of the season, this prolonged period of unacceptable turf would render growth regulation as undesirable until turf was more established. There were no adequate multiple application treatments as a mowing was needed to remove weeds and seedheads to gain an acceptable quality.

Quality 1988. Quality of turf treated with metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, the high rate of imazethapyr plus imazapyr, and all rates of DPX L5300 plus mefluidide dropped far below acceptable four weeks after treatment (Table 4). The low rate of imazethapyr plus imazapyr and the middle rate of ACP 2100 afforded the highest quality. The low rate of ACP 2100 and all rates of DPX L5300 plus mefluidide received low quality ratings due to seedhead elongation as well as discoloration by the

latter treatments. The most turf discoloration was afforded by metsulfuron plus mefluidide and chlorsulfuron plus mefluidide with the former also thinning the stand.

By the eighth week turf had recovered from the discoloration caused by all treatments except metsulfuron plus mefluidide. The best turf quality was afforded by the middle rate of imazethapyr plus imazapyr and the upper rates of ACP 2100 and exceeded the quality observed with metsulfuron plus mefluidide. By 14 weeks metsulfuron plus mefluidide and the nonmowed check caused lower quality turf than the experimental PGR's with one application. Metsulfuron plus mefluidide and the high rate of DPX L5300 plus mefluidide afforded the poorest turf quality and differed from one application. The high rate of imazethapyr plus imazapyr and ACP 2100, and the low rates of DPX L5300 plus mefluidide also differed from one application with all but the latter treatments remaining above acceptable.

The experimental PGR's at 18 weeks afforded a higher turf quality than metsulfuron plus mefluidide, but all PGR's remained above the nonmowed check. The second application of all PGR's in schedule two resulted in turf quality below acceptable and lower than one application. Turf treated twice in schedule three with metsulfuron plus mefluidide, the high rate of imazethapyr plus imazapyr and ACP 2100, and the upper rates of DPX L5300 plus mefluidide continued to

afford lower quality ratings than one application.

All experimental PGR's afforded excellent quality at 24 weeks and were superior to metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, and the nonmowed check in schedule one. For schedule two, all rates of imazethapyr plus imazapyr and ACP 2100, and the low rate of DPX L5300 plus mefluidide afforded excellent quality turf.

Metsulfuron plus mefluidide, chlorsulfuron plus mefluidide and the higher rates of DPX L5300 plus mefluidide, when applied more than once, regardless of the application schedule, resulted in a lower quality turf than one application. The high rate of imazethapyr plus imazapyr and ACP 2100, and the low rate of DPX L5300 plus mefluidide reduced quality in schedule three as compared to one application.

Seedhead 1987 and 1988. In 1987 only the low rates of DPX L5300 plus mefluidide did not adequately control seedhead culm elongation (Table 7). In 1988 results were similar to 1987 with the exception that the low rate of ACP 2100 failed to sufficiently suppress seedhead culm elongation. All other treatments in both years afforded adequate suppression.

All rates of imazethapyr plus imazapyr, the upper rates of ACP 2100, and chlorsulfuron plus mefluidide were the most consistent treatments for the two years. These treatments

provided adequate growth regulation and seedhead suppression of 7 month old minimal maintenance tall fescue and maintained an acceptable turf quality. Chlorsulfuron plus mefluidide did result in early discoloration that was unacceptable for rough turf but plants quickly outgrew the effect. DPX L5300 plus mefluidide at the low rates did not adequately suppress seedhead elongation and at the high rate was somewhat variable in height and seedhead suppression, rendering this compound inappropriate for growth regulation. Metsulfuron plus mefluidide afforded excessive injury regardless of the schedule.

Further testing is needed to find the appropriate timing for a second application of imazethapyr plus imazapyr and ACP 2100 to provide suppression of fall growth without injury to the turf. Multiple applications of these PGR's gave no beneficial growth suppression relative to one application and did not increase turf quality. Therefore, under these circumstances multiple applications do not appear economical but with proper timing fall growth suppression may be obtained.

"KY 31" EXPERIMENTS

Height. All PGR's reduced turf height relative to the nonmowed check with metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, all rates of imazethapyr plus imazapyr, and the upper rates of ACP 2100 having the

greatest influence by four weeks (Table 5). By eight weeks no differences occurred between the low rates of DPX L5300 plus mefluidide and the nonmowed control. The best suppression was afforded by metsulfuron plus mefluidide, the higher rates of imazethapyr plus imazapyr, and the high rate of ACP 2100.

At 14 weeks, in schedule three, metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, the higher rates of imazethapyr plus imazapyr and ACP 2100 all suppressed turf height relative to one application. At 18 weeks, four weeks after the second application in schedule two, metsulfuron plus mefluidide and the low rates of ACP 2100 gave additional growth suppression with metsulfuron plus mefluidide causing necrosis in schedules two and three. The suppression from the low rates of ACP 2100 was beneficial in slowing the fall growth without unacceptable injury (Table 6).

At 24 weeks, four weeks after the third application in schedule three, metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, the high rate of imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide caused necrosis (Table 5). All these treatments differed from one application. The low rate of DPX L5300 plus mefluidide in schedule three differed from one application but this suppression did not result in turf desiccation. Metsulfuron

plus mefluidide, chlorsulfuron plus mefluidide, and the high rate of DPX L5300 plus mefluidide in schedule two caused necrosis and differed from one application.

Quality. The lower rates of imazethapyr plus imazapyr and the middle rate of ACP 2100 afforded the highest quality turf at 4 weeks (Table 6). At eight weeks, however, the higher rates of imazethapyr plus imazapyr and the middle rate of ACP 2100 resulted in the best turf quality.

Metsulfuron plus mefluidide caused the poorest quality due to excessive turf discoloration and thinning. By 14 weeks all rates of imazethapyr plus imazapyr, ACP 2100, and the low rates of DPX L5300 plus mefluidide afforded excellent turf quality with one application. At this time, four weeks after the second application of schedule three, metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, the higher rates of imazethapyr plus imazapyr and ACP 2100 reduced quality relative to one application with the greatest reduction occurring from metsulfuron plus mefluidide.

At 18 weeks all rates of imazethapyr, ACP 2100, and the lower rates of DPX L5300 maintained excellent quality. Metsulfuron plus mefluidide resulted in the lowest quality with one application. In schedule two, metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, and the high rate of ACP 2100 caused a reduction in quality compared to schedule one with chlorsulfuron plus mefluidide affording

some necrosis and the high rate of ACP 2100 causing excessive discoloration. For schedule three, metsulfuron plus mefluidide and the high rate of DPX L5300 plus mefluidide caused quality reduction relative to one application with metsulfuron plus mefluidide causing complete necrosis in both schedule two and three.

All PGR's except metsulfuron plus mefluidide afforded excellent quality by 24 weeks. At 24 weeks, four weeks after the third application in schedule three, all PGR's caused a reduction in turf quality relative to one application with only the low rate of imazethapyr plus imazapyr, ACP 2100 and DPX L5300 plus mefluidide affording acceptable quality. The low rate of imazethapyr plus imazapyr, the lower rates of ACP 2100 and the low rate of DPX L5300 plus mefluidide in schedule two maintained quality above acceptable levels.

Seedheads. All rates of DPX L5300 plus mefluidide and the low rate of ACP 2100 failed to suppress seedhead culm elongation adequately (Table 7). The low rate of DPX L5300 plus mefluidide did not differ from the nonmowed check. All other treatments prevented seedhead culm elongation.

No additional growth suppression from multiple applications was achieved without sacrificing quality. However, the low rate of ACP 2100, after being mowed to remove weeds and seedheads, did suppress fall growth and

remained acceptable. Therefore, one application of chlorsulfuron plus mefluidide, all rates of imazethapyr plus imazapyr, and the upper rates of ACP 2100 proved to be superior in growth regulation when all aspects are considered. These compounds could be applied to well established 7 month old roadside turf without excessive injury or stand loss and with retention of acceptable quality. Applying these PGR's to turf not well established would result in stand loss. DPX L5300 plus mefluidide did not adequately suppress seedhead elongation and metsulfuron plus mefluidide decreased the density of the stand regardless of the application schedule.

Four applications. The only treatment to receive an acceptable quality rating after the fourth application was the low rate of ACP 2100 when applied to 'KY 31' (data not shown). In this schedule turf quality remained far below that receiving one application and did not afford better quality than schedule two, therefore jeopardizing the feasibility of this schedule. All other treatments caused excessive injury and would not be considered under such conditions.

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Table 1. Effects of one, two and three annual applications of FGR's on foliar height of 7 month old 'Rebel' tall fescue four weeks after each application and 8 weeks after initial application in 1987^a.

Treatment	(g/ha)	Foliar Height										
		4(a11) 8(a11)		14(1) 14(2)		14(1) 14(2)		18(1) 18(2)		18(3) 24(1)		24(3)
Metsulfuron	10.0	19 a	16 a	11 aA	11 aA	13 aA	11 aA	15 aA	0 dB	14 deA	0 fB	0 eB
Chlorsulfuron	20.0	19 a	15 a	11 aA	11 aA	11 aA	12 aA	14 aA	3 cdB	13 eA	16 bodA	0 eB
Imazethapyr & Imazapyr	67.5	2.5	18 a	15 a	12 aA	13 aA	11 aA	13 aA	11 aA	16 cdeA	18 bodA	19 cA
Imazethapyr & Imazapyr	96.4	3.6	18 a	16 a	12 aA	12 aA	12 aA	14 aA	11 aA	20 b-eA	17 bodA	17 cA
Imazethapyr & Imazapyr	115.7	4.3	19 a	18 a	12 aA	12 aA	13 aA	12 aA	0 dB	21 bodA	14 dA	0 eB
ACP 2100	60.0	20 a	20 a	15 aA	15 aA	13 aA	15 aA	13 aA	11 aA	22 bca	17 bodA	18 cA
ACP 2100	120.0	20 a	16 a	14 aA	15 aA	16 aA	16 aA	13 aA	10 abA	18 cdeA	15 cda	13 dA
ACP 2100	180.0	19 a	16 a	11 aA	12 aA	14 aA	11 aA	13 aA	7 bca	13 eA	15 cda	0 eB
DPX L5300	10.0	21 a	20 a	16 aA	15 aA	17 aA	16 aA	15 aA	13 aA	23 bca	20 bA	22 bA
DPX L5300	20.0	19 a	20 a	15 aA	16 aA	16 aA	16 aA	13 aA	14 aA	21 bodA	19 bca	22 bA
DPX L5300	70.0	19 a	19 a	15 aA	16 aA	17 aA	16 aA	14 aA	11 aA	25 bA	17 bodB	14 dB
Nonmowed	--	19 a	19 a	20 aA	19 aA	16 aA	16 aA	15 aA	14 aA	32 aA	36 aA	36 aA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Table 2. Effects of one, two and three annual applications of PGR's on foliar height of 7 month old 'Rebel' tall fescue four weeks after each application and 8 weeks after initial application in 1988a.

Treatment	(g/ha)	Foliar Height										
		4(all) 8(all)		14(1) 14(2)		18(1) 18(2)		18(3) 24(1) 24(2) 24(3)				
		18 e	22 d	21 ba	20 cda	11 fb	24 da	21 bca	0 eb	27 ca	0 fb	0 cb
Metsulfuron	10.0	18 e	22 d	21 ba	20 cda	11 fb	24 da	21 bca	0 eb	27 ca	0 fb	0 cb
Chlorsulfuron	20.0	19 e	32 a-d	21 ba	21 boda	19 bca	25 cda	22 bca	26 boda	28 ca	22 ea	27 ba
Imazethapyr & Imazapyr	67.5	24 de	27 cd	22 ba	24 ba	18 b-ea	26 cda	21 bodb	25 cdab	30 bca	31 boda	31 ba
Imazethapyr & Imazapyr	96.4	19 e	26 cd	21 ba	21 boda	12 defb	25 cda	19 bodb	25 cda	28 ca	26 dea	24 ba
Imazethapyr & Imazapyr	115.7	21 de	27 cd	21 ba	21 boda	15 b-fb	26 cda	18 odb	27 boda	28 ca	30 boda	30 ba
ACP 2100	60.0	28 cd	37 abc	22 ba	20 cda	18 b-ea	27 boda	17 da	23 da	32 ba	31 boda	30 ba
ACP 2100	120.0	24 de	31 bcd	20 ba	19 cda	13 c-fb	25 cda	21 boda	25 cda	30 bca	31 boda	25 ba
ACP 2100	180.0	23 de	25 cd	20 ba	21 boda	11 fb	24 da	20 boda	24 da	30 bca	34 ba	31 ba
DPX L5300	10.0	37 b	41 ab	22 ba	23 bca	20 ba	30 ba	23 ba	29 bca	32 ba	32 bca	29 ba
DPX L5300	20.0	34 bc	33 a-d	21 ba	20 boda	18 b-ea	30 ba	21 bca	30 ba	30 bca	27 odea	30 ba
DPX L5300	70.0	24 de	33 a-d	21 ba	18 dAa	12 defb	24 da	20 boda	23 da	31 ba	29 boda	25 ba
Normowed	—	40 a	44 a	39 aA	38 aA	39 aA	43 aA	42 aA	43 aA	43 aA	41 aA	49 aA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Table 3. Effects of one, two and three annual applications of PGR's on quality of 7 month old 'Rebel' tall fescue four weeks after each application and 8 weeks after initial application in 1987a.

Treatment	Quality												
	4(all)	8(all)	Weeks After Initial Application			Application Schedule ^b							
(g/ha)	14(1)	14(2)	14(3)	18(1)	18(2)	18(3)	24(1)	24(2)	24(3)				
Metsulfuron	10.0	5.3 a	2.3 b	3.7 aA	3.7 aA	2.7 aA	2.7 aA	2.7 aA	1.0 cB	2.5 bA	1.0 cB	1.0 eB	
Chlorsulfuron	20.0	5.7 a	5.0 ab	4.3 aA	4.0 aA	1.0 cB	4.7 aA	4.0 aA	1.0 cB	5.8 aA	1.7 cB	1.0 eB	
Imazethapyr & Imazapyr	67.5	2.5	6.3 a	5.3 ab	4.3 aA	4.7 aA	3.0 abCA	5.0 aA	4.3 aA	3.1 abCA	6.1 aA	3.7 abCA	3.3 bcdA
Imazethapyr & Imazapyr	96.4	3.6	6.3 a	5.3 ab	4.7 aA	4.7 aA	1.3 bcB	4.7 aA	4.6 aA	1.4 bcB	6.1 aA	3.3 abcB	1.7 deB
Imazethapyr & Imazapyr	115.7	4.3	6.3 a	5.3 ab	5.0 aA	4.7 aA	1.3 bcB	4.7 aA	5.0 aA	1.4 bcB	6.0 aA	2.7 bcB	1.0 eB
ACP 2100	60.0	7.0 a	5.3 ab	4.7 aA	5.3 aA	3.3 aA	6.0 aA	5.7 aA	3.6 abB	6.3 aA	5.0 abA	4.0 abCA	
ACP 2100	120.0	6.7 a	5.0 ab	4.7 aA	5.0 aA	4.0 aA	4.3 aA	3.0 aA	1.3 bcB	6.3 aA	2.7 bcB	2.0 cdeB	
ACP 2100	180.0	6.7 a	4.3 b	4.3 aA	4.0 aA	1.0 cB	3.3 aA	2.7 aA	1.0 cB	6.0 aA	2.3 bcB	1.3 deB	
DPX I5300	10.0	6.3 a	5.7 a	4.0 aA	5.0 aA	4.0 aA	4.3 aA	4.3 aA	4.2 aA	6.2 aA	5.7 aA	4.0 abCA	
DPX I5300	20.0	6.3 a	5.3 ab	4.3 aA	5.0 aA	4.0 aA	5.6 aA	3.7 aA	4.2 aA	6.3 aA	6.0 aA	5.0 abA	
DPX I5300	70.0	6.3 a	5.3 ab	4.7 aA	5.0 aA	1.3 bcB	5.3 aA	4.3 aA	1.2 bcB	6.0 aA	5.0 abA	1.7 deB	
Nonmowed	--	6.3 a	1.0 c	4.3 aA	4.0 aA	4.0 aA	4.7 aA	4.6 aA	4.0 aA	2.0 bA	2.0 cA	2.0 cdeA	

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication Schedule 1 = one application at week 0; 2 = applications at week 0 and 14; 3 = applications at week 0, 10, and 20.

Table 4. Effects of one, two and three annual applications of FGR's on quality of 7 month old 'Rebel' tall fescue four weeks after each application and 8 weeks after initial application in 1988^a.

Treatment	Quality																																			
	4 (all)			8 (all)			14 (1)			14 (2)			14 (3)			18 (1)			18 (2)			18 (3)			24 (1)			24 (2)			24 (3)					
(g/ha)																																				
Metsulfuron	10.0	2.0	de	3.0	cd	6.0	ba	6.0	ba	3.3	fb	5.0	ba	1.7	eb	3.3	bb	5.0	ca	1.0	db	1.0	eb													
Chlorsulfuron	20.0	2.0	de	6.0	abc	7.5	aba	7.7	aa	5.0	deFA	7.7	aba	3.0	db	7.0	aa	7.5	ba	1.3	dc	3.7	cdB													
Imazethapyr & Imazapyr	67.5	2.5	7.0	a	7.5	ab	9.0	aa	9.0	aa	8.7	aba	9.0	aa	5.0	abb	8.0	aa	8.8	aba	8.0	aa	6.0	ba												
Imazethapyr & Imazapyr	96.4	3.6	5.0	b	8.0	a	9.0	aa	9.0	aa	7.7	abca	9.0	aa	5.3	abb	8.0	aa	9.0	aa	7.7	aa	6.0	ba												
Imazethapyr & Imazapyr	115.7	4.3	4.5	bc	7.0	ab	9.0	aa	9.0	aa	6.7	bcdB	9.0	aa	4.3	bcc	6.7	ab	9.0	aa	7.3	abAB	5.7	bcB												
ACP 2100	60.0	5.0	b	5.0	bc	9.0	aa	8.7	aa	9.0	aa	9.0	aa	5.7	ab	8.3	aa	8.7	aba	8.0	aa	6.0	ba													
ACP 2100	120.0	7.0	a	7.5	ab	9.0	aa	8.7	aa	7.3	abca	9.0	aa	5.3	abc	8.0	aa	9.0	aa	8.0	aa	6.7	ba													
ACP 2100	180.0	5.0	b	8.0	a	9.0	aa	9.0	aa	6.7	bcdB	9.0	aa	5.3	abb	7.3	ab	9.0	aa	8.0	aaB	6.3	bb													
DPX L5300	10.0	2.0	de	2.5	cd	9.0	aa	9.0	aa	6.3	cdeB	9.0	aa	5.3	abb	7.3	aa	8.5	aba	7.3	abAB	5.0	bcB													
DPX L5300	20.0	3.0	cd	5.0	bc	9.0	aa	7.7	aa	5.7	cdeB	9.0	aa	4.7	abc	7.3	ab	8.4	aba	5.7	bcB	5.0	bcB													
DPX L5300	70.0	4.0	bc	5.0	bc	9.0	aa	8.7	aa	4.3	efB	9.0	aa	3.3	cdB	6.7	ab	8.9	aa	4.0	cb	2.3	deB													
Nonmowed	--	1.0	e	1.0	e	1.0	ca	1.0	ca	1.0	ga	1.0	ca	1.0	ea	1.0	ca	1.0	da	1.0	da	1.0	ea													

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication Schedule 1 = one application at week 0; 2 = applications at week 0 and 14; 3 = applications at week 0, 10, and 20.

Table 5. Effects of one, two and three annual applications of PGR's on foliar height of 7 month old 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application^a.

Treatment	(g/ha)	Foliar Height										
		4(all) 8(all)		Weeks After Initial Application		Application Schedule ^b						
		14(1)	14(2)	14(3)	18(1)	18(2)	18(3)	24(1)	24(2)	24(3)		
		(cm)										
Metsulfuron	10.0	22 e	21 f	18 ba	17 dA	4 gB	21 eA	8 fB	0 fB	27 eA	0 dB	0 dB
Chlorsulfuron	20.0	22 e	27 de	19 ba	20 bCA	13 eFB	26 cDA	26 bodA	26 deA	28 eA	17 cB	6 dB
Imazethapyr & Imazapyr	67.5	22 e	32 bod	19 ba	18 cDA	17 deA	29 bodA	30 bCA	31 ba	33 cdeA	32 abA	26 ba
Imazethapyr & Imazapyr	96.4	22 e	25 ef	19 ba	20 bCA	13 eFB	27 cDA	26 bodA	27 cdeA	30 deA	30 ba	29 ba
Imazethapyr & Imazapyr	115.7	22 e	25 ef	18 ba	20 bCA	13 eFB	26 cDA	26 bodA	27 cdeA	30 deA	27 ba	10 cdB
ACP 2100	60.0	27 c	32 bod	20 ba	21 bCA	18 cDA	30 bCA	22 deB	30 bCA	35 bodA	36 abA	29 ba
ACP 2100	120.0	22 e	28 cde	20 ba	19 cDA	13 eFB	28 bodA	22 deB	27 cdeA	35 bodA	34 abA	27 ba
ACP 2100	180.0	22 e	24 ef	18 ba	20 bCA	11 fB	25 dA	20 eA	24 eA	32 cdeA	32 abA	0 dB
DPX I5300	10.0	30 b	36 ab	20 ba	23 ba	22 bCA	32 ba	30 ba	29 bodA	37 ba	33 abA	31 abb
DPX I5300	20.0	29 b	37 ab	20 ba	23 ba	25 ba	32 ba	30 ba	31 ba	36 bCA	34 abA	33 abA
DPX I5300	70.0	24 d	33bc	19 ba	20 bCA	19 cDA	29 bodA	22 deA	29 bodA	30 deA	0 dC	22 bcB
Notmowed	--	33 a	41 a	39 aA	39 aA	39 aA	46 aA	48 aA	40 aA	43 aA	40 aA	44 aA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Table 6. Effects of one, two and three annual applications of FCR's on quality of 7 month old 'KY 31' tall fescue four weeks after each application and 8 weeks after initial application^a.

Treatment	Quality																					
	4 (all)		8 (all)		14 (1)		14 (2)		14 (3)		18 (1)		18 (2)		18 (3)		24 (1)		24 (2)		24 (3)	
Metsulfuron	10.0	3.0 f	2.3 f	3.7 cA	3.7 cA	1.0 eB	3.0 cA	1.0 dB	1.0 dB	1.0 CB	3.7 BA	1.0 dB	1.0 dB	1.0 CB	3.7 BA	1.0 dB	1.0 dB	1.0 dB	1.0 dB	1.0 CB	1.0 CB	
Chlorsulfuron	20.0	4.0 e	5.7 c	7.2 bA	6.3 bA	2.5 deB	7.6 bA	2.5 cB	6.5 abA	8.6 aA	1.0 dB	1.0 dB	1.0 dB	1.0 CB	8.6 aA	1.0 dB	1.0 dB	1.0 dB	1.0 dB	1.0 CB	1.0 CB	
Imazethapyr & Imazapyr	67.5	2.5	6.3 a	6.0 bc	9.0 aA	9.0 aA	7.7 aA	9.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA
Imazethapyr & Imazapyr	96.4	3.6	6.7 a	6.7 ab	9.0 aA	9.0 aA	9.0 aA	5.3 bcB	9.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA
Imazethapyr & Imazapyr	115.7	4.3	5.0 cd	7.0 a	8.5 aA	8.3 aA	2.3 deB	8.6 aA	7.3 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA
ACP 2100	60.0	5.3 bc	4.7 d	9.0 aA	8.7 aA	9.0 aA	9.0 aA	8.3 aA	8.3 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA
ACP 2100	120.0	6.7 a	7.0 a	9.0 aA	8.7 aA	8.7 aA	4.0 cdB	9.0 aA	7.7 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA
ACP 2100	180.0	6.0 ab	4.7 d	9.0 aA	7.7 abA	2.0 deB	9.0 aA	4.2 bB	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA
DPX L5300	10.0	4.0 e	3.7 e	9.0 aA	9.0 aA	8.7 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA	9.0 aA
DPX L5300	20.0	4.3 de	4.7 d	9.0 aA	9.0 aA	7.3 abA	9.0 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA	7.7 aA
DPX L5300	70.0	5.0 cd	6.3 abc	7.1 bA	7.0 abA	5.0 cA	7.6 bA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA	8.0 aA
Not mowed	--	1.0 g	1.0 g	1.0 dA	1.0 dA	1.0 eA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA	1.0 dA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication Schedule 1 = one application at week 0; 2 = applications at week 0 and 14; 3 = applications at week 0, 10, and 20.

Table 7. 'KY 31' and 'Rebel' tall fescue seedhead data for 1987 and 1988. Data from combined means of all application schedules^a. 'KY 31' data from combined years.

Treatment	(g/ha)	Seedhead					
		1987		'Rebel' 1988		'KY 31' all	
		ht (cm)	# (sq. m)	ht (cm)	# (sq. m)	ht (cm)	# (sq. m)
Metsulfuron	10.0	0 c	0 c	0 c	0 e	0 d	0 d
Chlorsulfuron	20.0	0 c	0 c	0 c	0 e	0 d	0 d
Imazethapyr & Imazapyr	67.5 2.5	0 c	0 c	0 c	0 e	0 d	0 d
Imazethapyr & Imazapyr	96.4 3.6	0 c	0 c	0 c	0 e	0 d	0 d
Imazethapyr & Imazapyr	115.7 4.3	0 c	0 c	0 c	0 e	0 d	0 d
ACP 2100	60.0	31 b	5 c	30 b	18 cd	30 bc	36 bc
ACP 2100	120.0	0 c	0 c	0 c	0 e	0 d	0 d
ACP 2100	180.0	0 c	0 c	0 c	0 e	0 d	0 d
DPX L5300	10.0	30 b	15 b	43 ab	68 ab	40 ab	98 ab
DPX L5300	20.0	29 b	12 b	36 b	24 bc	36 b	52 b
DPX L5300	70.0	0 c	0 c	13 bc	5 de	18 c	14 c
Nonmowed	—	42 a	31 a	63 a	106 a	61 a	147 a

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

CHAPTER V

TALL FESCUE ROOT RESPONSES TO PLANT GROWTH REGULATORS

Abstract. Greenhouse experiments were conducted to evaluate metsulfuron plus mefluidide at 10 plus 140 g ha⁻¹, chlorsulfuron plus mefluidide 20 plus 140 g ha⁻¹, imazethapyr plus imazapyr at 68 plus 2.5, 96 plus 3.6, and 116 plus 4.3 g ha⁻¹, ACP 2100 at 60, 120, and 180 g ha⁻¹, and DPX L5300 plus mefluidide at 10 plus 140, 20 plus 140, and 70 plus 140 g ha⁻¹ applied one, two, three, and four times annually, for possible effects on tall fescue root development. Applied once, all rates of imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide resulted in tall fescue plants with root dry weights of 0.5, 0.5, and 0.6 g, respectively, relative to metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, or the mowed control which resulted in root dry weights of 0.1, 0.3, and 0.2 g, respectively, but did reduce shoot fresh weights by 24, 35, and 25% and shoot dry weights by 31, 31, and 18%, relative to the nonmowed control. Tall fescue treated twice annually with ACP 2100 and DPX L5300 plus mefluidide resulted in root volume of 1.4 and 4.4 cc and root dry weights of 0.2 and 0.6 g compared to metsulfuron plus mefluidide and chlorsulfuron plus mefluidide which afforded root volumes of 0.4 and 0.7 cc and root dry weights of 0.1

and 0.1 g. DPX L5300 plus mefluidide, after two applications, also produced greater root volume and dry weight than the mowed treatment which afforded root volume of 3.0 cc and root dry weight of 0.4 g. In general, tall fescue treated with imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide afforded less root injury than metsulfuron plus mefluidide and chlorsulfuron plus mefluidide. The imidazolinones caused substantial injury to roots when applied as three treatments applied at 10 week intervals. With four annual applications, DPX L5300 plus mefluidide treated tall fescue had a root volume and dry weight of 3.4 cc and 0.5 g which was greater than the other chemical treatments but reduced root volume and dry weight by 40 and 44% relative to the nonmowed treatment. The imidazolinone treatments afforded excessive injury to tall fescue with four treatments per year. Nomenclature: ACP 2100, (not released); chlorsulfuron, 2-chloro-N-[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide; DPX L5300, methyl 2-[3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-N-methyl-amino]carbonyl]amino]sulfonyl]benzoate; imazapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid; imazethapyr, (\pm)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-pyridinecarboxylic acid; mefluidide, N-[2,4-dimethyl-5-

[[(trifluoromethyl)sulfonyl]amino]phenyl]acetamide;
metsulfuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-
yl)amino]carbonyl]amino]sulfonyl]benzoic acid; tall fescue
festuca arundinacea Schreb. #¹ FESAR.

Additional index words. ACP 2100, chlorsulfuron, DPX L5300,
growth retardant, imazapyr, imazethapyr, imidazolinone,
mefluidide, metsulfuron, root, sulfonylurea.

¹Letters following this symbol are a WSSA-approved
computer code from Composite List of Weeds, Weed Sci. 32,
Suppl. 2. Available from WSSA, 309 West Clark Street,
Champaign, IL 61820.

INTRODUCTION

The use of plant growth regulators (PGR's) along Virginia highway rights-of-way has increased substantially in recent years (16). Tall fescue stands, in areas treated with plant growth regulators, often appear to degenerate with time (16). One possible answer to the reduction of turf hardness in some instances may be reduction of root and tiller development caused by the use of plant growth regulators (16). Investigators have often dealt with chemical effects on above ground biomass with little attention devoted to root development.

In studies concerning root to shoot ratios, Crider (4) found that stoppage of root growth failed to take place in both single and repeated percentage-clipping tests only when 40% or less of the foliage was removed. The Virginia Department of Transportation often removes 50 to 80% of the foliage when mowing occurs. Crider (4) also reported that the length of the roots of turfgrass increased in direct proportion to the height to which the tops had grown. Ideally if a PGR could inhibit above ground vertical growth without limiting tillering or subterranean growth resulting in a healthier and more vigorous stand of turf than under a mowing regime.

Many commercial PGR's have been shown to inhibit

turfgrass rooting (5), while others show no adverse effects (17). Concentrations of chlorsulfuron as low as 1 ppb significantly inhibited corn (Zea mays L.) root growth and higher concentrations inhibited shoot growth within two to four hours of treatment (1). Recommended use rates of chlorflurenol (methyl 2-chloro-9-hydroxyfluorene-9-carboxylate), maleic hydrazide (1,2-dihydro-3,6-pyridazinedione) and mefluidide (5) have been shown to inhibit Kentucky bluegrass (Poa pratensis L.) rooting in sand culture. Root inhibition by PGR's in a field environment has not been well documented (5, 8). Prinster and Watschke (12) reported mefluidide plus metsulfuron caused the greatest reduction in tall fescue tiller dry weights followed by EPTC (S-ethyl dipropylcarbamoate). They (12) also found tall fescue turf treated with mefluidide plus metsulfuron tended to have the fewest tillers while glyphosate (N-(phosphonomethyl)glycine) plus chlorsulfuron treated turf did not differ in tiller number relative to nontreated turf. Elkins, Vandeventer and Briskovich (9) reported that mefluidide significantly reduced tall fescue height of top growth, root length, volume and dry weight as well as tiller number. They found that when turf height or dry weight of tops was significantly decreased, one or two parameters of root development were severely affected. Mefluidide had no

effect on red fescue or Kentucky bluegrass root length or weight, or root to shoot weight ratio after three consecutive annual applications (2). No deleterious effects to red fescue or Kentucky bluegrass tiller and root recuperative potential were found after treatment with mefluidide (6).

Chlorsulfuron, a common used PGR, has been reported to cause injury to tall fescue at a rate of 71 g ha^{-1} (10, 11). Metsulfuron has been shown to provide some growth retardation of bermudagrass [Cynodon dactylon (L.) Pers.] alone but effects were enhanced when in combination with sulfometuron (13). ACP 1910 (30 g ha^{-1}), ACP 2100 (20 to 60 g ha^{-1}) and ACP 2110 (25 to 75 g ha^{-1}) more than doubled stolon branching of common bermudagrass at four and seven weeks after treatment (7). Studies (16) have shown ACP 1911X, ACP 2100 and DPX L5300 plus mefluidide treatments to afford less injury to tall fescue roots than chlorsulfuron plus mefluidide or metsulfuron plus mefluidide.

The objective of these studies was to determine the influence of imazethapyr plus imazapyr, ACP 2100, DPX L5300 plus mefluidide on tall fescue shoot and root development as compared to metsulfuron plus mefluidide and chlorsulfuron plus mefluidide.

MATERIALS AND METHODS

Greenhouse studies were conducted in 1987 on 'KY 31' tall fescue. Field plots located along highway rights-of-way near Staunton and Shawsville, VA, were treated with one, two, three and four applications per year. Initial application was made on April 19 to Staunton plots and on May 1 to Shawsville plots when fescue reached the mid to late boot stage of growth. For plots receiving two, three and four treatments per year, applications were made at 14; 10 and 20; and 6, 12 and 18 weeks, respectively, after the initial treatment.

Treatments consisted of mowed and nonmowed plots, imazethapyr plus imazapyr (a pre-package mix) at rates of 68 + 2.5, 96 + 3.6, and 116 + 4.3 g ha⁻¹; ACP 2100 at 60, 120, and 180 g ha⁻¹, DPX L5300 at 10, 20, and 70 g ha⁻¹, chlorsulfuron at 20 g ha⁻¹, and metsulfuron at 10 g ha⁻¹. Mefluidide at the rate of 140 g ha⁻¹ was added to all rates of DPX L5300, chlorsulfuron, and metsulfuron. All treatments contained a nonionic surfactant² at 0.25% v/v. Treatments were applied to field plots with a CO₂ backpack sprayer in 280 L water ha⁻¹ delivered at 210 kPa utilizing

²X-77. Chevron Chem. Co., San Francisco CA 94119. Principal functioning agents are alkylaryl polyoxyethylene glycols, free fatty acids, and isopropanol.

8003 flat fan tips³.

Three tall fescue cores, measuring 10 cm in diameter, were removed from field plots 10 days after the last treatment of the interval was applied. Each core was trimmed to a uniform depth of 7 cm and placed in 15 cm plastic pots containing sterilized sand, similar to methods used by Elkins et al. (9). Pots were placed in the greenhouse on benches where the temperatures were maintained at 29/21 C (day/night), respectively. A weekly application of 0.12 g N, 0.03 g P, and 0.10 g K in the form of a 20-20-20 water soluble fertilizer was applied per pot to prevent nutrient deficiency. Mowed controls were trim mowed to 15 cm weekly. The above ground biomass was harvested 56 days after treatment for fresh and dry matter determination. Cores were then removed from the sand where upon root volume and dry weight was determined. Only those roots below the soil-core line, which indicated new root growth after treatment, were considered. Root volume was determined by water displacement in a graduated cylinder.

A randomized complete block design with three replications and three cores per replication was used and each greenhouse experiment was repeated. Treatment means were derived from combined data of the two runs. Runs

³TeeJet 8003 tips. Spraying Systems Co., Wheaton, IL 60287.

were combined when the two variances proved to be not significantly different (3, 14). Statistical evaluation was by analysis of variance. Class comparisons were used to separate treatments and regressions (linear, quadratic) were used to define trends of ACP 2100 and imazethapyr plus imazapyr (15).

RESULTS AND DISCUSSION

One application per year. With one application, ACP 2100, imazethapyr plus imazapyr, and DPX L5300 plus mefluidide proved less injurious to tall fescue roots than metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, or the mowed treatment, but still suppressed above ground biomass relative to the nonmowed treatment (Table 1). DPX L5300 plus mefluidide did not differ in root volume or dry weight compared to the nonmowed treatment.

Regression analysis revealed rate effects of imazethapyr plus imazapyr on shoot parameters and of ACP 2100 on shoot fresh weight and root volume (Table 2).

Two applications per year. Plants treated with the experimental growth regulators twice annually at a 14 week interval reduced root growth compared to the nonmowed treatment with ACP 2100 and imazethapyr plus imazapyr also reducing root growth relative to the mowed treatment (Table 1). ACP 2100 and DPX L5300 plus mefluidide caused less injury to tall fescue than either metsulfuron plus mefluidide or chlorsulfuron plus mefluidide with DPX L5300 affording greater root volume and dry weights than the mowed treatment. ACP 2100 and imazethapyr plus imazapyr reduced top growth of tall fescue while all experimental growth regulators decreased the root growth. DPX L5300 plus

mefluidide caused the least amount of injury to tall fescue while imazethapyr plus imazapyr treated plants resulted in the most injury with two applications.

Regression analysis revealed a decrease in shoot fresh and dry weight as rates of imazethapyr plus imazapyr increased (Table 2). Root volume and dry weight of tall fescue followed this same trend when treated with ACP 2100. Three applications per year. Although, in general, the experimental growth regulators showed less detrimental effects on tall fescue than metsulfuron plus mefluidide and chlorsulfuron plus mefluidide, three treatments of ACP 2100 and imazethapyr plus imazapyr afforded serious injury during the eight week examination period, which would jeopardize treatments three times annually at ten week intervals (Table 1). Metsulfuron plus mefluidide caused complete necrosis. DPX L5300 plus mefluidide showed potential for three annual treatments and requires further testing before a final conclusion can be drawn.

Regression analysis results indicated as rates of imazethapyr plus imazapyr increased shoot fresh and dry weights and root dry weights decreased (Table 2). There was a decrease in shoot fresh and dry weights and root volume as rates of ACP 2100 increased. Four applications per year. As with three applications, metsulfuron plus mefluidide applied four times per year

resulted in complete necrosis of tall fescue (Table 1). Root growth results were similar for turf treated with chlorsulfuron plus mefluidide, ACP 2100, and imazethapyr plus imazapyr. ACP 2100 and imazethapyr plus imazapyr applied four times annually at six week intervals afforded unacceptable injury to tall fescue and would not be recommended provided data from this experiment can be duplicated under field conditions. DPX L5300 plus mefluidide did show a greater margin of safety to tall fescue, and further research on this compound is needed to determine its fate under field conditions.

Regression analysis indicated as rates of imazethapyr plus imazapyr increased shoot parameters decreased and as rates of ACP 2100 increased there was a decrease in all parameters measured (Table 2).

Overall, ACP 2100 and imazethapyr plus imazapyr applied once provided excellent growth regulation of tall fescue foliage with less root reduction than the mowed treatment, metsulfuron plus mefluidide or chlorsulfuron plus mefluidide. Additional treatments of these two experimental compounds proved somewhat detrimental to the root growth of tall fescue. DPX L5300 plus mefluidide did not always suppress foliar growth of tall fescue but appeared less detrimental to root development. These compounds are currently being tested in the field for their growth

regulation abilities on above ground biomass.

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Table 1. Class comparisons and means for shoot fresh and dry weights, and root volume and dry weights 6 weeks after treatment for 1-4 annual treatments of ACP 2100, ACP 1911X and DPX L5300 plus mefluidide on tall fescue contrasted with metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, mowed, and normowed treatments.^a

Class Comparisons ^b	1 Application			2 Applications			3 Applications			4 Applications		
	Shoot		Root	Shoot		Root	Shoot		Root	Shoot		Root
	FWT	DWT	Vol	FWT	DWT	Vol	FWT	DWT	Vol	FWT	DWT	Vol
ACP 2100 vs metsulfuron	**	**	NS	**	**	**	**	**	**	**	**	NS
ACP 2100 vs chlorsulfuron	NS	NS	NS	*	*	*	**	**	*	NS	**	NS
ACP 2100 vs mowed	NS	**	NS	NS	**	**	**	NS	**	**	**	**
ACP 2100 vs normowed	**	**	**	**	**	**	**	**	**	**	**	**
Ime & ima vs metsulfuron	**	**	*	**	**	NS	**	**	**	**	**	NS
Ime & ima vs chlorsulfuron	**	NS	NS	NS	NS	NS	**	**	**	*	**	NS
Ime & ima vs mowed	NS	**	NS	NS	**	**	**	**	**	**	**	**
Ime & ima vs normowed	**	**	*	**	**	**	**	**	**	**	**	**
DPX L5300 vs metsulfuron	**	**	**	**	**	**	**	**	**	**	**	**
DPX L5300 vs chlorsulfuron	**	**	NS	**	**	**	**	**	**	**	**	**
DPX L5300 vs mowed	NS	**	NS	**	**	**	NS	**	NS	*	**	NS
DPX L5300 vs normowed	**	**	NS	NS	**	**	**	**	**	**	**	**
Ime & ima vs ACP 2100	**	NS	NS	NS	*	**	*	**	*	NS	NS	NS
Ime & ima vs DPX L5300	NS	*	NS	**	**	**	**	**	**	**	**	**
DPX L5300 vs ACP 2100	*	**	*	**	**	**	**	**	**	**	**	**
Metsulfuron	4.7	1.5	0.9	0.1	7.0	1.3	0.4	0.1	0.0	0.0	0.0	0.0
Chlorsulfuron	7.6	2.4	1.6	0.3	11.5	2.2	0.7	0.1	3.3	0.8	0.1	0.0
Imazethapyr & imazapyr	9.9	2.7	1.6	0.5	9.9	2.0	0.7	0.1	5.9	1.9	0.3	0.1
ACP 2100	8.5	2.7	1.4	0.5	11.6	2.3	1.4	0.2	7.0	2.5	0.7	0.1
DPX L5300	9.7	3.2	1.9	0.6	20.4	3.9	4.4	0.6	11.4	3.9	2.3	0.4
Mowed	9.5	1.7	1.7	0.2	11.0	2.0	3.0	0.4	11.0	2.8	2.8	0.5
Normowed	13.0	3.9	2.3	0.7	19.3	4.1	5.6	0.9	17.7	5.6	6.1	0.9

^aFWT = fresh weight, DWT = dry weight, Vol = volume, Ime = imazethapyr, Ima = imazapyr, Metsulfuron, chlorsulfuron, and DPX L5300 all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v.

^b*, ** significant at the 5% and 1% level, respectively.

Table 2. Regression equations and R^2 values for the relationship between tall fescue shoot fresh weight, shoot dry weight, root volume, or root dry weight and rate of ACP 1911X and ACP 2100.

# of Appl.	Growth Regulator	Equation ^a	R^2
1	Ime & Ima	SFWT = $-18.66 + 8.48X - 0.59X^2$	0.42
1	Ime & Ima	SDWT = $4.28 - 0.28X$	0.47
1	ACP 2100	SFWT = $15.17 - 0.32X$	0.37
1	ACP 2100	RV = $4.78 - 0.13X + 0.001X^2$	0.22
2	Ime & Ima	SFWT = $29.57 - 2.29X$	0.43
2	Ime & Ima	SDWT = $4.90 - 0.33X$	0.37
2	ACP 2100	SFWT = $16.61 - 0.13X$	0.19
2	ACP 2100	SDWT = $3.03 - 0.019X$	0.15
2	ACP 2100	RV = $2.70 - 0.037X$	0.29
2	ACP 2100	RDWT = $0.41 - 0.006X$	0.29
3	Ime & Ima	SFWT = $18.07 - 1.82X$	0.30
3	Ime & Ima	SDWT = $5.03 - 0.46X$	0.45
3	Ime & Ima	RDWT = $0.32 - 0.004X$	0.29
3	ACP 2100	SFWT = $22.08 - 0.51X + 0.004X^2$	0.65
3	ACP 2100	SDWT = $4.41 - 0.04X$	0.35
3	ACP 2100	RV = $2.18 - 0.03X$	0.29
4	Ime & Ima	SFWT = $17.47 - 1.52X$	0.36
4	Ime & Ima	SDWT = $5.60 - 0.47X$	0.28
4	ACP 2100	SFWT = $10.33 - 0.13X$	0.51
4	ACP 2100	SDWT = $3.38 - 0.04X$	0.51
4	ACP 2100	RV = $1.13 - 0.01X$	0.25
4	ACP 2100	RDWT = $0.21 - 0.003X$	0.35

^aSFWT = shoot fresh weight, SDWT = shoot dry weight, RV = root volume, RDWT = root dry weight, Ime = imazethapyr, Ima = imazapyr, X = herbicide rate.

CHAPTER VI

UPTAKE AND TRANSLOCATION OF DPX L5300 BY TALL FESCUE AS AFFECTED BY MEFLUIDIDE

Abstract. Formulated mefluidide plus DPX L5300 was applied to tall fescue at ratios of 0:70, 70:70, 140:70, and 280:70 g ai ha⁻¹ and plants were immediately spotted with ¹⁴C DPX L5300. There was no difference in uptake for the first 12 hours. By 48 hours more ¹⁴C was absorbed when formulated mefluidide was present with the high ratio resulting in the greatest uptake. By 120 hours both middle ratios of mefluidide to DPX L5300 afforded 44% uptake of ¹⁴C. Translocation of ¹⁴C generally increased as mefluidide rates and time increased. The most translocation of ¹⁴C occurred with 280 g ha⁻¹ of formulated mefluidide in combination with 70 g ha⁻¹ of formulated DPX L5300 at 120 hours. Translocated ¹⁴C into old and young leaves was concentrated in the tips. Little translocation occurred to the crown or roots. Nomenclature: DPX L5300, methyl 2-[[[[3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-N-methyl-amino]carbonyl]amino]sulfonyl]benzoate; mefluidide, N-[2,4-dimethyl-5-[[[(trifluoromethyl)sulfonyl]amino]phenyl]acetamide; tall

fescue Festuca arundinacea Schreb. 'KY 31' #¹ FESAR.

Additional index words. Growth regulator, growth retardant, sulfonylurea.

¹Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

INTRODUCTION

DPX L5300 is a sulfonylurea herbicide being evaluated for the selective control of many broadleaf weeds in small grain crops such as wheat (Triticum aestivum L.), barley (Hordeum vulgare L.), and oats (Avena sativa L.) (1, 4, 5, 6, 7, 12, 13, 14),. It has also shown potential for plant growth regulation activity on tall fescue (17, 18). Tall fescue is the most common cultivated turf type grown along Virginia highway rights-of-way. Other sulfonylurea herbicides like metsulfuron (2, 16, 17, 18) and chlorsulfuron (2, 17, 18) afford plant growth regulation activity and are used for the suppression of tall fescue in Virginia. DPX L5300 is rapidly absorbed by plant foliage and roots and is translocated throughout the plant². Susceptible species cease growth almost immediately after postemergence treatment with DPX L5300. Similar results have been found for chlorsulfuron (2, 3, 9, 15) and metsulfuron (2). Both chlorsulfuron (2, 8, 10, 17, 18) and metsulfuron (2, 16, 17, 18) have shown potential to injure tall fescue, whereas DPX L5300 has shown a greater margin of safety to tall fescue with respect to rate (17, 18).

The objectives of these studies were to determine the

²Tech. Bul. Express: experimental cereal herbicide. 1986. E.I. Du Pont de Nemours and Co., Inc., Agricultural Products Dept., Wilmington, DE.

absorption, translocation, and metabolism of DPX
L5300 in tall fescue.

MATERIALS AND METHODS

Plant culture. 'KY 31' tall fescue was planted in the field with a Groseclose silt loam (Clayey, mixed, mesic Typic Hapludult) soil type on September 1, 1987. On September 28, 1988, plants were removed from the field, roots were washed free of soil, and plants were transplanted into flats containing sterilized sand. Flats were fertilized biweekly with Hoagland's #1 solution fortified with iron. Plants were removed from the sand medium on January 21, 1989, and placed in 130 ml glass jars wrapped with aluminum foil and filled with half strength Hoagland's #1 solution fortified with iron. The plants were grown in a greenhouse where temperature was maintained at 21 ± 3 C with a 10-h photoperiod. The average high for the photosynthetic photon flux density was $250 \text{ uE}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and $330 \text{ uE}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for runs one and two, respectively. The average relative humidity was $43 \pm 4\%$. Tall fescue was blocked by number of leaves and arranged in a randomized complete block design with one plant per replication, two replications and two runs. A separate set of plants were treated for autoradiography and metabolism.

Uptake and translocation. Radiolabeled DPX L5300 (triazine-2- ^{14}C ; sp. act. $16.2 \text{ mCi mmole}^{-1}$; radiochemical purity of 97.5%) was dissolved in distilled water containing 330 ug of

formulated DPX L5300 ml⁻¹, distilled water and 0.1% v/v oxysorbic³ to a concentration of approximately 0.1 uCi ¹⁴C DPX L5300 per 13.6 uL⁻¹. Formulated mefluidide:DPX L5300 at ratios of 0:70, 70:70, 140:70, and 280:70 g ha⁻¹ was broadcast applied to respective plants in 280 L distilled water ha⁻¹ containing oxysorbic at 0.25% v/v at 210 kPa using a CO₂ backpack sprayer with 8003 flat fan tips⁴. Whatman No. 1 filter papers (7 mm diam. discs) immersed in the isotope solution at a pH of 6.5 were immediately placed on the adaxial leaf surface of intact plants (12). Each disc held approximately 13.6 uL of solution. The disc remained on the leaf for periods of 2, 12, 48 and 120 hours. After the respective exposure time each treated leaf was excised from the plant and separated into acropetal, treated, and basipetal portions. The treated portion was rinsed in 10 ml distilled water to remove nonassimilated isotope and a 1 ml sample was placed into 10 ml scintillation cocktail⁵. Plants were further separated into newest leaf and tillers, other leaves, culm, crown and roots. Plants were placed immediately into an insulated

³Tween 20, Matheson, Coleman and Bell, Manuf. Chemicals, Norwood, OH. Polyoxyethylene sorbitan monolaurate.

⁴TeeJet 8003 tips. Spraying Systems Co., Wheaton, IL 60287.

⁵Scinti Verse E. Fisher Scientific Co. Chemical Manufacturing Division. Fairlawn, NJ 07410.

plastic container of dry ice. Tissue samples were air dried and combusted in a biological sample oxidizer⁶. The evolved $^{14}\text{CO}_2$ was trapped in 10 ml CO_2 absorber⁷ and then mixed with 10 ml scintillation cocktail⁸. All scintillation cocktail was assayed by liquid scintillation spectrometry⁹.

Plants from one replication were sectioned into appropriate portions and placed between two pieces of lithograph paper, dried at 60 C for 48 h, and pressed. Plants were exposed to X-ray film¹⁰ for 28 days.

Metabolism. All leaves of the plant were treated with formulated mefluidide plus DPX L5300 at rates of 140 plus 70 g ha⁻¹, respectively, as described above. Immediately 150 uL of solution, prepared as described earlier, containing 1.1 uCi of labeled DPX L5300 were applied to the leaf surface. Plants were arranged in a randomized complete block design with three replications, 1 plant per replicate, and two runs. Tall fescue was harvested 120 hours later and

⁶Packard Tricarb sample oxidizer, Packard Instruments Co. Inc. Downers Grove, IL 60515.

⁷Carbo-sorb carbon dioxide absorber for scintillation counting, Packard Instrument Co. Inc. Downers Grove IL 60514

⁸Permafluor V, Packard Instrument Co. Inc. Downers Grove, IL 60515.

⁹Beckman LS-255 Liquid Scintillation Counter, Beckman Instruments, Inc., Columbia, MD 21045.

¹⁰Kodak Diagnostic X-ray Film X-OMAT. Eastman Kodak Co., Rochester, NY 14650.

segmented into leaf, crown and root. Extraction procedures were supplied by E. I. Du Pont de Nemours and Company, Inc¹¹. Plant samples were frozen in liquid nitrogen and ground to a fine powder with a mortar and pestle. A 30 ml aliquot of acetonitrile was added and the sample reground for two minutes after which the acetonitrile was decanted. This step was repeated twice. The final rinse was accomplished by pouring the slurry into a glass funnel lined with a Whatman #1 filter paper and washing with 10 ml of acetonitrile. The solution was then evaporated under a fume hood to 2 ml. Recovery was 87 to 95%. Extract from leaves, crown, and roots were spotted on a 0.25 mm silica gel TLC plate. The reference spots included one spiked (0.1 uCi) sample of plant material and one spot of ¹⁴C DPX L5300. The mobile phase used was a 7.8:1.1:1.1:0.01:0.001 v/v mixture of cyclohexane:2-propanol:methanol:glacial acetic acid:distilled water. TLC plates were developed on X-ray film for 14 days.

¹¹L. W. Hershberger and N. S. Heckendorn. 1986. Determination of residue of DPX-L5300 in crops by liquid chromatography. E. I. Du Pont de Nemours and Company, Inc. Wilmington, DE 19898.

RESULTS AND DISCUSSION

Absorption. Formulated mefluidide had no effect on uptake of ^{14}C at 2 and 12 hours (Table 1). However, by 48 hours the high rate of mefluidide had increased uptake of ^{14}C with the least amount of uptake occurring when DPX L5300 was applied alone. At 120 hours, treatments containing mefluidide at 70 and 140 g ha⁻¹ afforded 11% more uptake of ^{14}C than when DPX L5300 was applied alone. These data indicate that mefluidide in general caused an increased uptake of ^{14}C but ^{14}C uptake was unaffected by rate of mefluidide at 120 hours.

In general, as time increased so did ^{14}C uptake when mefluidide was added. However, there were no differences between 12 and 48 hours for the 1:1 and 2:1 ratios of formulated mefluidide:DPX L5300 as well as no additional uptake by the 4:1 ratio of formulated mefluidide:DPX L5300 after 48 hours. Uptake of DPX L5300 alone did not increase after 12 hours.

Translocation. After 2 hours, mefluidide at 280 g ha⁻¹ increased translocation of ^{14}C by 8.1 to 12.3% to the tip of the treated leaf with some basipetal movement following application of ^{14}C -DPX L5300 (Table 2). By 12 hours after ^{14}C -DPX L5300 was applied, ^{14}C had concentrated in the tip of the treated leaf with less accumulation of ^{14}C as

mefluidide rates increased. More ^{14}C was found in the treated spot for mefluidide combinations at 12 hours but not at 2, 48, or 120 hours. However, mefluidide increased the basipetal movement of ^{14}C to the base of the treated leaf.

Autoradiography showed no visual difference between treatments at 2 or 12 hours (Figure 1.) but revealed concentration of ^{14}C in the tip of the tip of the treated leaf (Figure 2-4). At 48 hours DPX L5300 alone provided no additional net movement of ^{14}C into or from the tip of the treated leaf than at 12 hours (Table 2). At this time for treatments containing mefluidide, more ^{14}C had moved from the treated spot into other portions of the plant. The middle rates of mefluidide afforded more ^{14}C concentration at the tip and bottom of the treated leaf than the high rate of mefluidide. However, the high rate of mefluidide afforded greater mobility of the ^{14}C DPX L5300 to the young and old leaves and the culm of the tall fescue than the other treatments in general (Figure 4).

Autoradiography also revealed accumulation of ^{14}C was occurring in the tips of the other leaves (Figure 2-4). At 120 hours after treatment with ^{14}C -DPX L5300, as the rate of mefluidide increased the amount of ^{14}C in the treated spot and the bottom of the treated leaf decreased (Table 2). The high rate of mefluidide plus DPX L5300 afforded the least amount of radioactivity in the treated leaf tip. The

addition of mefluidide increased translocation to the young and old leaves with the high rate affording the most movement of 13.7 and 15.6%, respectively. Treatments containing the higher rates of mefluidide showed concentrations of ^{14}C to be greater in the culm than for other treatments. All treatments containing mefluidide showed more ^{14}C in the culm than DPX L5300 alone.

No additional net movement to the tip of the treated leaf was found for DPX L5300 alone after 12 hours. However, a steady decrease occurred from the treated spot. Translocation occurred to the bottom of the treated leaf and increased after 48 hours. Additional movement occurred at 120 hours to the young and old leaves. Trace amounts of radioactivity were found for this treatment in culm, crown or roots.

The addition of mefluidide to DPX L5300 afforded increasing movement from the treated spot as time progressed. This caused a net increase in radioactivity to the tip of the treated leaf with concentration of radioactivity increasing using the middle rates of mefluidide. However, by 120 hours, a net decrease was occurring from the tip using the high rate of mefluidide. Radioactivity in the bottom of the treated leaf, as well as in the young and old leaves, increased from 12 to 48 hours but no differences were noted thereafter. Concentration of

^{14}C increased in the culm by 120 hours for all rates of mefluidide plus DPX L5300. No significant movement occurred to the crown or roots.

Metabolism. TLC autoradiographs revealed that the ^{14}C extracted from tall fescue was in more than one form. R_f values were 0.23, 0.85, 0.91, and 0.95 for the control, 0.17, 0.85, 0.90, and 0.97 for the spiked control (control plus chlorophyll extract), and 0.07, 0.85, 0.89, and 0.95 for the leaf extract (Figure 5). The crown and root extracts contained no radioactivity.

Translocation of DPX L5300 increased in general as the rate of mefluidide increased. The addition of mefluidide would increase growth regulation by DPX L5300, resulting in turf with a more uniform appearance.

The accumulation of ^{14}C in the leaf tips and not in the meristematic tissue perhaps explains the results found by some researchers under field conditions where poor foliar and culm suppression was obtained with DPX L5300 plus mefluidide when turf was trim mowed. (19).

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Table 1. Uptake of ^{14}C following application of ^{14}C -DPX L5300 to 'KY 31' tall fescue at 2, 12, 48 and 120 hours after treatment alone and in combination with mefluidide^a.

Chemical	Rate	2 h	12 h	48 h	120 h
(g/ha)		----- (% of applied) -----			
DPX L5300	70	20 aB	33 aA	26 cAB	33 bA
DPX L5300 + Mefluidide	70 70	21 aC	35 aB	28 bcB	44 aA
DPX L5300 + Mefluidide	70 140	23 aC	34 aB	31 bB	44 aA
DPX L5300 + Mefluidide	70 280	24 aC	33 aB	37 aA	38 abA

^aMeans within columns followed by the same small letter or means within rows followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

Table 2. Distribution of absorbed ^{14}C following application of ^{14}C -DPX L5300 by 'KY 31' tall fescue at 2, 12, 48 and 120 hours after treatment alone and in combination with mefluidide^a.

Chemical	Rate (g/ha)	----- Time After Treatment -----			
		2 h	12 h	48 h	120 h
		----- (% of absorbed) -----			
Tip of Treated Leaf					
DPX L5300	70	11.9 bB	43.3 aA	47.6 aA	40.7 aA
DPX L5300 + Mefluidide	70	21.5 aC	32.9 bB	41.8 bcA	43.9 aA
DPX L5300 + Mefluidide	70	24.2 aC	29.3 bcB	46.6 abA	45.7 aA
DPX L5300 + Mefluidide	140	20.0 aC	22.6 cC	40.9 cA	35.3 bB
DPX L5300 + Mefluidide	280	20.0 aC	22.6 cC	40.9 cA	35.3 bB
Treated Spot					
DPX L5300	70	85.4 aA	53.9 cB	46.0 aC	38.6 aD
DPX L5300 + Mefluidide	70	75.8 bA	61.1 bB	24.0 bC	20.7 bC
DPX L5300 + Mefluidide	70	76.7 bA	66.1 abA	24.7 bB	19.6 bcC
DPX L5300 + Mefluidide	140	76.2 bA	73.1 aA	21.4 bB	17.4 cB
DPX L5300 + Mefluidide	280	76.2 bA	73.1 aA	21.4 bB	17.4 cB
Bottom of Treated Leaf					
DPX L5300	70	2.0 bC	2.2 bC	6.0 cB	9.0 dA
DPX L5300 + Mefluidide	70	1.7 bB	5.4 aB	18.5 aA	16.2 aA
DPX L5300 + Mefluidide	70	1.8 bB	4.1 aB	15.4 abA	13.4 bA
DPX L5300 + Mefluidide	140	1.8 bB	4.1 aB	15.4 abA	13.4 bA
DPX L5300 + Mefluidide	280	3.4 aB	4.1 aB	10.1 bcA	11.5 cA

^aMeans within columns and rows followed by the same small capital letter are not significantly different at the 5% level according to a Waller/Duncan K-ratio t-test.

Table 2 (Cont.). Distribution of absorbed ^{14}C following application of $^{14}\text{-DPX L5300}$ by 'KY 31' tall fescue at 2, 12, 48 and 120 hours after treatment alone and in combination with mefluidide^a.

Chemical	Rate (g/ha)	Time After Treatment			
		2 h	12 h	48 h	120 h
		----- (% of absorbed) -----			
Young Leaves					
DPX L5300	70	0.0 aB	0.0 aB	0.0 cB	5.3 cA
DPX L5300 + Mefluidide	70 70	0.0 aB	0.0 aB	8.1 abA	8.2 bA
DPX L5300 + Mefluidide	70 140	0.0 aB	0.0 aB	7.8 bA	9.4 bA
DPX L5300 + Mefluidide	70 280	0.0 aB	0.0 aB	10.9 aA	13.7 aA
Old Leaves					
DPX L5300	70	0.0 aB	0.0 aB	0.1 cB	6.3 cA
DPX L5300 + Mefluidide	70 70	0.0 aB	0.0 aB	7.2 bA	8.3 bA
DPX L5300 + Mefluidide	70 140	0.2 aB	0.1 aB	4.9 bA	9.1 bA
DPX L5300 + Mefluidide	70 280	0.2 aB	0.0 aB	15.1 aA	15.6 aA
Culm					
DPX L5300	70	0.1 aA	0.2 aA	0.0 cA	0.0 dA
DPX L5300 + Mefluidide	70 70	0.0 aB	0.1 aB	0.2 bcB	1.2 cA
DPX L5300 + Mefluidide	70 140	0.0 aC	0.1 aC	0.4 bB	3.6 bA
DPX L5300 + Mefluidide	70 280	0.1 aC	0.0 aC	1.4 aB	6.1 aA

^aMeans within columns and rows and within plant part followed by the same small and capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

Table 2 (Cont.). Distribution of absorbed ^{14}C following application of ^{14}C -DPX L5300 by 'KY 31' tall fescue at 2, 12, 48 and 120 hours after treatment alone and in combination with mefluidide^a.

Chemical	Rate (g/ha)	----- Time After Treatment -----			
		2 h	12 h	48 h	120 h
		----- (% of absorbed) -----			
Crown					
DPX L5300	70	0.3 aA	0.2 aA	0.1 aA	0.2 aA
DPX L5300 + Mefluidide	70 70	0.3 aA	0.3 aA	0.1 aA	0.3 aA
DPX L5300 + Mefluidide	70 140	0.2 aA	0.1 aA	0.1 aA	0.1 aA
DPX L5300 + Mefluidide	70 280	0.1 aA	0.0 aA	0.0 aA	0.3 aA
Roots					
DPX L5300	70	0.1 aA	0.2 aA	0.0 aA	0.0 aA
DPX L5300 + Mefluidide	70 70	0.2 aA	0.1 aA	0.1 aA	0.1 aA
DPX L5300 + Mefluidide	70 140	0.1 aA	0.1 aA	0.0 aA	0.1 aA
DPX L5300 + Mefluidide	70 280	0.0 aA	0.1 aA	0.0 aA	0.1 aA

^aMeans within columns and rows and plant part followed by the same small and capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

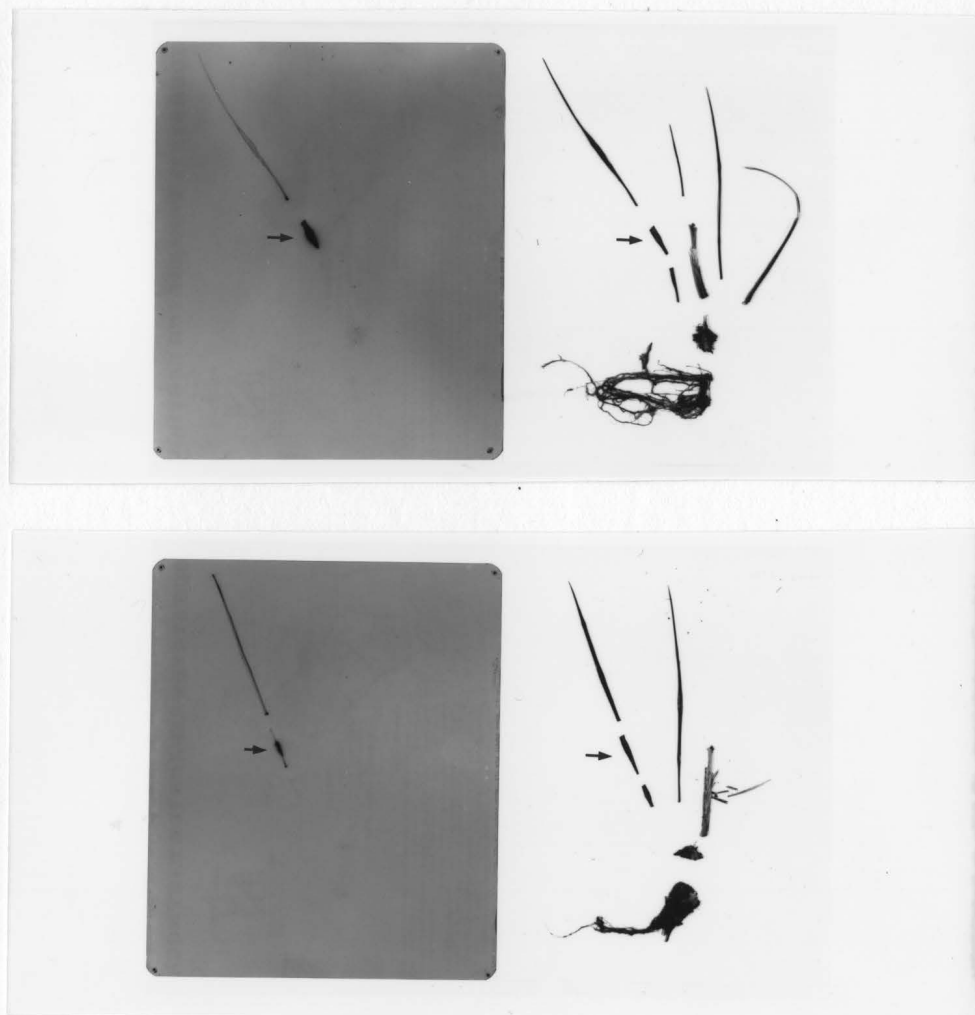


Figure 1. Left autoradiograph, right tall fescue plant at 2 (top) and 12 (bottom) hours after spot treatment with 0.1 uCi ^{14}C -DPX L5300. Representative autoradiographs were used as no visible differences occurred between ratios of formulated mefluidide:DPX L5300 (0:1, 1:1, 2:1 and 4:1). Arrow indicates site of ^{14}C -DPX L5300 application.

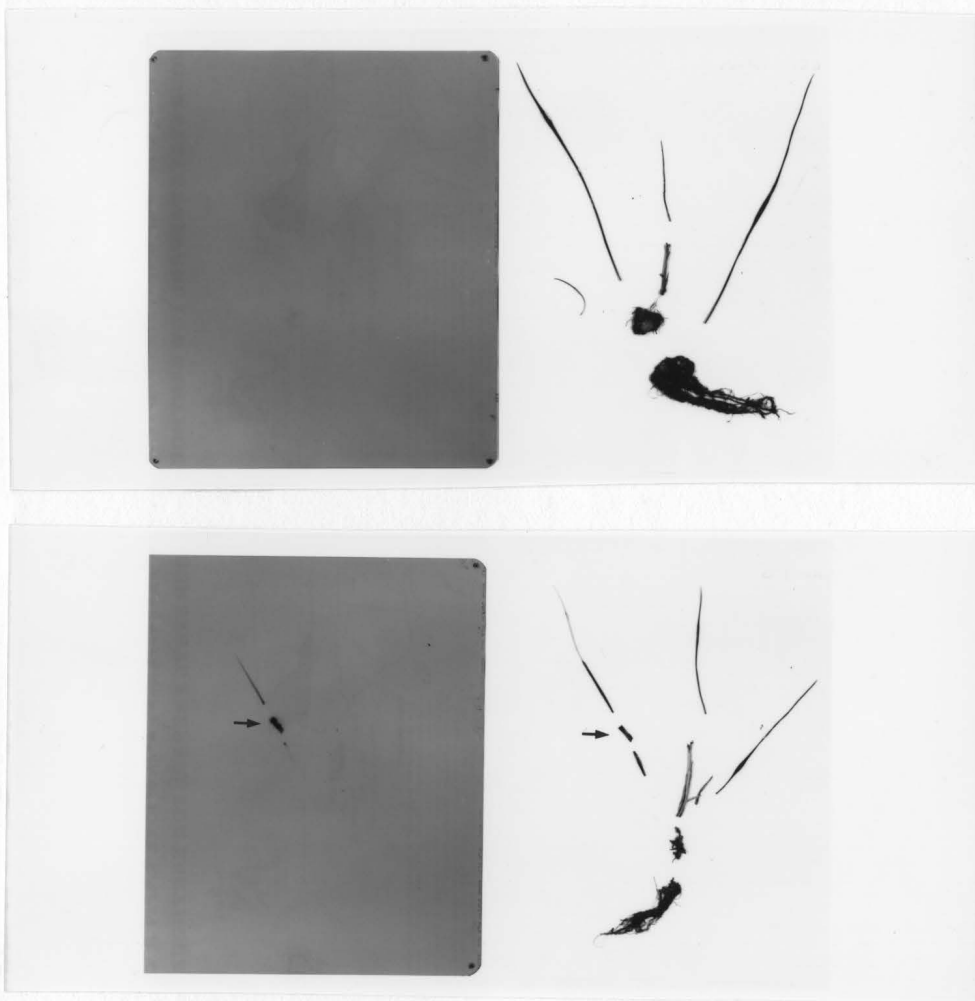


Figure 2. Left autoradiograph, right tall fescue plant. Nontreated (top) and a treated (bottom) plant. Treated plant was broadcast treated with 70 g ha^{-1} formulated DPX L5300 and spot treated with $0.1 \text{ uCi } ^{14}\text{C-DPX L5300}$. Arrow indicates site of $^{14}\text{C-DPX L5300}$ application.

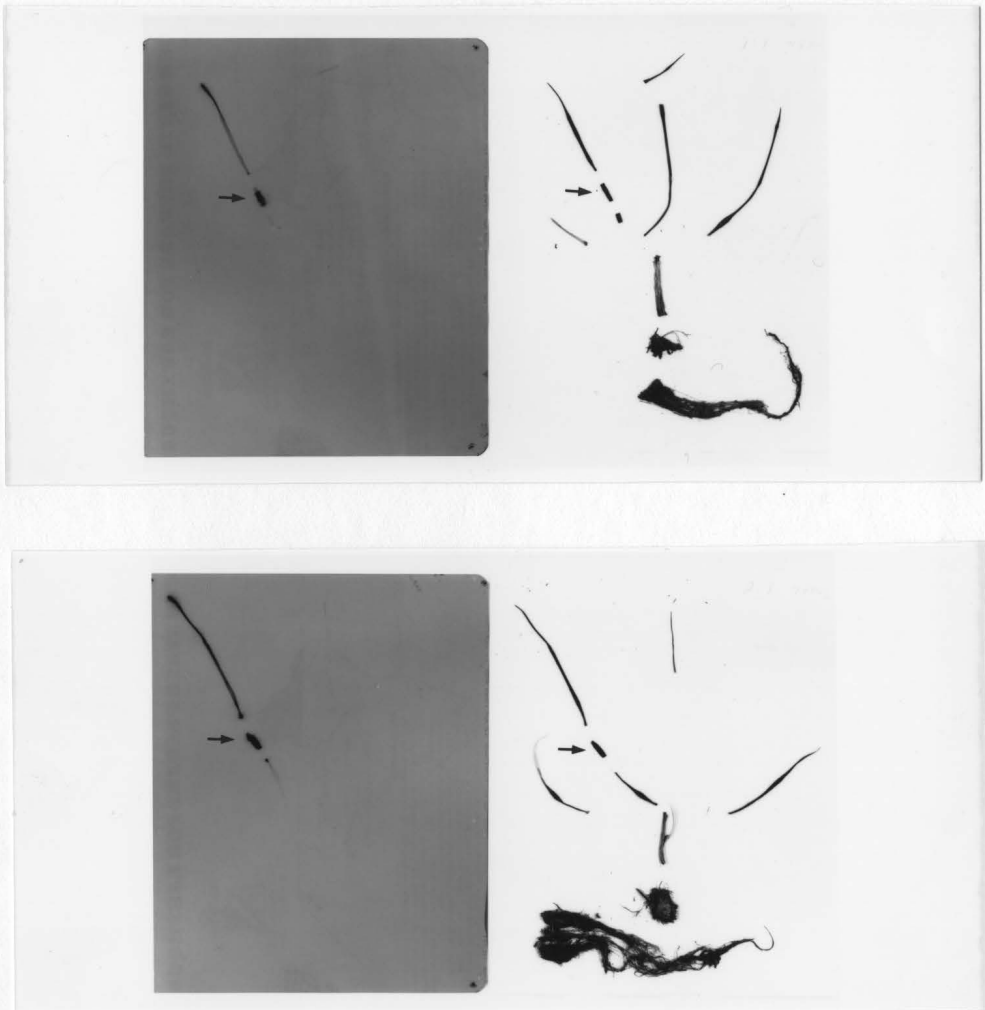


Figure 3. Left autoradiograph, right tall fescue plant. Top plant broadcast treated with 70:70 g ha⁻¹ (1:1) and bottom plant broadcast treated with 140:70 (2:1) ratio of formulated mefluidide:DPX L5300 and spot treated with 0.1 uCi ¹⁴C-DPX L5300. Arrow indicates site of ¹⁴C-DPX L5300 application.

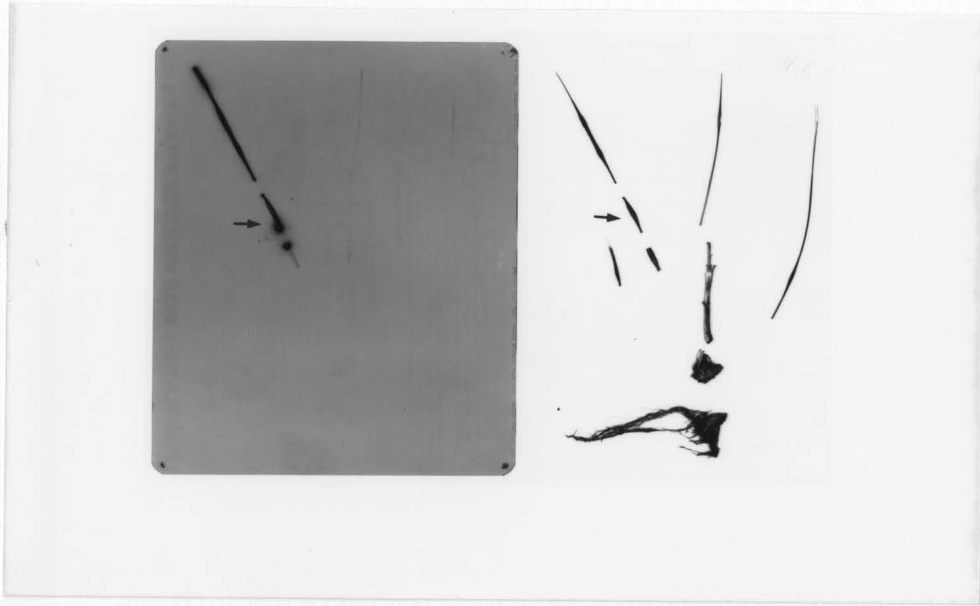


Figure 4. Left autoradiograph, right tall fescue plant. Plant was broadcast treated with 280:70 g ha⁻¹ (4:1) of formulated mefluidide:DPX L5300 and spot treated with 0.1 uCi ¹⁴C-DPX L5300. Arrow indicates site of ¹⁴C-DPX L5300 application.

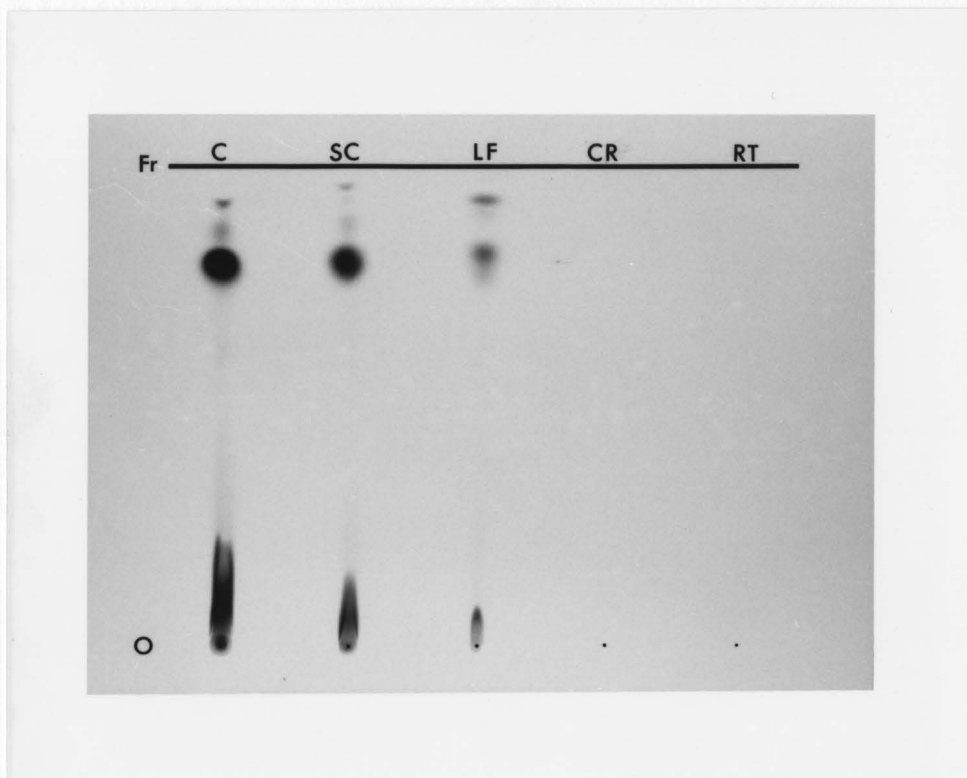


Figure 5. Autoradiograph of tall fescue foliage, crown, and root extract obtained from plants 120 days after foliar application of formulated DPX L5300 plus mefluidide at 70 plus 140 g ha⁻¹ which also included 1.1 uCi of ¹⁴C-DPX L5300. The lanes are designated from left to right: C = control (DPX L5300 reference), SC = spiked control (chlorophyll extract plus DPX L5300 reference), LF = Foliar extract from treated foliage, CR = Crown extract, and RT = Root extract. Origin (O) is at bottom, solvent front (Fr) is 15 cm above.

CHAPTER VII

SUMMARY AND CONCLUSION

Tall fescue is the most common cultivated turfgrass grown along Virginia highway rights-of-way. It can often be found in mixed stands with red fescue. These two species are the main targets of chemical growth regulation in Virginia. The currently used plant growth regulators metsulfuron plus mefluidide and chlorsulfuron plus mefluidide have been known to cause thinning of turf stands. Therefore this study was conducted to determine if turf possessed greater tolerance to experimental growth regulators imazethapyr plus imazapyr, ACP 2100 and DPX L5300 plus mefluidide and if these growth regulators were sufficient in suppression of growth.

Field experiments were conducted at three locations in 1987 and 1988, to evaluate metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide applied one to four times annually, for growth suppression of "KY 31" tall fescue. After one application all rates of imazethapyr plus imazapyr and ACP 2100, and chlorsulfuron plus mefluidide afforded a higher turf quality than metsulfuron plus mefluidide. These treatments all suppressed foliar and

seedhead growth relative to the nonmowed check. The most consistent seedhead suppression was achieved with ACP 2100 at 120 and 180 g ha⁻¹, imazethapyr plus imazapyr at 96.4 plus 3.6 and 115.7 plus 4.3 g ha⁻¹, DPX L5300 plus mefluidide at 70 plus 140 g ha⁻¹ and metsulfuron plus mefluidide at 10 plus 140 g ha⁻¹. Seedhead suppression with chlorsulfuron plus mefluidide at 20 plus 140 g ha⁻¹ was variable. Although turf withstood two treatments per year of imazethapyr plus imazapyr at 67.5 plus 2.5, 96.4 plus 3.6, and 115.7 plus 4.3 g ha⁻¹, ACP 2100 at 60, 120 and 180 g ha⁻¹, and DPX L5300 plus mefluidide at 10 plus 140 and 20 plus 140 g ha⁻¹, no additional benefits occurred from the second application and rendered this treatment unfeasible. After three applications, only the lower rates of imazethapyr plus imazapyr elicited an acceptable quality turf in 1988. No treatments afforded acceptable quality after three treatments in 1987. Three applications per year of any of these PGR's would not be economically feasible or justifiable for additional growth suppression. Multiple applications are not recommended for highway rights-of-way.

Another set of field experiments were conducted on seven month old 'Rebel' and 'KY 31' tall fescue. In 1987 the 'Rebel' was located in Mecklenburg County, VA while 1988 'Rebel' and both years of 'KY 31' were located at the Virginia Tech Airport Research Station, Blacksburg, VA. The

Mecklenburg County site consisted of a poor quality turf resulting in the lower initial quality ratings than for the Blacksburg location. All rates of imazethapyr plus imazapyr and the ACP 2100 at 120 and 180 g ha⁻¹ provided growth regulation with minimal discoloration at four weeks and exceptional quality thereafter when applied both years to 'KY 31' and in 1988 to 'Rebel' tall fescue. Chlorsulfuron plus mefluidide caused objectionable injury by four weeks but turf generally recovered by the eighth week. DPX L5300 plus mefluidide did not uniformly suppress seedheads of either cultivar. Metsulfuron plus mefluidide, regardless of timing, afforded excessive injury to the stand and is not recommended. ACP 2100 at 60 and 120 g ha⁻¹, imazethapyr plus imazapyr at 68 plus 2.5 g ha⁻¹ and DPX L5300 plus mefluidide at 10 plus 140 g ha⁻¹ did not significantly reduce quality when applied twice to 'KY 31' tall fescue in 1987 and 1988 and 1988 to 'Rebel' tall fescue. The low rate of ACP 2100 and DPX L5300 plus mefluidide did not decrease quality after three applications regardless of cultivar. These compounds show potential for suppression of fall growth with a split application. However, further research is needed to find an ideal timing for the second application.

Studies were conducted at two locations on red fescue growing along highway rights-of-way near Blacksburg and

Staunton, VA. Plant growth regulators applied once per year did not discolor the red fescue except for slight discoloration with metsulfuron plus mefluidide. Towards the end of the rating period, chlorsulfuron plus mefluidide and the high rate of DPX L5300 plus mefluidide afforded excellent turf quality while all other treatments afforded a reduction in this parameter. Two applications per year caused some phytotoxicity to the turf, but all treatments except the high rate of ACP 2100 recovered by the twenty-fourth week. Turf did not recover from three applications prior to the first frost. No differences were observed following one or two applications per year when plots were rated for spring green-up the following year. However, those treated three or four times resulted in a delay in spring green-up. DPX L5300 plus mefluidide afforded the greatest safety margin regardless of application interval. Red fescue appeared the most sensitive to metsulfuron plus mefluidide, imazethapyr plus imazapyr and ACP 2100 at the higher rates. Multiple applications of these compounds are not recommended. Multiple applications of the other compounds were not feasible as no benefits were achieved beyond one application.

Greenhouse experiments were conducted to evaluate metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus

mefluidide applied one, two, three, and four times annually, for possible effects to 'KY 31' tall fescue root development. Applied once, imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide resulted in tall fescue plants with greater root dry weights than metsulfuron plus mefluidide, chlorsulfuron plus mefluidide, or the mowed control but did reduce above ground biomass compared to the nonmowed control. Of these treatments, imazethapyr plus imazapyr and the higher rates of ACP 2100 were the best choice of plant growth regulators due to their safety and overall growth regulatory properties on the species investigated and lack of injury to the root system.

Tall fescue treated twice annually with ACP 2100 and DPX L5300 plus mefluidide resulted in greater root volume and dry weight than metsulfuron plus mefluidide and chlorsulfuron plus mefluidide. DPX L5300 plus mefluidide, after two applications, also produced greater root parameters than the mowed treatment. Although not feasible for highway use, two applications of low rates of ACP 2100 and DPX L5300 plus mefluidide maybe acceptable for other maintenance situations where longevity of suppression is sacrificed for less objectionable discoloration.

In general, imazethapyr plus imazapyr, ACP 2100, and DPX L5300 plus mefluidide afforded less root injury to tall fescue than metsulfuron plus mefluidide and chlorsulfuron

plus mefluidide, the imidazolinones caused substantial injury to roots which would jeopardize their use as three treatments per year applied at 10 week intervals. With four applications, DPX L5300 plus mefluidide treated tall fescue gave greater root volume and dry weight relative to all other chemical treatments but reduced root growth compared to the nonmowed treatment. The imidazolinone treatments afforded excessive injury to tall fescue with four treatments per year and would not be considered acceptable under field conditions.

'KY 31' tall fescue was selected to find if mefluidide had an effect on uptake or translocation of ^{14}C -DPX L5300. Mefluidide plus DPX L5300 were applied to tall fescue at ratios of 0:70, 70:70, 140:70, and 280:70 g ai ha⁻¹ and plants were immediately spotted with ^{14}C -DPX L5300. There was no difference in uptake for the first 12 hours. By 48 hours more ^{14}C DPX L5300 was absorbed when mefluidide was present with the high ratio resulting in the greatest uptake. By 120 hours the middle ratios of mefluidide to DPX L5300 afforded the most uptake. Translocation generally increased as mefluidide rates and time increased. The most translocation occurred with the high rate of mefluidide in combination with DPX L5300 at 120 hours. There was an accumulation of radioactivity in the tip of old and young leaves. No accumulation occurred in the crown or roots.

In final conclusion with all aspects in mind, one application of all rates of imazethapyr plus imazapyr and the upper rates of ACP 2100 provided the best overall foliar and seedhead growth suppression of all cultivars and species tested with minimal effect on root parameters after one application. A second application regardless of the PGR provided no additional benefit for roadside use and often was detrimental to the turf stand.

Appendix Table 1. Effects of one to four applications of PGR's on foliar height of 'KY 31' tall fescue in 1987^a.

Treatment (g/ha)	Weeks After Initial Application (Application Schedule ^b)				Foliar Height (cm)									
	2(all) 6(all) 10(all) 12(all) 16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(3)	20(4)						
Metsulfuron	10.0	26 c	27 cd	23 f	28 a	23 deA	20 cA	14 eB	5 gC	27 cA	19 dB	10 eC	0 iD	
Chlorsulfuron	20.0	28 bc	28 bod	27 cd	29 a	26 b-e	24 cd	22 bcd	18 de	30 bcA	26 cA	26 bodA	18 fgB	
Imazethapyr & Imazapyr	2.5	27 bc	28 bod	27 cd	28 a	27 a-dA	27 abA	25 bcAB	20 cdB	28 bc	28 bc	28 b	25 cd	
Imazeth & Imazapyr	96.4	3.6	27 bc	28 bod	26 de	30 a	24 cdeA	25 bAB	19 dB	30 bcA	25 cAB	24 cdB	22 defB	
Imazeth & Imazapyr	115.7	4.3	29 bc	28 bod	28 b-d	29 a	26 b-eA	25 bA	21 cdAB	15 eB	30 bodA	25 cA	26 bodA	10 hB
ACP 2100	60.0	30 b	32 b	30 abc	30 a	27 a-dA	27 abA	25 bA	25 bA	31 bA	31 bA	28 bA	29 bA	
ACP 2100	120.0	30 b	29 bc	28 b-d	29 a	29 abA	28 abA	24 bcA	20 cdA	31 bA	26 cA	27 bcA	23 dA	
ACP 2100	180.0	30 b	27 cd	29 a-d	28 a	29 abA	23 bcAB	24 bcAB	18 deB	32 bA	25 cB	25 bodB	19 efgC	
DPX L5300	10.0	30 b	30 bc	31 ab	30 a	28 abcA	27 abA	23 bcA	22 bcA	29 bcA	30 bA	26 bcA	28 bcA	
DPX L5300	20.0	28 bc	30 bc	29 a-d	29 a	27 a-dA	26 bA	22 bodA	23 bcA	32 bA	28 bcA	26 bodA	27 bcA	
DPX L5300	70.0	27 bc	26 e	24 ef	26 a	25 b-eA	23 bcA	21 cdAB	17 deB	27 cA	26 cA	23 dAB	16 ghB	
Nonmowed	--	37 a	43 a	32 a	30 a	30 aA	31 aA	29 aA	29 aA	36 aA	35 aA	36 aA	29 aA	

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = applications at week 0, 6, 12, and 18.

Appendix Table 2. Effects of one to four applications of PGR's on foliar height of 'KY 31' tall fescue in 1987^a.

Treatment (g/ha)	Weeks After Initial Application (Application Schedule ^b)												
	22(1)	22(2)	22(3)	22(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulf	10.0	28 cA	19 gB	9 fC	0 iD	29 fA	13 eB	6 eBC	0 iC	29 gA	14 fB	6 eC	0 hC
Chlorsulf	20.0	29 bCA	24 eFA	24 c-eA	17 fgB	32 defA	28 cdAB	26 bcdB	20 defC	32 efgA	29 cdeA	27 cA	20 deB
Imazeth & Imazapyr	67.5 2.5	28 cA	28 bcdA	25 b-eA	22 cdA	32 defA	30 bCA	25 cdB	22 cdeB	32 efgA	31 bcdA	25 cdB	23 cdB
Imazeth & Imazapyr	96.4 3.6	30 bCA	23 fB	23 deB	18 eFB	31 eFA	26 dB	24 dBC	20 eFC	32 efgA	27 eAB	25 cdBC	20 deC
Imazeth & Imazapyr	115.7 4.3	31 abCA	23 fAB	25 b-eB	10 hC	33 cdeA	28 cdAB	25 cdB	9 hC	33 defA	28 deAB	27 cB	10 gC
ACP 2100	60.0	33 abA	29 bCA	29 bA	27 bA	36 abCA	33 bAB	30 bB	27 bB	37 abCA	34 bAB	31 bAB	28 bB
ACP 2100	120.0	31 abCA	27 cdeA	27 bCA	21 defB	36 abCA	31 bcAB	28 bcB	21 deC	37 abCA	32 bcAB	28 bcB	21 dC
ACP 2100	180.0	30 bCA	24 efAB	24 c-eAB	19 defB	34 b-eA	28 cdB	25 cdB	16 fgC	35 cdeA	28 deB	26 cdB	16 eFC
DPX L5300	10.0	31 abCA	29 bCA	26 bcdA	27 bA	37 abA	33 bAB	28 bcB	28 bB	38 abA	34 bAB	29 bcB	28 bB
DPX L5300	20.0	31 abCA	30 bA	25 b-eA	26 bCA	35 a-dA	32 bA	25 cdB	25 bcB	36 bcdA	34 bA	26 cdB	26 bcB
DPX L5300	70.0	28 cA	25 defA	22 eA	14 gB	30 eFA	27 dAB	22 dBC	15 gC	31 fgA	27 eAB	23 dBC	32 eC
Nonmowed	--	34 aA	36 aA	35 aA	37 aA	38 aA	39 aA	38 aA	38 aA	39 aA	40 aA	39 aA	39 aA

^aMetsulf = metsulfuron, chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 3. Effects of one to three applications of PGR's on foliar height of 'KY 31' tall fescue in 1988a.

Treatment (g/ha)	Foliar Height (cm)								
	2(all)		6(all)		10(all)		16(all)		
	6(1)	16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(4)	
Metsulfuron	10.0	32 c	31 b	32 b	32 b	37 bc	--	39 cd	--
Chlorsulfuron	20.0	34 bc	31 b	35 ab	33 b	36 bcA	38 bcDA	31 b-eA	40 bcDA 37 cdA 35 bcDA
Imazethapyr & Imazapyr	67.5	2.5	35 bc	32 b	35 ab	39 bcA	38 bcDA	32 bcDA	--
Imazethapyr & Imazapyr	96.4	3.6	35 bc	33 b	37 ab	38 bcA	34 dA	29 b-eA	--
Imazethapyr & Imazapyr	115.7	4.3	33 bc	31 b	34 ab	35 cA	37 bcDA	28 cdeA	--
ACP 2100	60.0	37 bc	35 b	40 ab	38 ab	40 bcA	40 bcA	31 b-eA	--
ACP 2100	120.0	36 bc	34 b	37 ab	35 ab	39 bcA	38 bcDA	28 cdeB	--
ACP 2100	180.0	33 bc	31 b	33 b	34 ab	38 bcA	37 bcDA	27 deB	--
DPX I5300	10.0	38 b	35 b	37 ab	39 ab	41 bA	41 bA	34 bA	--
DPX I5300	20.0	35 bc	34 b	35 ab	34 ab	39 bcA	37 bcDA	33 bcA	--
DPX I5300	70.0	35 bc	32 b	34 ab	34 ab	39 bcA	35 cdA	26 eA	--
Nonmowed	--	45 aA	44 aA	43 aA	41 aA	48 aA	47 aA	47 aA	52 aA 53 aA 53 aA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within rows and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 4. Effects of one to four applications of PCR's on foliar height of 'KY 31' tall fescue in 1988a.

Treatment (g/ha)	Foliar Height (cm)												
	22(1)	22(2)	22(3)	22(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulfuron	10.0	40 c	--	--	43 bc	--	--	--	44 cd	--	--	--	--
Chlorsulfuron	20.0	41 bca	40 cdeA	34 cda	45 bca	43 bodA	36 cda	--	45 bodA	45 cba	40 bca	--	--
Imazethapyr & Imazapyr	67.5 2.5	44 bca	42 bodA	34 cda	46 bca	44 bodA	35 cdeA	--	46 bodA	46 bca	39 bca	--	--
Imazethapyr & Imazapyr	96.4 3.6	43 bca	36 eA	33 cda	45 bca	38 eA	33 deA	--	46 bodA	39 eA	34 cdeA	--	--
Imazethapyr & Imazapyr	115.7 4.3	40 cA	37 deA	31 dA	42 cA	32 deAB	25 cdBA	--	43 dA	41 eA	33 deA	--	--
ACP 2100	60.0	45 bA	42 bodA	35 cda	47 bca	45 bca	37 cda	--	47 bodA	45 bodA	40 bca	--	--
ACP 2100	120.0	41 bca	38 cdeA	35 cda	45 bca	41 cdeA	35 cdeA	--	45 bodA	42 cdeA	37 cda	--	--
ACP 2100	180.0	42 bca	39 cdeA	32 dA	45 bca	40 cdeA	32 deB	--	46 bodA	41 deAB	33 deB	--	--
DPX L5300	10.0	46 bA	45 bA	40 bA	48 bA	46 bA	32 deA	--	49 bA	47 bA	45 bA	--	--
DPX L5300	20.0	45 bA	43 bca	38 bca	47 bca	46 bA	41 bca	--	48 bca	47 bA	43 bA	--	--
DPX L5300	70.0	45 bA	38 cdeA	30 dA	47 bca	41 cdeA	31 eB	--	47 bodA	42 cdeA	32 eB	--	--
Nonmowed	--	53 aA	53 aA	54 aA	54 aA	54 aA	54 aA	--	55 aA	54 aA	55 aA	--	--

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 5. Effects of one to four applications of FGR's on quality of 'KY 31' tall fescue in 1987^a.

Treatment (g/ha)	Quality										
	2(all)	6(all)	Weeks After Initial Application			Application Schedule ^b					
	10(1)	10(1)	10(2)	10(3)	10(4)	12(1)	12(2)	12(3)	12(4)		
Metsulfuron	10.0	5.0 d	4.9 d	5.5 dA	5.5 dA	1.2 gB	5.4 deA	5.5 deA	2.4 dB	1.9 dB	
Chlorsulfuron	20.0	5.7 bc	5.8 c	5.7 cdA	5.8 cA	2.8 eB	6.1 cdA	6.1 cdA	4.7 bcB	3.3 dC	
Imazethapyr & Imazapyr	67.5	2.5	6.1 ab	6.1 bc	6.5 bCA	6.5 bCA	6.6 bCA	6.3 bCA	6.3 bCA	5.4 abA	3.8 abcB
Imazethapyr & Imazapyr	96.4	3.6	6.1 ab	6.5 ab	7.0 abA	6.9 abA	7.0 abA	6.8 abCA	6.9 abCA	5.3 abB	4.3 bcB
Imazethapyr & Imazapyr	115.7	4.3	5.7 bc	6.4 ab	6.9 abA	7.0 abA	7.0 abA	6.4 abCA	6.3 bCA	4.9 abcB	2.0 dC
ACP 2100	60.0	6.4 a	6.3 abc	5.9 bCA	6.0 bCA	5.8 cA	4.8 abB	5.3 eA	5.5 deA	4.9 abcAB	4.0 abcB
ACP 2100	120.0	6.5 a	6.6 ab	7.0 abA	7.0 abA	6.9 abA	5.0 ab	6.9 abA	6.8 abCA	5.6 aAB	4.3 abB
ACP 2100	180.0	6.4 a	6.8 a	7.4 aA	7.3 aA	7.1 abA	4.4 abB	7.1 aA	7.2 aA	4.9 abcB	3.5 cdC
DPX I5300	10.0	6.4 a	5.2 d	4.2 eA	4.1 eA	4.0 eA	3.7 cdA	4.5 fA	4.5 fA	4.3 cA	3.9 abcA
DPX I5300	20.0	6.0 ab	5.8 c	5.2 dA	5.3 dA	5.2 dA	3.6 dA	5.5 deA	5.5 deA	4.7 bcA	4.5 aA
DPX I5300	70.0	5.6 bc	4.9 d	6.5 bCA	6.4 bCA	6.4 bCA	1.9 fB	6.4 abCA	6.5 abCA	4.7 bcB	2.2 dC
Nonmowed	—	5.0 dA	1.8 eA	1.0 fA	1.0 fA	1.0 gA	1.0 gA	1.0 gA	1.0 gA	1.0 eA	1.0 eA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 6. Effects of one to four applications of FGR's on quality of 'KY 31' tall fescue in 1987^a.

Treatment (g/ha)	Quality													
	Weeks After Initial Application (Application Schedule ^b)													
	16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)		
Metsulf	10.0	5.9 deA	4.2 eB	1.6 cC	1.4 fgC	6.6 cdA	2.3 fB	1.4 dBC	1.0 gC	6.0 fA	2.1 gB	1.3 dB	1.2 eB	
Chlorsulf	20.0	6.0 cdeA	6.6 aA	4.7 bcB	2.5 deC	6.9 bca	6.0 abA	5.6 bA	2.2 eFB	7.1 eA	4.2 eFB	5.0 cB	2.4 bcdC	
Imazeth & Imazapyr	67.5	2.5	6.4 bcdA	5.5 bcdAB	4.8 abBC	4.0 abC	7.8 abA	5.5 bcdB	5.6 bB	4.4 abC	7.4 deA	5.4 bBC	6.3 aAB	4.4 abC
Imazeth & Imazapyr	96.4	3.6	7.0 abA	5.6 bcB	3.9 bc	2.8 cdC	7.8 abA	5.6 bcdB	3.9 bB	3.5 cdC	8.2 abca	5.0 bcc	6.3 ab	3.0 bD
Imazeth & Imazapyr	115.7	4.3	7.3 aA	6.2 abB	4.6 abC	1.9 eFD	8.4 aA	5.0 deB	6.0 abB	2.1 fC	8.7 aA	5.0 deB	5.9 abc	1.8 deD
ACP 2100	60.0	5.5 eFA	4.9 cdA	5.1 aA	4.5 aA	6.6 cdA	5.1 cdA	6.0 cdA	5.2 aA	6.1 fA	5.0 bca	5.3 bca	5.1 aA	
ACP 2100	120.0	6.7 a-dA	5.6 bcB	5.0 ab	3.6 bcc	8.2 aA	5.6 bcdC	6.8 ab	4.7 abd	8.2 abca	4.9 bcdC	6.3 ab	4.6 ac	
ACP 2100	180.0	7.5 aA	6.5 aA	4.2 ab	3.1 cdB	8.2 aA	5.7 abcB	5.8 bB	3.0 deC	8.6 abA	4.4 deC	5.7 abcB	2.6 bcd	
DPX L5300	10.0	4.7 fA	4.7 deA	4.6 abA	4.2 abA	4.6 ea	4.4 ea	4.6 ca	4.2 bca	5.1 ga	4.5 cdeA	4.9 ca	4.7 aA	
DPX L5300	20.0	5.9 deA	5.6 bcAB	4.5 abBC	4.1 abc	6.9 bca	6.3 aA	4.5 abB	5.0 abB	7.2 deA	4.7 cdeB	4.9 cB	5.1 ab	
DPX L5300	70.0	6.8 abca	5.8 abB	4.4 abc	1.7 efgD	8.0 aA	5.9 abB	5.3 bcB	2.4 eFC	7.9 bcdA	4.7 cdeB	5.2 bcB	1.9 cdeC	
Nonmowed	--	1.0 gA	1.0 fA	1.0 ca	1.0 gA	1.0 fA	1.0 gA	1.0 dA	1.0 gA	1.0 hA	1.0 hA	1.0 dA	1.0 fA	

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 7. Effects of one to four applications of PGR's on quality of 'KV 31' tall fescue in 1987^a.

Treatment	(g/ha)	Quality							
		Weeks After Initial Application				Application Schedule ^b			
		26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)
Metsulfuron	10.0	5.4 eA	1.6 eB	1.0 dB	1.0 gB	5.5 eA	1.0 gB	1.0 gB	1.0 fB
Chlorsulfuron	20.0	6.9 dA	5.1 dB	2.4 cC	1.8 fC	7.4 cDA	5.5 efB	1.9 fC	1.7 efC
Inazethapyr & Inazapyr	67.5	2.5	7.9 bcA	6.2 bcB	4.4 abc	4.0 cC	8.4 abA	7.2 cB	3.9 bcC
Inazethapyr & Inazapyr	96.4	3.6	8.9 aA	7.5 aB	4.7 abc	3.3 dD	8.8 aA	8.3 aA	3.3 cdB
Inazethapyr & Inazapyr	115.7	4.3	9.0 aA	6.2 bcB	4.3 BC	1.8 fD	8.9 aA	6.6 cdB	2.8 deC
ACP 2100	60.0	6.7 dA	5.8 bcDA	5.6 aA	5.6 aA	6.8 dA	5.6 deA	4.9 aA	5.3 aA
ACP 2100	120.0	8.5 abA	7.5 aB	4.9 abc	4.7 bc	8.7 aA	8.3 aA	3.6 cdB	4.3 bcB
ACP 2100	180.0	9.0 aA	7.4 aB	4.2 bc	2.7 deD	9.0 aA	8.1 abA	3.1 cdB	2.9 dB
DPX I5300	10.0	5.0 eA	4.9 dA	4.7 abA	4.5 bcA	5.0 eA	4.8 fA	4.6 abA	4.1 bcA
DPX I5300	20.0	7.7 cA	6.7 abA	5.0 abB	5.0 bcB	7.8 bcA	7.3 bcA	4.5 abB	4.6 abB
DPX I5300	70.0	8.8 aA	5.7 cdB	3.2 cC	2.6 eC	8.7 aA	6.4 deB	2.0 efC	1.6 efC
Nonmowed	--	1.0 fA	1.0 eA	1.0 dA	1.0 gA	1.0 fA	1.0 gA	1.0 gA	1.0 fA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = best.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 8. Effects of one to three applications of FGR's on quality of 'KY 31' tall fescue in 1988^a.

Treatment	(g/ha)	Quality										
		2(all) 6(all) 10(all)		12(1) 12(2)		12(3) 16(1)		16(2) 16(3)		20(1) 20(2)		20(3)
Metsulf	10.0	6.4 e	3.3 f	5.7 cd	5.4 d	--	6.2 c	--	6.2 d	--	--	--
Chlorsulf	20.0	7.2 d	5.2 d	7.9 a	8.0 ca	4.2 cdB	8.0 ba	5.6 cb	4.2 cdC	8.0 ba	5.1 fb	4.8 cdB
Imazeth & Imazapyr	67.5	8.9 ab	8.1 a	8.2 a	8.2 bcA	8.1 bcA	7.4 aA	8.8 aA	7.9 abAB	7.4 ab	8.9 aA	8.4 aA
Imazeth & Imazapyr	96.4	8.3 bc	8.1 a	8.6 a	9.0 aA	8.8 aA	7.4 aB	8.9 aA	8.0 aA	6.8 ab	9.0 aA	7.7 bB
Imazeth & Imazapyr	115.7	8.8 ab	7.0 b	8.6 a	8.9 aba	8.7 aA	6.0 bB	9.0 aA	8.1 ab	4.4 bcC	9.0 aA	5.6 eB
ACP 2100	60.0	9.0 a	6.1 c	6.1 c	6.1 ca	6.2 dA	5.8 ba	6.3 ca	5.2 cb	5.0 bB	7.0 cb	8.4 aA
ACP 2100	120.0	9.0 a	7.9 a	8.6 a	8.7 abA	8.6 abA	7.8 ab	9.0 aA	8.2 aA	7.2 ab	9.0 aA	8.4 aA
ACP 2100	180.0	8.8 ab	6.8 bc	8.4 a	9.0 aA	8.9 aA	6.4 bB	9.0 aA	7.3 bB	3.6 dC	9.0 aA	6.3 dB
DPX I5300	10.0	8.4 ab	4.2 e	4.1 e	3.9 eA	4.1 eA	4.1 cdA	4.0 dA	4.2 dA	4.0 cdA	4.4 eA	4.3 gA
DPX I5300	20.0	7.8 cd	5.0 d	5.0 d	4.8 deA	5.0 deA	4.9 cA	5.0 dA	5.3 cA	4.9 bA	5.0 eA	5.3 eFA
DPX I5300	70.0	7.3 d	4.0 ef	7.1 b	7.8 cA	7.6 cA	3.4 dB	8.4 abA	5.1 cb	2.6 eC	8.8 aA	4.1 gB
Normowed	--	6.1 e	1.0 g	1.0 f	1.0 fA	1.0 fA	1.3 eA	1.0 eA	1.0 eA	1.0 fA	1.0 fA	1.0 hA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 9. Effects of one to three applications of PGR's on quality of 'KV 31' tall fescue in 1988^a.

Treatment (g/ha)	Weeks After Initial Application						Quality (Application Schedule ^b)				
	22(1)	22(2)	22(3)	25(1)	25(2)	25(3)	28(1)	28(2)	28(3)		
Metsulfuron	10.0	6.2 d	--	6.0 d	--	--	6.0 d	--	--		
Chlorsulfuron	20.0	8.0 BA	5.9 dB	3.9 dC	8.0 BA	6.9 CA	2.7 FB	8.0 BA	6.7 dB	2.2 iC	
Imazethapyr & Imazapyr	67.5	2.5	8.9 aA	8.7 aA	6.4 aA	9.0 aA	8.8 aA	6.9 aB	9.0 aA	8.7 aBA	7.1 aB
Imazethapyr & Imazapyr	96.4	3.6	9.0 aA	8.0 BB	6.9 aC	9.0 aA	8.4 aB	6.2 BC	9.0 aA	8.9 aA	6.7 BB
Imazethapyr & Imazapyr	115.7	4.3	9.0 aA	7.8 BB	4.8 CC	9.0 aA	8.7 aA	3.7 dB	9.0 aA	8.3 BCb	4.0 fC
ACP 2100	60.0	7.0 CA	5.5 dB	4.8 CB	7.2 CA	5.8 dB	5.0 CB	7.3 CA	9.0 aA	5.8 eB	4.8 eB
ACP 2100	120.0	9.0 aA	8.6 aA	6.2 BB	9.0 aA	8.8 aA	6.0 BB	9.0 aA	9.0 aA	8.8 aBA	6.2 CB
ACP 2100	180.0	9.0 aA	6.4 CB	3.8 DC	9.0 aA	7.9 BB	3.3 eC	9.0 aA	9.0 aA	8.0 CB	6.2 CC
DPX L5300	10.0	4.0 eA	4.3 eA	3.2 eB	4.0 eA	4.3 eA	3.2 eB	4.0 eA	4.0 eA	4.3 fA	3.6 gB
DPX L5300	20.0	5.0 eA	5.6 dA	4.4 CB	5.0 eAB	5.6 dA	4.9 CB	5.0 eA	5.0 eA	5.6 eA	5.2 dA
DPX L5300	70.0	8.8 aA	4.4 eB	1.9 FC	8.7 aA	5.6 dB	1.3 gC	8.8 aA	8.8 aA	5.8 eB	1.4 jC
Not mowed	--	1.0 fA	1.0 fA	1.0 gA	1.0 fA	1.0 fA	1.0 hA	1.0 fA	1.0 fA	1.0 fA	1.0 lA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; application 3 = application at week 0, 10, and 20.

Appendix Table 10. Phytotoxicity of one to four applications of PFR's on 'KY 31' tall fescue at Shawsville, VA in 1987^a.

Treatment (g/ha)	Phytotoxicity													
	Weeks After Initial Application (Application Schedule ^b)													
	2(all)	4(all)	6(all)	8(1-3)	8(4)	10(1-3)	10(4)	12(1-2)	12(3)	12(4)	14(1-2)	14(3)	14(4)	
Metsulfuron	10.0	25 ab	40 a	13 b	15 ab	45 aa	5 ab	95 aa	0 ac	73 ab	98 aa	0 ab	100 aa	100 aa
Chlorsulfuron	20.0	20 b	30 b	0 c	0 bb	33 ba	0 bb	45 ca	0 ac	30 defB	50 defA	0 aa	0 ca	8 dea
Imazethapyr	67.5													
& Imazapyr	2.5	0 d	0 d	0 c	0 ba	0 ea	0 bb	28 defA	0 ab	12 ghB	43 fA	0 aa	0 ca	0 ea
Imazethapyr	96.4													
& Imazapyr	3.6	3 cd	5 cd	0 c	0 ba	8 deA	0 bb	33 odeA	0 ac	22 efgB	58 odeA	0 ab	0 cb	18 dA
Imazethapyr	115.7													
& Imazapyr	4.3	8 c	13 c	0 c	0 ba	10 dA	0 bb	43 ca	0 ac	58 bodB	78 bB	0 ab	0 cb	38 cA
ACP 2100	60.0	3 cd	0 d	0 c	0 ba	0 ea	0 bb	18 fA	0 ab	10 ghB	45 fA	0 aa	0 ca	0 ea
ACP 2100	120.0	0 d	0 d	0 c	0 ba	0 ea	0 bb	38 odA	0 ac	38 deB	60 odA	0 aa	0 ca	0 ea
ACP 2100	180.0	0 d	0 d	0 c	0 ba	0 ea	0 bb	45 ca	0 ab	53 bca	68 odA	0 aa	0 ca	0 ea
DPX L5300	10.0	20 b	8 cd	0 c	0 ba	3 deA	0 bb	20 efa	0 ab	20 fga	0 gb	0 aa	0 ca	0 ea
DPX L5300	20.0	30 cd	30 b	0 c	0 bb	20 ca	0 bb	40 odA	0 ab	20 fgAB	48 efa	0 ab	40 bA	0 eb
DPX L5300	70.0	30 a	40 a	20 a	0 bb	40 abA	0 bb	60 bA	0 ac	43 bodB	73 bA	0 ac	40 bB	80 bA
Nonmowed	--	0 d	0 d	0 c	0 ba	0 ea	0 ba	0 ga	0 aa	0 ha	0 ga	0 aa	0 ca	0 ea

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four applications at weeks 0, 6, 12, and 18.

Appendix Table 11. Phytotoxicity of one to four applications of PCR's on 'KY 31' tall fescue at Shawsville, VA in 1987^a.

Treatment (g/ha)	Phytotoxicity Weeks After Initial Application (Application Schedule ^b)																
	16(1)	16(2)	16(3)	16(4)	18(1)	18(2)	18(3)	18(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)	
Metsulfuron	10.0	0 aC	22 aB	100 aA	0 aC	30 aB	0 aC	100 aA	0 aB	80 aA	0 aB	100 aA	0 aA	83 aA	75 aA	100 aA	
Chlorsulfuron	20.0	0 aA	0 bA	0 cA	7 dA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aB	0 bB	43 bA	38 dA
Imazethapyr & Imazapyr	67.5 2.5	0 aA	0 bA	0 cA	0 eA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 eA	3 eA
Imazethapyr & Imazapyr	96.4 3.6	0 aB	0 bB	0 cB	17 dA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aB	0 bB	0 eB	35 dA
Imazethapyr & Imazapyr	115.7 4.3	0 aB	0 bB	0 cB	38 cA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aC	0 bC	30 cB	68 bA
ACP 2100	60.0	0 aA	0 bA	0 cA	0 eA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 eA	0 eA
ACP 2100	120.0	0 aA	0 bA	0 cA	0 eA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 eA	0 eA
ACP 2100	180.0	0 aA	0 bA	0 cA	0 eA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aB	0 bB	18 dA	0 eB
DPX L5300	10.0	0 aB	30 aA	0 cB	0 eB	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 eA	0 eA
DPX L5300	20.0	0 aB	22 aA	0 cB	0 eB	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 eA	0 eA
DPX L5300	70.0	0 aC	30 aB	20 bB	80 bA	0 aB	30 aA	0 aB	48 bA	0 aB	0 bB	0 aB	50 bA	0 aB	0 bB	50 bA	53 cA
Nonmowed	—	0 aA	0 bA	0 cA	0 eA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 aA	0 cA	0 aA	0 bA	0 eA	0 eA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatment all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 12. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Shawsville, VA in 1987^a.

Treatment	Phytotoxicity												
	24(1)	24(2)	24(3)	24(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulfuron	10.0	0 aB	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA	100 aA
Chlorsulfuron	20.0	0 aB	0 bB	53 bCA	48 cDA	0 aB	0 bA	65 bB	65 bCB	0 aB	0 bB	73 bCA	80 abB
Imazethapyr & Imazapyr	67.5 2.5	0 aB	0 bB	15 efAB	33 deA	0 aC	0 bC	25 dB	48 cdeA	0 aB	0 bB	10 fB	50 cDA
Imazethapyr & Imazapyr	96.4 3.6	0 aB	0 bB	13 fgB	35 deA	0 aC	0 bC	20 deB	63 bcdA	0 aC	0 bC	38 eB	65 bCA
Imazethapyr & Imazapyr	115.7 4.3	0 aC	0 bC	40 cdB	80 bA	0 aC	0 bC	30 cdB	78 bA	0 aB	0 bB	60 cDA	90 aA
ACP 2100	60.0	0 aA	0 bA	0 gA	0 gA	0 aA	0 bA	0 fA	13 fA	0 aB	0 bB	0 fB	23 eA
ACP 2100	120.0	0 aA	0 bA	0 gA	13 fgA	0 aB	0 bB	2 efB	38 eA	0 aB	0 bB	38 eA	45 cDA
ACP 2100	180.0	0 aB	0 bB	28 deA	28 eFA	0 aB	0 bB	48 bCA	43 deA	0 aB	0 bB	80 bA	95 aA
DPX L5300	10.0	0 aA	0 bA	0 gA	0 gA	0 aA	0 bA	0 fA	0 fA	0 aA	0 bA	0 fA	0 fA
DPX L5300	20.0	0 aA	0 bA	0 gA	0 gA	0 aA	0 bA	0 fA	0 fA	0 aA	0 bA	0 fA	0 fA
DPX L5300	70.0	0 aB	0 bB	58 bA	53 cA	0 aC	0 bC	60 bA	38 eB	0 aB	0 bB	52 deA	30 deA
Normowed	--	0 aA	0 bA	0 gA	0 gA	0 aA	0 bA	0 fA	0 fA	0 aA	0 bA	0 fA	0 fA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 13. Phytotoxicity of one to three applications of RGR's on 'KY 31' tall fescue at Shawsville, VA in 1988^a.

Treatment (g/ha)	Phytotoxicity											
	Weeks After Initial Application (Application Schedule ^b)											
	2(all)	4(all)	6(all)	8-12(all)	14(1&2)	14(3)	16(1)	16(2)	16(3)	18(1&3)	18(2)	20(all)
Metsulfuron	10.0	20 a	50 ab	43 a	0 a	0 a	0 a	--	--	0 a	--	0 a
Chlorsulfuron	20.0	7 b	30 bc	17 bc	0 a	0 aB	47 aA	0 aB	30 aA	17 aAB	0 aB	53 aA
Imazethapyr & 67.5 Imazapyr	2.5	0 c	3 de	8 cd	0 a	0 aA	3 bCA	0 aA	3 bCA	3 aA	0 aB	17 dA
Imazethapyr & 96.4 Imazapyr	3.6	0 c	0 e	10 bcd	0 a	0 a	23 abc	0 a	0 c	10 a	0 a	30 bc
Imazethapyr & 115.7 Imazapyr	4.3	0 c	17 cde	23 b	0 a	0 aB	40 aA	0 aB	10 bAB	27 aA	0 aB	30 bCA
ACP 2100	60.0	0 c	0 e	0 d	0 a	0 aA	0 cA	0 aA	0 cA	0 aA	0 aA	0 eA
ACP 2100	120.0	0 c	28 c	10 bcd	0 a	0 aA	17 abcA	0 aA	0 cA	0 aA	0 aA	0 eA
ACP 2100	180.0	0 c	0 e	23 b	0 a	0 aB	37 abA	0 aB	7 bcB	20 aA	0 aB	37 bA
DPX I5300	10.0	0 c	3 d	8 cd	0 a	0 aA	13 abcA	0 aA	3 bCA	7 aA	0 aB	20 cDA
DPX I5300	20.0	0 c	23 cd	23 b	0 a	0 aB	23 abcA	0 aA	3 bCA	7 aA	0 aA	30 bcB
DPX I5300	70.0	0 c	53 a	43 a	0 a	0 aB	47 aA	0 aB	7 bcB	43 aA	0 aB	37 bA
Normowed	--	0 c	0 e	0 d	0 a	0 aA	0 cA	0 aA	0 cA	0 aA	0 aA	0 eA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 14. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Shawsville, VA in 1988^a.

Treatment	Weeks After Initial Application (g/ha)	Phytotoxicity (Application Schedule ^b)					
		24(1&2)	24(3)	26(1&2)	26(3)	28(1&2)	28(3)
Metsulfuron	10.0	0 a	—	0 a	—	0 a	—
Chlorsulfuron	20.0	0 aB	50 bA	0 aB	70 aA	0 aB	73 aA
Imazethapyr & Imazapyr	67.5 2.5	0 aB	20 dA	0 aB	30 cA	0 aA	0cA
Imazethapyr & Imazapyr	96.4 3.6	0 aB	20 dA	0 aB	30 cA	0 aB	30 bA
Imazethapyr & Imazapyr	115.7 4.3	0 aB	40 bcA	0 aB	30 cA	0 aB	60 aA
ACP 2100	60.0	0 aA	0 eA	0 aA	0 dA	0 aA	10 cA
ACP 2100	120.0	0 aA	0 eA	0 aA	0 dA	0 aB	30 bA
ACP 2100	180.0	0 aB	30 cdA	0 aB	50 bA	0 aB	63 aA
DPX L5300	10.0	0 aA	0 eA	0 aA	0 dA	0 aA	0 cA
DPX L5300	20.0	0 aA	0 eA	0 aA	0 dA	0 aA	0 cA
DPX L5300	70.0	0 aB	67 aA	0 aB	67 aA	0 aB	57 aA
Normowed	—	0 aA	0 eA	0 aA	0 dA	0 aA	0 cA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 15. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1987^a.

Treatment (g/ha)	Phytotoxicity													
	Weeks After Initial Application (Application Schedule ^b)													
	2(all)	4(all)	6(all)	8(1-3)	8(4)	10(1-3)	10(4)	12(1-2)	12(3)	12(4)	14(1-2)	14(3)	14(4)	
Metsulfuron	10.0	40 a	43 a	20 b	20 aB	67 aA	20 aB	100 aA	0 aB	83 aA	100 aA	0 aB	90 aA	100 aA
Chlorsulfuron	20.0	27 b	13 b	0 c	0 aB	47 bcdA	0 aB	73 bA	0 aC	30 bB	73 bA	0 aC	53 bCB	90 aA
Imazethapyr & Imazapyr	67.5 2.5	0 d	0 b	0 c	0 aB	30 deA	0 aA	10 eFA	0 aA	0 eA	3 dA	0 aB	23 eFA	7 CAB
Imazethapyr & Imazapyr	96.4 3.6	8 cd	8 b	0 c	0 aA	16 eFA	0 aB	40 cdA	0 aB	17 bcdA	20 cdA	0 aB	23 eFA	7 CAB
Imazethapyr & Imazapyr	115.7 4.3	13 c	10 b	0 c	0 aB	50 abCA	0 aB	57 bCA	0 aB	13 cdeB	70 bA	0 aB	60 bA	13 CB
ACP 2100	60.0	0 d	0 b	0 c	0 aA	10 fA	0 aA	3 eFA	0 aA	10 cdeA	3 dA	0 aB	17 fgA	0 CA
ACP 2100	120.0	0 d	0 b	0 c	0 aA	10 fA	0 aA	10 eFA	0 aB	3 deAB	20 cdA	0 aB	43 bcdA	7 CB
ACP 2100	180.0	0 d	8 b	0 c	0 aA	10 fA	0 aB	27 deA	0 aB	23 bCA	33 CA	0 aB	37 cdeA	0 CB
DPX L5300	10.0	3 d	0 b	0 c	0 aA	13 eFA	0 aB	27 deA	0 aB	17 bcdA	0 dA	0 aB	17 fgA	0 CB
DPX L5300	20.0	8 cd	0 b	0 c	0 aB	37 cdA	0 aB	23 defA	0 aB	30 bA	7 dB	0 aB	27 defA	0 CA
DPX L5300	70.0	23 b	16 b	37 a	20 aB	63 abA	20 aB	70 bA	0 aC	23 bCB	43 CA	0 aB	40 cdeA	50 bA
Not mowed	--	0 d	0 b	0 c	0 aA	0 gA	0 aA	0 fA	0 aA	0 eA	0 dA	0 aA	0 fA	0 CA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 16. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1987^a.

Treatment (g/ha)	Phytotoxicity																	
	Weeks After Initial Application (Application Schedule ^b)																	
	16(1)	16(2)	16(3)	16(4)	18(1)	18(2)	18(3)	18(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)		
Metsulf	10.0	0 aC	53 aB	80 aAB	100 aA	0 aC	63 aB	30 aB	100 aA	0 aC	70 aA	30 aB	100 aC	0 aD	73 aB	50 aC	100 aA	
Chlorsulf	20.0	0 aB	13 cdeB	13 bcB	93 bA	0 aC	17 defB	0 bC	93 aA	0 aC	20 cdeB	0 bC	93 aA	0 aC	50 bcB	0 bC	100 aA	
Imazeth & Imazapyr	67.5 2.5	0 aB	3 deB	7 bcB	30 dA	0 aA	7 eFA	0 bA	3 bA	0 aA	0 gA	0 bA	0 bA	0 aB	0 aB	33 eA	0 bB	13 cda
Imazeth & Imazapyr	96.4 3.6	0 aC	13 cdeB	20 bcB	53 cA	0 aB	17 defA	0 bA	0 bA	0 aB	17 defA	0 bB	0 bB	0 aB	40 deA	0 bB	40 bA	
Imazeth & Imazapyr	115.7 4.3	0 aC	20 cdeB	36 bB	80 aBA	0 aB	30 bcA	0 bA	0 bA	0 aB	30 bcA	0 bB	0 bB	0 aC	40 deB	0 bC	77 aA	
ACP	2100	60.0	0 aA	0 eA	10 bcA	13 deA	0 aA	7 fGA	0 bA	0 bA	0 aA	0 gA	0 bA	0 bA	0 aA	7 fGA	0 bA	3 cda
ACP	2100	120.0	0 aB	3 deB	20 bcA	26 dA	0 aB	23 bcda	0 bB	7 bB	0 aB	25 bcda	0 bB	7 bB	0 aB	40 deA	0 bA	23 bcda
ACP	2100	180.0	0 aC	27 bcB	30 bcB	53 cA	0 aB	33 bA	0 bB	7 bB	0 aB	33 bA	0 bB	7 bB	0 aC	43 cda	0 bC	27 bcB
DPX	L5300	10.0	0 aA	3 deA	0 cA	13 deA	0 aA	10 efgA	0 bA	0 bA	0 aA	10 efgA	0 bA	0 bA	0 aA	10 fA	0 bA	10 cda
DPX	L5300	20.0	0 aB	17 cdeA	10 bcA	17 deA	0 aB	20 cdeA	0 bB	0 bB	0 aB	20 cdeA	0 bB	0 bB	0 aB	33 eA	0 bB	17 bcda
DPX	L5300	70.0	0 aC	40 bcB	33 bB	77 bA	0 aB	23 bcda	0 bB	0 bB	0 aB	23 bcda	0 bB	0 bB	0 aB	57 bA	0 bB	77 aA
Normowed	--	0 aA	0 eA	0 cA	0 eA	0 aA	0 gA	0 bA	0 bA	0 aA	0 gA	0 bA	0 bA	0 aA	0 gA	0 bA	0 bA	0 dA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 17. Phytotoxicity of one to four applications of FGR's on 'KV 31' tall fescue at Lexington, VA in 1987^a.

Treatment	Phytotoxicity													
	24(1)	24(2)	24(3)	24(4)	Weeks After Initial Application (Application Schedule ^b)				25(4)	28(1)	28(2)	28(3)	28(4)	
(g/ha)					26(1)	26(2)	26(3)	26(4)						
Metsulfuron	10.0	0 aB	83 aA	100 aA	100 aA	0 aB	93 aA	100 aA	100 aA	0 aB	10 aB	100 aA	100 aA	
Chlorsulfuron	20.0	0 aC	40 bB	43 bB	100 aA	0 aD	30 bC	70 bB	100 aA	0 aB	0 bB	93 aA	100 aA	
Imazethapyr & Imazapyr	67.5	2.5	0 aA	7 eFA	3 eFA	0 cA	0 aA	0 cA	10 efgA	0 cA	0 aB	0 bB	33 eA	0 cA
Imazethapyr & Imazapyr	96.4	3.6	0 aB	20 cdA	17 cdAB	0 cB	0 aB	0 cB	37 cdA	0 cB	0 aB	0 bB	63 cdA	0 cA
Imazethapyr & Imazapyr	115.7	4.3	0 aC	13 deBC	17 cdAB	17 cdAB	0 aB	3 cB	40 cdA	43 bA	0 aC	0 bC	70 bcdA	33 bB
ACP 2100	60.0	0 aA	0 gA	3 eFA	0 cA	0 aA	0 cA	7 fgA	0 cA	0 aB	0 bB	40 eA	0 cB	
ACP 2100	120.0	0 aA	7 eFA	13 c-fA	7 cA	0 aB	0 cB	23 defA	0 cB	0 aA	0 aA	7 dA	0 cA	
ACP 2100	180.0	0 aB	20 cdA	20 cdA	10 cAB	0 aB	0 cB	30 dA	3 cB	0 aB	0 bB	73 bcdA	0 cB	
DPX I5300	10.0	0 aA	3 eFA	7 defA	0 cA	0 aA	3 cA	7 fgA	0 cA	0 aB	0 bB	30 eA	0 cB	
DPX I5300	20.0	0 aB	10 defAB	17 cdAB	0 cB	0 aB	3 cB	27 deA	0 cB	0 aB	0 bB	60 dA	0 cB	
DPX I5300	70.0	0 aC	30 bcB	23 cB	87 aA	0 aC	10 cC	50 cB	97 aA	0 aC	0 bC	80 bB	100 aA	
Nonmowed	—	0 aA	0 gA	0 fA	0 cA	0 aA	0 cA	0 gA	0 cA	0 aA	0 aA	0 fA	0 cA	

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 18. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1988a.

Treatment	Phytotoxicity												
	2(all)	4(all)	6(all)	8-12(all)	Weeks After Initial Application			(Application Schedule ^b)			18(1)	18(2)	18(3)
(g/ha)					14(1&2)	14(3)	16(1)	16(2)	16(3)				
Metsulfuron	10.0	20 a	57 a	63 a	0 a	0 a	0 a	---	---	0 a	---	---	---
Chlorsulfuron	20.0	13 ab	33 bc	27 c	0 a	83 aA	0 aC	27 bB	100 aA	0 aB	17 bB	100 aA	100 aA
Imazethapyr & 67.5 Imazapyr	2.5	7 ab	3 f	3 d	0 a	7 deA	0 aA	0 dA	0 dA	0 cA	0 aA	0 cA	0 cA
Imazethapyr & 96.4 Imazapyr	3.6	10 ab	10 ef	0 d	0 a	23 bcdA	0 aA	13 cA	0 cA	0 aA	0 cA	0 cA	0 cA
Imazethapyr & 115.7 Imazapyr	4.3	7 ab	20 de	23 c	0 a	33 bcdA	0 aA	13 cA	0 cA	0 aB	30 aA	0 cB	0 cA
ACP 2100	60.0	0 b	0 f	0 d	0 a	0 eA	0 aA	0 dA	0 cA	0 aA	0 cA	0 cA	0 cA
ACP 2100	120.0	0 b	0 f	0 d	0 a	23 bcdA	0 aA	0 dA	0 cA	0 aA	0 cA	0 cA	0 cA
ACP 2100	180.0	0 b	0 f	0 d	0 a	37 bA	0 aB	20 bcdA	0 cB	0 aA	0 cA	0 cA	0 cA
DPX L5300	10.0	7 ab	7 f	0 d	0 a	13 cdeA	0 aB	23 bA	0 cB	0 aA	0 cA	0 cA	0 cA
DPX L5300	20.0	23 a	23 cd	30 bc	0 a	20 b-eA	0 aB	27 bA	0 cB	0 aA	0 cA	0 cA	0 cA
DPX L5300	70.0	23 a	40 b	43 b	0 a	83 aA	0 aB	40 aB	67 bA	0 aB	0 cB	67 bA	67 bA
Not mowed	--	0 b	0 f	0 d	0 a	0 eA	0 aA	0 dA	0 cA	0 aA	0 cA	0 cA	0 cA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 19. Phytotoxicity of one to three applications of PGR's on 'KV 31' tall fescue at Lexington, VA in 1988^a.

Treatment	Phytotoxicity													
	20(1)	20(2)	20(3)	Weeks After Initial Application (Application Schedule ^b)			24(1)	24(2)	24(3)	26(1)	26(2)	26(3)	28(1&2)	28(3)
(g/ha)				22(1)	22(2)	22(3)	24(1)	24(2)	24(3)	26(1)	26(2)	26(3)	28(1&2)	28(3)
Metsulfuron	10.0	0 a	---	0 a	---	---	0 a	---	---	0 a	---	---	0 a	---
Chlorisulfuron	20.0	0 ac	47 ab	100 aa	0 ac	47 ab	100 aa	0 ac	40 ab	100 aa	0 ac	30 ab	100 aa	0 ab
Imazethapyr & 67.5 Imazapyr	2.5	0 aa	0 ba	0 ca	0 aa	0 ba	0 da	0 aa	0 ba	13 ea	0 aa	0 ba	0 da	0 aa
Imazethapyr & 96.4 Imazapyr	3.6	0 aa	0 ba	0 ca	0 aa	0 ba	0 da	0 ab	0 bb	27 cdb	0 aa	0 ba	0 da	0 aa
Imazethapyr & 115.7 Imazapyr	4.3	0 aa	0 ba	0 ca	0 aa	0 ba	0 da	0 ab	0 bb	30 ca	0 aa	0 ba	17 ca	0 aa
ACP 2100	60.0	0 aa	0 ba	0 ca	0 aa	0 ba	0 da	0 ab	0 bb	20 dea	0 aa	0 ba	0 da	0 aa
ACP 2100	120.0	0 aa	0 ba	0 ca	0 aa	0 ba	0 da	0 ab	0 bb	20 dea	0 aa	0 ba	0 da	0 aa
ACP 2100	180.0	0 aa	0 ba	0 ca	0 aa	0 ba	0 da	0 ab	0 bb	20 dea	0 aa	0 ba	0 da	0 aa
DPX I5300	10.0	0 aa	0 ba	0 ca	0 ab	0 b	20 ca	0 ab	0 bb	30 ca	0 aa	0 ba	0 da	0 aa
DPX I5300	20.0	0 aa	0 ba	0 ca	0 ab	0 bb	20 ca	0 ab	0 bb	30 ca	0 aa	0 ba	0 da	0 aa
DPX I5300	70.0	0 ab	0 bb	67 ba	0 ab	0 bb	77 ba	0 ab	0 bb	90 ba	0 ab	0 bb	80 ba	0 ab
Not mowed	---	0 aa	0 ba	0 ca	0 aa	0 ba	0 da	0 aa	0 bb	0 fa	0 aa	0 ba	0 da	0 aa

^aMetsulfuron, chlorisulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 20. 1987 Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA^a.

Treatment (g/ha)	Phytotoxicity													
	Weeks After Initial Application (Application Schedule ^b)													
	2(all)	4(all)	6(all)	8(1-3)	8(4)	10(1-3)	10(4)	12(1-2)	12(3)	12(4)	14(1-2)	14(3)	14(4)	
Metsulf	10.0	23 a	70 a	57 a	46 aB	87 aA	13 aB	60 bCA	0 aB	56 aA	40 bA	0 aC	70 aA	53 aB
Chlorsulf	20.0	10 b	43 bc	13 b	0 bB	67 bODa	0 bB	63 bA	0 aB	33 bA	7 dB	0 aB	40 bCA	50 aA
Imazeth & Imazapyr	67.5 2.5	3 b	10 de	0 b	0 bB	26 fA	0 bB	17 eFA	0 aA	3 dA	0 eA	0 aB	17 eAf	0 cB
Imazeth & Imazapyr	96.4 3.6	0 b	37 bc	0 b	0 bB	50 deA	0 bB	37 cdeA	0 aB	20 cA	7 dB	0 aB	37 bODa	13 cB
Imazeth & Imazapyr	115.7 4.3	0 b	33 bc	0 b	0 bB	70 abCA	0 bB	60 bCA	0 aB	20 cA	27 cA	0 aB	47 bA	33 bA
ACP 2100	60.0	0 b	0 e	0 b	0 bB	23 fA	0 bB	20 eFA	0 aA	0 dA	0 eA	0 aA	17 eFA	0 cA
ACP 2100	120.0	0 b	10 de	0 b	0 bB	20 fA	0 bB	27 deA	0 aA	0 dA	0 eA	0 aB	40 bCA	0 cB
ACP 2100	180.0	10 b	37 bc	0 b	0 bB	30 fA	0 bB	50 bODa	0 aC	20 cB	50 aA	0 aB	50 bA	43 abA
DPX L5300	10.0	0 b	10 de	0 b	0 bB	33 eFA	0 bB	33 deA	0 aB	33 bA	0 eB	0 aB	20 deA	0 cB
DPX L5300	20.0	7 b	27 bc	0 b	0 bB	57 cDA	0 aB	37 cdeA	0 aB	20 cA	0 eB	0 aB	27 cdeB	0 cB
DPX L5300	70.0	30 a	53 abc	7 b	0 bB	83 abA	0 aB	90 aA	0 aB	30 bCA	0 eB	0 aB	43 bCA	50 aA
Nonmowed	--	0 b	0 e	0 b	0 bA	0 gA	0 aA	0 fA	0 aA	0 dA	0 eA	0 aA	0 fA	0 cA

^aMetsulf = metsulfuron, chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four applications at weeks 0, 6, 12, and 18.

Appendix Table 21. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1987^a.

Treatment (g/ha)	Phytotoxicity															
	Weeks After Initial Application				(Application Schedule ^b)											
	16(1)	16(2)	16(3)	16(4)	18(1&3)	18(2)	18(4)	20(1&3)	20(2)	20(4)	22(1)	22(2)	22(3)	22(4)		
Metsulf	10.0	0 aC	53 aB	77 aA	0 aC	37 aB	60 aA	0 aB	83 aA	100 aA	0 aD	80 aB	46 aC	100 aA		
Chlorsulf	20.0	0 aC	30 bB	0 dC	70 aA	0 aB	40 aA	27 bA	0 aB	80 bA	0 aC	53 bcB	0 fC	90 aA		
Imazeth & Imazapyr	67.5	2.5	0 aA	7 cA	0 dA	13 deFA	0 aB	20 deA	0 cB	0 aB	27 deFA	10 eA	0 aB	43 cdA	0 fB	0 gB
Imazeth & Imazapyr	96.4	3.6	0 aB	17 bcA	0 dB	23 cdeA	0 aB	30 abca	0 cA	0 aB	33 cdA	0 fB	0 aB	40 odeA	0 fB	30 eA
Imazeth & Imazapyr	115.7	4.3	0 aC	3 cdC	23 cB	43 bA	0 aB	37 aA	0 cB	0 aB	47 bA	40 dA	0 aB	67 abA	0 fB	57 bA
ACP 2100	60.0	0 aA	0 aA	0 dA	7 eFA	0 aA	10 deA	0 cA	0 aA	0 aA	0 gA	0 fA	0 aA	0 gA	0 fA	20 fA
ACP 2100	120.0	0 aB	3 cdB	33 bcA	27 bodA	0 aB	30 abca	0 cB	0 aB	30 deA	10 eB	0 aB	37 deFA	10 eB	30 eA	
ACP 2100	180.0	0 aB	0 dB	43 bA	37 bcA	0 aB	23 deA	0 cB	0 aB	23 eFA	40 dA	0 aB	33 deFA	40 bA	40 dA	
DPX L5300	10.0	0 aB	17 bcB	0 dB	37 bcA	0 aB	30 abca	0 cB	0 aB	30 deA	0 fA	0 aC	23 eFB	0 fC	50 cA	
DPX L5300	20.0	0 aB	27 bA	0 dB	20 cdeA	0 aB	33 abA	0 cB	0 aC	20 fB	40 dA	0 aC	20 fB	20 dB	40 dA	
DPX L5300	70.0	0 aC	27 bB	23 cB	73 aA	0 aB	33 abA	0 cB	0 aB	40 bcA	53 cA	0 aC	47 cdA	20 dB	50 cA	
Notmowed	--	0 aA	0 dA	0 dA	0 fA	0 aA	0 eA	0 cA	0 aA	0 gA	0 fA	0 aA	0 gA	0 fA	0 gA	

^aMetsulf = metsulfuron, chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within rows and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 22. Phytotoxicity of one to four applications of PGR's on 'KY 31' tall fescue at Staunton, VA in 1987a.

Treatment (g/ha)	Phytotoxicity												
	Weeks After Initial Application			Application Schedule ^{b)}									
	24(1)	24(2)	24(3)	24(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulfuron	10.0	0 aB	10aB	96 aA	100 aA	0 aB	10 aB	100 aA	100 aA	0 aB	10 aB	100 aA	100 aA
Chlorsulfuron	20.0	0 aC	0 bC	50 bB	90 aA	0 aC	0 bC	63 bcB	100 aA	0 aC	0 bC	67 bB	90 aA
Imazethapyr & 67.5 Imazapyr	2.5	0 aB	0 bB	27 eA	0 eB	0 aB	0 bB	40 eFA	0 dA	0 aB	0 bB	37 deA	0 dB
Imazethapyr & 96.4 Imazapyr	3.6	0 aB	0 bB	27 eA	30 dA	0 aB	0 bB	43 deFA	0 dB	0 aB	0 bB	57 bcB	0 dA
Imazethapyr & 115.7 Imazapyr	4.3	0 aB	0 bB	43 bcA	67 bA	0 aB	0 bB	60 cA	53 bA	0 aC	0 bC	67 bA	33 bcB
ACP 2100	60.0	0 aA	0 bA	3 gA	0 eA	0 aB	0 bB	23 hA	0 dB	0 aB	0 bB	26 eFA	0 dB
ACP 2100	120.0	0 aB	0 bB	17 fAB	20 dA	0 aB	0 bB	47 deA	0 dB	0 aB	0 bB	47 cDA	0 dB
ACP 2100	180.0	0 aB	0 bB	40 cDA	30 dA	0 aB	0 bB	37 fgA	0 dB	0 aB	0 bB	50 bcDA	0 dB
DPX L5300	10.0	0 aB	0 bB	33 deA	20 dA	0 aB	0 bB	30 ghA	0 dB	0 aA	0 bA	10 fgA	0 dA
DPX L5300	20.0	0 aC	0 bC	33 deB	50 cA	0 aC	0 bC	50 dA	30 cB	0 aB	0 bB	40 cdeA	13 cdB
DPX L5300	70.0	0 aC	0 bC	50 bB	70 bA	0 aB	0 bB	70 bA	53 bA	0 aC	0 bC	87 aA	53 bB
Not mowed	--	0 aA	0 bA	0 gA	0 eA	0 aA	0 bA	0 iA	0 dA	0 aA	0 bA	0 gA	0 dA

^{a)}Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within rows and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^{b)}Application schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at weeks 0, 6, 12, and 18.

Appendix Table 23. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1988^a.

Treatment	Phytotoxicity												
	2(all) 4(all) 6(all) 8-12(all) 14(1&2) 14(3) 16(1) 16(2) 16(3)			Weeks After Initial Application (Application Schedule ^b)			18(1) 18(2) 18(3)						
Metsulfuron	10.0	47 a	73 a	77 a	0 a	0 a	--	0 a	--	33 a	0 a	--	33 a
Chlorsulfuron	20.0	43 a	50 b	50 b	0 a	0 aB	43 aA	0 aB	37 aBA	0 aB	0 aB	57 aA	0 aB
Imazethapyr & Imazapyr	2.5	17 cd	7 d	0 d	0 a	0 aA	3 cdA	0 aA	7 fgA	0 aA	0 aB	20 gA	0 aB
Imazethapyr & Imazapyr	3.6	17 cd	27 c	7 d	0 a	0 aB	30 abcA	0 aB	17 deA	0 aB	0 aB	30 dFA	0 aB
Imazethapyr & Imazapyr	4.3	33 ef	27 c	33 c	0 a	0 aB	33 aBA	0 aA	10 eFA	0 aA	0 aB	40 bA	0 aB
ACP 2100	60.0	0 f	0 d	0 d	0 a	0 aB	23 a-dA	0 aA	0 gA	0 aA	0 aA	0 hA	0 aA
ACP 2100	120.0	0 f	7 d	13 d	0 a	0 aB	37 aA	0 aA	10 eFA	0 aA	0 aB	23 fgA	0 aB
ACP 2100	180.0	10 de	27 c	46 bc	0 a	0 aB	50 aA	0 aA	17 deA	0 aA	0 aB	37 bCA	0 aB
DPX I5300	10.0	23 bc	20 c	3 d	0 a	0 aA	0 dA	0 aB	23 cdA	0 aB	0 aB	33 cdA	0 aB
DPX I5300	20.0	30 b	40 b	33 c	0 a	0 aA	7 bcdA	0 aB	30 bCA	0 aB	0 aB	27 eFA	0 aB
DPX I5300	70.0	40 a	70 a	67 a	0 a	0 aB	27 a-dA	0 aB	43 aA	33 aA	0 aB	60 aA	33 aAB
Normowed	--	0 f	0 d	0 d	0 a	0 aA	0 dA	0 aA	0 gA	0 aA	0 aA	0 hA	0 aA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 24. Phytotoxicity of one to three applications of PGR's on 'KY 31' tall fescue at Lexington, VA in 1988^a.

Treatment	Phytotoxicity											
	20(1)	20(2)	20(3)	22(1&2)	22(3)	24(1&2)	24(3)	26(1&2)	26(3)	28(1&2)	28(3)	
Metsulfuron	10.0	0 a	--	--	0 a	--	0 a	--	0 a	--	0 a	--
Chlorsulfuron	20.0	0 aB	40 aA	33 aA	0 aB	53 aA	0 aB	67 aA	0 aB	80 aA	0 aB	87 aA
Imazethapyr & Imazapyr	67.5	2.5	0 aA	0 dA	0 aA	0 CA	0 aB	20 CA	0 aA	0 eA	0 aA	0 dA
Imazethapyr & Imazapyr	96.4	3.6	0 aA	0 dA	0 aA	0 aB	20 abca	0 aB	30 CA	0 aB	30 cda	0 dA
Imazethapyr & Imazapyr	115.7	4.3	0 aA	0 dA	0 aA	0 aB	20 abca	0 aB	33 bca	0 aB	53 ba	0 aB
ACP 2100	60.0	0 aA	0 dA	0 aA	0 aA	13 bca	0 aB	30 CA	0 aA	0 eA	0 aA	0 dA
ACP 2100	120.0	0 aA	0 dA	0 aA	0 aB	20 abca	0 aB	33 bca	0 aA	0 eA	0 aA	0 dA
ACP 2100	180.0	0 aA	0 dA	0 aA	0 aB	20 abca	0 aB	50 abA	0 aB	40 bca	0 aB	23 CA
DPX L5300	10.0	0 aB	20 cA	0 aB	0 aB	20 abca	0 aB	30 CA	0 aB	23 dA	0 aA	0 dA
DPX L5300	20.0	0 aA	0 dA	0 aA	0 aB	20 abca	0 aB	33 bca	0 aB	23 dA	0 aA	0 dA
DPX L5300	70.0	0 aB	30 bA	33 aA	0 aB	47 abA	0 aB	67 aA	0 aB	73 aA	0 aB	53 bA
Nonmowed	--	0 aA	0 dA	0 aA	0 aA	0 CA	0 aA	0 aA	0 aA	0 eA	0 aA	0 dA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20.

Appendix Table 25. Effects of four applications of PGR's on 'KY 31' tall fescue in 1987a.

Treatment	(g/ha)	Weeks After Initial Application (Application Schedule ^b)					
		Height			Quality		
		14(4)	18(4)	24(4)	14(4)	18(4)	24(4)
Metsulfuron	10.0	5 g	6 h	0 h	1.5 ef	1.2 e	1.0 g
Chlorsulfuron	20.0	19 def	17 gf	20 cd	2.9 d	2.8 cd	2.0 f
Imazethapyr & Imazapyr	67.5 2.5	22 cd	24 cd	22 c	3.9 abc	3.8 b	4.2 c
Imazethapyr & Imazapyr	96.4 3.6	21 cde	19 ef	19 cde	3.6 bcd	3.5 bc	3.4 d
Imazethapyr & Imazapyr	115.7 4.3	18 ef	15 g	9 g	2.1 e	2.4 d	1.9 f
ACP 2100	60.0	27 b	29 b	28 b	4.4 a	5.2 a	5.3 a
ACP 2100	120.0	21 cde	22 de	21 cd	4.3 ab	3.4 bc	4.6 bc
ACP 2100	180.0	17 f	18 gf	18 de	3.5 cd	2.7 cd	2.7 e
DPX L5300	10.0	25 bc	28 b	29 b	3.8 abc	4.0 b	4.5 bc
DPX L5300	20.0	23 bc	26 bc	26 b	4.1 abc	4.0 b	5.0 bc
DPX L5300	70.0	19 def	19 ef	15 f	1.9 e	2.0 de	2.5 ef
Nonmowed	--	32 a	35 a	39 a	1.0 f	1.3 e	1.0 g

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within rows and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 4 = application at week 0, 6, 12, & 18.

Appendix Table 26. Effects of one to four applications of FGR's on height of red fescue^a.

Treatment (g/ha)	Foliar Height Weeks After Initial Application (Application Schedule ^b)												
	2(all)	6(all)	10(all)	12(all)	16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(3)	20(4)	
Metsulf	10.0	26 dA	27 bcdA	27 aA	22 aA	26 abca	19 cC	19 dC	23 bcB	26 aA	18 bC	19 dBC	23 deAB
Chlorsulf	20.0	29 bca	28 bca	28 aA	24 aA	29 aA	21 bcC	25 aB	23 bcBC	28 aA	23 aB	27 abA	18 fC
Imazeth & Imazapyr	2.5	26 dA	28 bca	25 aA	22 aA	23 bca	25 abA	21 bcdA	22 bcdA	27 aA	23 aB	23 cdB	23 deAB
Imazeth & Imazapyr	3.6	26 dA	28 bca	25 aA	21 aA	24 bca	22 abca	23 abca	21 cda	24 aA	25 aA	25 bcdA	22 eA
Imazeth & Imazapyr	4.3	27 cda	27 bcdA	25 aA	22 aA	26 abca	22 abca	23 abca	24 bca	27 aA	25 aA	25 bcdA	26 bcdA
ACP 2100	60.0	30 abA	30 ba	28 aA	24 aA	26 abca	25 abA	25 aA	23 bca	25 aA	25 aA	26 abca	28 ba
ACP 2100	120.0	26 dA	26 cda	24 aA	22 aA	26 abca	26 aA	25 aA	22 bca	26 aA	24 aA	23 cda	24 cdeA
ACP 2100	180.0	27 cda	25 ba	25 aA	23 aA	28 abA	20 cB	21 cdB	18 dB	24 aA	23 aA	23 cda	24 cdeA
DPX L5300	10.0	28 bcdA	29 ba	28 aA	24 aA	22 cA	22 abca	24 abA	25 abA	24 aA	26 aA	25 bcdA	27 bca
DPX L5300	20.0	26 dA	27 bcdA	27 aA	24 aA	28 abA	21 bcB	23 abcB	23 bcB	23 aA	23 aA	25 bcdA	24 cdeA
DPX L5300	70.0	27 cda	27 bcdA	28 aA	23 aA	26 abca	24 abca	23 abca	23 bca	23 aA	25 aA	22 dA	25 b-eA
Normowed	--	31 aA	36 aA	27 aA	26 aA	23 bca	25 abA	25 aA	28 aA	24 aA	26 aA	29 aA	32 aA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 27. Effects of one to four applications of RGR's on foliar height of red rescue^a.

Treatment (g/ha)	Foliar Height (cm)												
	22(1)	22(2)	22(3)	22(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulf	10.0	27 bca	23 ebc	21 fc	25 odea	27 odea	23 ebc	21 ec	24 c-fb	27 b-ea	23 dbc	22 ec	26 odeAB
Chlorsulf	20.0	29 ba	26 bodA	28 ba	19 gb	28 bodA	26 b-ea	27 ba	21 gb	29 bca	27 bodA	27 ba	21 gb
Imazeth & Imazapyr	67.5 2.5	27 bca	26 bodAB	25 b-eb	25 odea	28 bodA	27 bodA	25 bodB	25 odea	28 bodA	27 bodA	25 bodA	25 c-fA
Imazeth & Imazapyr	96.4 3.6	24 ca	25 odea	23 c-fA	24 defA	24 ea	25 c-ea	24 odeA	23 efgA	24 ea	25 bodA	24 odeA	23 efgA
Imazeth & Imazapyr	115.7 4.3	27 bca	26 bodA	23 c-fA	25 odea	27 b-ea	26 b-ea	23 odeA	24 c-fA	26 odeA	27 bodA	23 dea	24 defA
ACP 2100	60.0	29 ba	28 ba	27 bca	28 ba	30 ba	29 aba	26 bca	29 ba	30 ba	29 aba	26 bca	29 ba
ACP 2100	120.0	29 ba	27 bca	22 efb	24 defB	29 bca	28 bca	23 deb	23 d-gb	29 bca	28 abca	23 deb	23 efgB
ACP 2100	180.0	27 bca	24 deb	22 efb	23 efb	27 b-ea	24 deAB	22 deb	22 fgb	27 b-ea	24 cda	23 dea	22 fga
DPX L5300	10.0	25 ca	26 bodA	28 ba	26 bodA	26 dea	26 b-ea	27 ba	26 bodA	25 dea	27 bodA	28 ba	27 bodA
DPX L5300	20.0	27 bca	27 bca	26 bodA	27 bca	28 bodA	27 bodA	26 bca	27 bca	28 bodA	28 abca	26 bca	28 bca
DPX L5300	70.0	26 ca	25 odeA	24 b-fA	26 bodA	26 odeA	25 odeA	25 bodA	27 bca	25 dea	26 bodA	26 bca	27 bodA
Notmowed	--	38 aA	32 aA	38 aA	34 aA	38 aA	32 aA	37 aA	35 aA	37 aA	32 aA	36 aA	34 aA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 28. Effects of one to four applications of RGR's on quality of red fescue^a.

Treatment	Quality										
	2(all) 6(all)	10(1)	10(2)	10(3)	10(4)	12(1)	12(2)	12(3)	12(4)		
Metsulfuron	10.0	6.0 a	5.9 c	5.9 aba	5.6 aba	5.4 bca	3.8 fgb	6.0 aba	5.5 bca	4.0 fb	4.3 dB
Chlorsulfuron	20.0	6.0 a	6.0 bc	6.4 aA	6.0 aba	5.4 bcAB	4.6 deB	6.4 aba	5.6 bca	5.6 bca	5.2 aba
Imazethapyr & Imazapyr	67.5	2.5	6.0 a	6.1 abc	5.7 bca	5.8 aba	4.6 deB	5.9 abca	5.6 bca	5.0 deA	4.6 bca
Imazethapyr & Imazapyr	96.4	3.6	6.0 a	6.1 abc	5.8 bca	5.6 aba	4.5 defB	6.0 abca	5.4 cA	5.3 cda	4.8 bca
Imazethapyr & Imazapyr	115.7	4.3	6.0 a	6.1 abc	5.6 bca	5.8 aba	3.9 efgB	6.1 abca	5.5 bca	5.0 deAB	4.3 cB
ACP 2100	60.0	6.1 a	6.4 ab	5.9 aba	5.5 aba	5.4 bca	5.1 cda	5.9 abca	6.3 aA	5.4 cda	5.1 bA
ACP 2100	120.0	6.0 a	6.1 abc	5.2 cda	5.8 aba	5.1 cA	4.0 efgA	6.6 aA	5.8 abcAB	5.3 cdBC	4.5 bcC
ACP 2100	180.0	6.0 a	6.0 bc	4.9 dA	5.4 bA	5.1 cA	3.3 gB	5.4 cA	5.2 cA	4.6 eA	2.3 eB
DPX L5300	10.0	6.0 a	6.4 ab	5.8 bca	5.8 aba	5.8 bca	6.1 aba	5.6 bca	5.8 abca	5.6 bca	6.0 aA
DPX L5300	20.0	6.0 a	6.6 a	6.0 aba	6.1 aba	5.9 bca	5.6 abca	6.1 abca	5.2 cA	5.8 abca	5.0 bca
DPX L5300	70.0	6.0 a	6.3 abc	5.6 bca	6.0 aba	6.0 aA	5.5 bca	6.0 abca	6.3 aA	6.3 aA	5.2 aba
Nonmowed	--	6.0 a	6.0 bc	6.0 aba	6.0 aba	6.0 aA	6.2 aA	6.0 abca	6.0 aba	6.0 aba	6.0 aA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 29. Effects of one and four applications of PGR's on quality of red fescue^a.

Treatment (g/ha)	Quality																										
	Weeks After Initial Application (Application Schedule ^b)				Quality																						
	16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)															
Metsulf	10.0	6.8	aA	4.0	fB	3.0	dB	3.5	cB	7.5	bA	6.4	dA	3.5	fgB	4.4	dB	7.4	b-eA	6.8	dA	4.8	gB	4.6	ghB		
Chlorsulf	20.0	6.5	abca	6.5	aA	5.8	abAB	5.0	abb	7.8	bA	6.8	deAB	5.8	cdBC	5.2	cdC	8.7	aA	7.0	bcdB	7.0	b-eB	7.0	a-dB		
Imazeth & Imazapyr	67.5	2.5	5.6	cdAB	6.3	abA	5.5	abAB	4.8	bB	7.0	bcA	7.0	bcDA	6.3	bcA	6.1	bcA	7.6	b-eA	7.0	bcDA	7.0	b-e	6.4	b-eA	
Imazeth & Imazapyr	96.4	3.6	5.4	dA	5.4	b-eA	5.3	abca	4.8	bA	6.1	cdB	7.2	bcDA	5.0	deB	4.7	dB	5.6	gA	6.9	cdA	6.4	odeA	6.2	c-fA	
Imazeth & Imazapyr	115.7	4.3	5.8	b-dA	6.0	abca	5.0	bcA	3.4	cB	7.5	bA	6.9	bcDA	4.8	eB	5.2	cdB	7.5	b-eA	6.6	dAB	6.0	efB	5.4	efgB	
ACP 2100	60.0	5.4	dA	5.6	a-dA	5.4	abca	4.3	bcB	7.4	bA	6.6	dcAB	4.6	eC	6.0	bcB	7.1	odeA	7.9	abca	6.1	defA	6.7	a-dA		
ACP 2100	120.0	6.0	a-dA	4.8	defB	5.8	abAB	3.3	cdC	6.9	bcA	6.6	dCA	4.1	efB	4.2	dB	7.6	b-eA	7.4	a-dA	7.0	b-eA	5.1	fgB		
ACP 2100	180.0	5.9	a-dA	4.4	efB	4.5	cB	2.3	dC	6.6	bcA	4.6	eB	3.0	gC	2.5	fC	6.7	efA	4.9	dB	5.0	fgB	3.6	hB		
DPX L5300	10.0	6.6	abA	5.8	a-dA	6.0	aA	6.0	aA	7.8	bA	7.9	abca	8.0	aA	8.6	aA	7.9	a-dA	7.4	a-dA	7.4	abca	7.4	abca		
DPX L5300	20.0	6.1	a-dA	5.0	c-fB	5.3	abcb	6.0	aA	7.4	bA	8.3	abA	8.3	aA	7.0	bA	6.8	defA	7.5	a-dA	7.3	a-dA	7.5	abA		
DPX L5300	70.0	6.3	a-dA	5.2b-eB	6.0	aA	5.3	abb	9.0	aA	8.8	aA	8.8	aA	8.7	aA	8.3	abA	8.3	abA	8.3	abA	8.3	abA	7.3	abcb	
Normowed	--	6	a-dA	6.0	abca	6.0	aA	6.0	aA	7.0	bcA	7.0	bcA	7.0	bA	7.0	bA	8.0	abca	8.0	abA	8.0	abA	8.0	abA	7.8	aA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within rows and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 30. Effects of one to four applications of PGR's on quality of red fescue^a.

Treatment	Quality									
	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)		
Metsulfuron	10.0	7.1 bcdA	7.1 bcA	1.8 gB	2.7 dB	7.1 deA	7.4 bcdA	1.8 fC	3.1 dB	
Chlorsulfuron	20.0	8.3 aba	6.2 cB	4.6 cdBC	4.5 cC	8.4 aba	6.4 cdB	4.8 cBC	4.6 cC	
Imazethapyr & Imazapyr	67.5	2.5	7.6 bcdA	7.2 bcA	4.3 cdB	3.1 dC	7.6 b-eA	7.1 bcA	4.4 cdB	3.1 dC
Imazethapyr & Imazapyr	96.4	3.6	6.5 dA	6.8 bcA	4.8 cB	3.0 dC	6.5 eA	6.9 bcA	4.9 bcB	3.0 dC
Imazethapyr & Imazapyr	115.7	4.3	6.9 cdA	7.5 abca	3.6 defB	3.1 dB	7.0 deA	7.6 abca	3.6 deB	3.1 dB
ACP 2100	60.0	7.8 bcA	7.4 bcA	3.8 cdeB	4.5 cB	7.9 bcdA	7.5 abca	4.1 cdB	4.5 cbb	
ACP 2100	120.0	6.9 cdA	6.9 bcA	2.9 eFB	2.7 dB	7.0 deA	7.1 bcA	3.0 ebb	2.7 dB	
ACP 2100	180.0	7.3 bcdA	4.6 dB	2.6 fgC	1.4 eC	7.3 cdeA	4.9 dB	2.6 efc	1.4 eC	
DPX I5300	10.0	7.1 bcdA	7.1 bcA	5.9 bA	5.6 bA	7.1 deA	7.1 bcA	5.9 bA	5.8 bA	
DPX I5300	20.0	7.7 bcA	7.5 abca	4.8 cB	4.2 cB	7.7 bcdA	7.5 abca	4.9 bcB	4.2 cB	
DPX I5300	70.0	8.3 aba	8.2 aba	4.8 cB	5.1 bcB	8.3 abca	8.2 aba	4.8 cB	5.2 bcB	
Normowed	—	9.0 aA	9.0 aA	9.0 aA	8.7 aA	9.0 aA	9.0 aA	9.0 aA	8.8 aA	

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = applications at week 0 and 14; 3 = applications at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 31. Phytotoxicity of one to four applications of PGR's on red fescue^a.

Treatment (g/ha)	Phytotoxicity													
	Weeks After Initial Application (Application Schedule ^b)													
	2(all) 6(all) 8(4)	10(1-3) 10(4)	12(1-2) 12(3)	12(4) 14(4)	16(1-2) 16(3)	16(4) 18(4)								
Metsulf	10.0	21 a	5 a	40 a	0 aB	51 aBA	0 aB	2 aB	42 aA	58 b	0 aC	36 aB	61 aA	54 aA
Chlorsulf	20.0	12 b	0 a	15 bc	0 aB	25 deA	0 aA	6 aA	1 cA	34 cd	0 aB	0 bB	15 bA	6 bA
Imazeth & Imazapyr	67.5	2.5	0 c	0 a	15 bc	0 aB	38 cA	0 aA	0 aA	0 cA	36 c	0 aA	0 bA	0 cA
Imazeth & Imazapyr	96.4	3.6	0 c	0 a	15 bc	0 aB	34 cDA	0 aA	4 aA	0 cA	27 d	0 aA	0 bA	0 cA
Imazeth & Imazapyr	115.7	4.3	5 c	0 a	20 b	0 aB	42 bcA	0 aB	8 aA	0 cB	52 b	0 aA	0 bA	0 cA
ACP 2100	60.0	0 c	0 a	9 cd	0 aB	26 deA	0 aA	4 aA	0 cA	39 c	0 aA	0 bA	0 cA	0 cA
ACP 2100	120.0	0 c	0 a	19 b	0 aB	40 cA	0 aB	6 aA	0 cB	59 b	0 aA	0 bA	0 cA	0 cA
ACP 2100	180.0	3 c	0 a	18 b	0 aB	56 aA	0 aB	11 aAB	18 bA	75 a	0 aA	0 bA	0 cA	0 cA
DPX L5300	10.0	4 c	0 a	4de	0 aA	0 fA	0 aA	1 aA	0 cA	4 e	0 aA	0 bA	0 cA	0 cA
DPX L5300	20.0	4 c	0 a	7 cde	0 aA	4 fA	0 aA	0 aA	0 cA	32 cd	0 aA	0 bA	0 cA	0 cA
DPX L5300	70.0	6 c	0 a	20 b	0 aB	16 eA	0 aA	5 aA	0 cA	35 cd	0 aA	0 bA	0 cA	0 cA
Normowed	—	0 c	0 a	0 e	0 aA	0 fA	0 aA	0 aA	0 cA	0 e	0 aA	0 bA	0 cA	0 cA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within rows and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four applications at weeks 0, 6, 12, and 18.

Appendix Table 32. Phytotoxicity of one to four applications of FGR's on red fescue at Shawsville, VA^a.

Treatment (g/ha)	Phytotoxicity Weeks After Initial Application (Application Schedule ^b)																										
	20(1&2)	20(3)	20(4)	22(1&2)	22(3)	22(4)	24(4)	26(1&2)	26(3)	26(4)	28(1&2)	28(3)	28(4)														
Metsulf	10.0	0	aC	30	aB	50	aA	0	aB	59	aA	52	aA	0	aC	72	aA	62	aB	0	aC	74	aA	61	bB		
Chlorsulf	20.0	0	aB	0	bB	22	deA	0	aC	25	cA	12	cB	19	cdA	0	aC	19	cdB	39	cdA	0	aB	20	cA	38	dA
Imazeth & Imazapyr	67.5 2.5	0	aB	0	bB	8	fA	0	aB	11	dB	8	cdA	22	cA	0	aB	0	fB	34	deA	0	aB	0	eB	41	cdA
Imazeth & Imazapyr	96.4 3.6	0	aB	0	bB	22	deA	0	aA	27	cA	26	bA	38	bA	0	aC	10	eB	32	deA	0	aC	11	dB	36	dA
Imazeth & Imazapyr	115.7 4.3	0	aB	0	bB	38	bcA	0	aC	42	bA	34	bA	39	bA	0	aC	20	cdB	49	bA	0	aC	24	cB	48	cA
ACP 2100	60.0	0	aB	0	bB	10	eFA	0	aB	16	dA	5	cbB	5	eA	0	aA	0	fA	5	fA	0	aB	0	eB	8	eA
ACP 2100	120.0	0	aB	0	bB	30	cdA	0	aB	26	cA	31	bA	39	bA	0	aC	26	cB	46	bcA	0	aC	21	cB	59	bA
ACP 2100	180.0	0	aB	0	bB	60	aA	0	aC	58	aA	46	aB	42	bA	0	aC	39	bB	62	aA	0	aC	33	bB	75	aA
DPX L5300	10.0	0	aA	0	bA	0	fA	0	aA	0	eA	0	dA	0	eA	0	aA	0	fA	0	gA	0	aA	0	eA	0	eA
DPX L5300	20.0	0	aA	0	bA	0	fA	0	aA	0	eA	0	dA	18	cdA	0	aC	14	deB	28	eFA	0	aA	0	eA	0	eA
DPX L5300	70.0	0	aA	0	bA	0	fA	0	aA	0	eA	0	dA	10	deA	0	aB	15	deA	21	fA	0	aA	0	eA	0	eA
Nonmowed	--	0	aA	0	bA	0	fA	0	aA	0	eA	0	dA	0	eA	0	aA	0	fA	0	gA	0	aA	0	eA	0	eA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 33. Effects of four applications of PGR's on red fescue^a.

Treatment	(g/ha)	Weeks After Initial Application (Application Schedule ^b)					
		Height			Quality		
		14(4)	18(4)	24(4)	14(4)	18(4)	24(4)
Metsulfuron	10.0	22 bc	23 def	25 cde	4.5 bc	5.9 de	2.7 e
Chlorsulfuron	20.0	23 bc	20 f	21 g	4.8 b	6.3 cde	4.5 c
Imazethapyr & Imazapyr	67.5 2.5	21 bc	24 cde	25 cde	4.5 bc	6.4 b-e	3.1 e
Imazethapyr & Imazapyr	96.4 3.6	20 bc	22 ef	23 e-h	4.5 bc	5.9 de	3.0 e
Imazethapyr & Imazapyr	115.7 4.3	22 bc	24 c	24 c-f	3.4 cd	5.3 e	3.2 de
ACP 2100	60.0	24 ab	27 b	29 b	4.5 bc	6.5 a-d	4.5 c
ACP 2100	120.0	20 bc	25 bcd	23 d-g	3.4 cd	5.4 de	2.7 e
ACP 2100	180.0	19 c	24 cde	21 e-h	2.2 d	3.0 f	1.4 f
DPX L5300	10.0	24 ab	25 bcd	26 bcd	5.6 ab	7.6 a	5.6 b
DPX L5300	20.0	22 bc	24 cde	27 bc	5.0 ab	7.5 ab	4.2 cd
DPX L5300	70.0	24 ab	25 bc	27 bc	4.5 bc	7.3 abc	5.1 bc
Nonmowed	--	27 a	30 a	35 a	6.0 a	6.0 de	8.8 a

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no injury.

^bApplication schedule 4 = application at week 0, 6, 12, & 18.

Appendix Table 34. Effects of one to four applications of PGR's on foliar height of 7 month old 'KY 31' tall fescue in 1987a.

Treatment	(g/ha)	Foliar Height												
		Weeks After Initial Application				Application Schedule ^b				Application Schedule ^b				
		2(all)	6(all)	10(all)	16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(3)	20(4)		
Metsulfuron	10.0	21 e	22 cd	24 d	14 bod	20 dA	19 dA	0 fB	0 fB	25 eA	0 fB	0 dB	0 f	
Chlorsulfuron	20.0	22 de	20 d	28 bod	15 bod	23 cdA	22 bodA	17 eA	19 cdA	27 deA	22 cdeA	22 cA	17 cdeA	
Imazethapyr & Imazapyr	67.5	2.5	22 de	22 cd	31 abc	15 bod	25 cAB	21 bodB	26 bcA	20 cdB	31 cdA	28 bcAB	31 bcA	23 bodB
Imazethapyr & Imazapyr	96.4	3.6	22 de	21 cd	27 cd	17 bod	23 cdA	20 cdAB	24 cdA	17 deB	31 cdA	26 bodA	30 bcA	15 deB
Imazethapyr & Imazapyr	115.7	4.3	23 d	22 cd	32 abc	17 bod	24 cdA	25 bA	18 eB	18 deB	27 deA	25 bodA	26 cA	20 cdeB
ACP 2100	60.0	24 c	30 b	26 cd	18 bod	23 cdA	23 bcA	23 cdA	16 deA	31 cdA	26 bodB	30 bcA	24 bodB	
ACP 2100	120.0	22 de	22 cd	29 bod	17 bod	20 dA	21 bodA	19 deA	16 deA	31 cdA	20 deB	30 bcA	26 bcA	
ACP 2100	180.0	22 de	25 c	26 cd	16 bod	23 cdA	22 bodA	18 eAB	15 eFB	29 cdeA	17 eFA	25 cA	19 cdeA	
DPX L5300	10.0	25 b	35 a	37 a	19 bc	29 bA	25 bA	28 cbA	28 bA	35 bA	29 bA	33 abca	31 bA	
DPX L5300	20.0	22 de	34 a	28 bod	17 bod	29 bA	24 bcB	31 bA	28 bA	36 bA	30 bA	37 abA	26 bcA	
DPX L5300	70.0	22 de	25 c	35 ab	21 b	25 cA	23 bcA	25 cA	23 cA	31 cdA	28 bcA	26 cA	10 eFB	
Normowed	--	31 a	35 a	30 bc	33 a	44 a	43 aA	41 aA	43 aA	44 aA	44 aA	43 aA	41 aA	

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 35. Effects of one to four applications of PGR's on foliar height of 'KY 31' tall fescue^a.

Treatment	(g/ha)	Foliar Height											
		Weeks After Initial Application				Application Schedule ^b							
		22(1)	22(2)	22(3)	22(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)
Metsulfuron	10.0 26 eA	0 eB	0 fB	0 fB	0 fB	27 fA	0 dB	0 dB	0 eB	28 dA	0 dB	0 cB	0 eB
Chlorsulfuron	20.0 26 eA	17 cdA	21 beA	0 fB	27 fA	17 cB	6 dC	6 dC	0 eC	29 cdA	18 cB	6 cC	0 eC
Imazethapyr & Imazapyr	67.5	2.5 30 deA	33 abA	25 cdA	26 bcA	31 deFA	32 bA	26 bA	34 abA	30 cdA	32 abA	25 bA	32 bA
Imazethapyr & Imazapyr	96.4	3.6 29 deA	28 abCA	29 bcdA	17 efB	29 efA	30 bA	29 bA	15 cdB	30 cdA	30 bA	28 bA	14 cdB
Imazethapyr & Imazapyr	115.7	4.3 29 deA	24 bcA	30 a-cA	0 fB	28 efA	28 bA	10 cdB	0 eB	28 dA	28 bA	10 cB	0 eB
ACP 2100	60.0 33 cA	32 abA	31 abCA	21 cdeB	33 bcdA	35 abA	29 bAB	29 bAB	17 cB	35 bcA	36 abA	28 bAB	16 cB
ACP 2100	120.0 32 cdA	32 abA	28 bcdA	18 defB	34 bcdA	33 abA	27 bAB	15 cdB	34 bCA	34 abA	26 bAB	14 cdB	
ACP 2100	180.0 30 deA	28 bcA	9 fB	2 fB	31 defA	34 abA	0 dB	4 deB	30 cdA	32 abA	0 cB	3 eB	
DPX L5300	10.0 37 bA	35 abA	35 abA	30 bB	34 bcA	35 abA	34 abA	34 abA	36 bA	33 abA	32 abA	32 bA	
DPX L5300	20.0 36 bA	32 abA	35 abA	30 bB	35 bA	35 abA	30 bA	30 bA	34 bCA	34 abA	33 abA	28 bA	
DPX L5300	70.0 33 cA	10 deB	33 abCA	25 bcdA	32 cdeA	0 dB	0 eB	0 eB	30 cdA	0 dC	26 bB	0 eA	
Nonmowed	—	42 aA	41 aA	39 aA	45 aA	44 aA	42 aA	44 aA	45 aA	43 aA	40 aA	44 aA	44 aA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 36. Effects of one to four applications of FGR's on quality of 7 month old 'KY 31' tall fescue in 1987a.

Treatment	Quality											
	2(all) (g/ha)	6(all)	10(1)	10(2)	10(3)	10(4)	12(1)	12(2)	12(3)	12(4)	-----	
Metsulfuron	10.0	4.0 e	2.3 g	2.7 ha	2.0 ea	1.7 fa	1.0 fa	2.3 fa	2.0 ba	1.0 cdb	1.0 cb	1.0 cb
Chlorsulfuron	20.0	4.7 e	5.7 cd	5.7 odeA	4.7 cda	4.0 dea	2.5 eb	7.0 ca	2.3 bb	3.0 a-dB	1.5 cb	1.5 cb
Imazethapyr & Imazapyr	67.5	2.5	8.0 a-d	6.0 bc	6.0 bodA	5.7 ba	6.3 aba	7.0 ca	7.0 aa	4.7 a-dA	7.7 aa	7.7 aa
Imazethapyr & Imazapyr	96.4	3.6	7.3 cd	6.7 ab	6.7 aba	6.7 aa	7.3 aa	7.0 ca	7.7 aa	5.3 a-dA	5.7 aba	5.7 aba
Imazethapyr & Imazapyr	115.7	4.3	7.7 bod	7.0 a	7.0 aa	6.7 aa	7.3 aa	7.0 ca	6.3 aa	1.7 cdb	5.7 aba	5.7 aba
ACP 2100	60.0	8.7 ab	4.7 e	5.3 defA	4.7 cda	5.0 cda	4.3 bca	6.2 da	6.3 aa	6.3 abcA	8.0 aa	8.0 aa
ACP 2100	120.0	8.3 abc	7.0 a	7.0 aa	7.3 aa	7.3 aa	6.3 aa	9.0 aa	7.3 aa	6.0 abcA	6.7 aa	6.7 aa
ACP 2100	180.0	8.3 abc	4.7 e	5.0 efa	4.7 ca	4.0 dea	3.2 dea	9.0 aa	6.0 aa	2.5 bodB	2.8 bcB	2.8 bcB
DPX L5300	10.0	9.0 a	3.7 f	3.7 ga	4.0 da	3.7 dea	4.0 cda	6.1 ea	6.7 aa	7.3 aa	6.3 aa	6.3 aa
DPX L5300	20.0	8.3 abc	4.7 e	4.7 fa	4.7 cda	4.0 dea	4.7 bca	6.0 da	6.0 aa	6.7 aba	7.0 aa	7.0 aa
DPX L5300	70.0	8.0 a-d	5.0 de	6.3 abca	5.3 bca	6.0 bca	4.7 bca	8.0 ba	7.5 aba	3.7 a-dB	5.7 abAB	5.7 abAB
Notmowed	—	7.0 d	1.0 h	1.0 ia	1.0 fa	1.0 fa	1.0 fa	1.0 ga	1.0 ba	1.0 da	1.0 ca	1.0 ca

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale of 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 37. Effects of one to four applications of PCR's on quality of 7 month old 'KY 31' tall fescue^a.

Treatment (g/ha)	Quality												
	Weeks After Initial Application				Application Schedule ^b								
	16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)	
Metsulf	10.0	3.8 CAB	4.7 CA	2.3 deAB	1.0 eB	3.2 CA	1.0 eB	1.0 BB	1.0 CB	3.5 BA	1.0 FB	1.0 eB	1.0 eB
Chlorsulf	20.0	7.5 BA	4.7 CB	4.5 CB	2.5 deB	8.0 BA	2.0 deB	6.0 AA	1.0 CB	8.3 AA	1.0 FB	1.7 eB	1.0 eB
Imazeth & Imazapyr	67.5	9.0 AA	8.0 AA	8.3 AA	8.7AA	9.0 AA	9.0 AA	8.0 AA	4.3 bCB	9.0 AA	7.7 abB	6.0 abCC	3.3 bcD
Imazeth & Imazapyr	96.4	9.0 AA	7.3 abCA	8.3 AA	5.0 bodB	9.0 AA	7.7 BA	7.7 AA	2.3 cdB	9.0 AA	5.0 deBC	5.6 bcB	2.3 dC
Imazeth & Imazapyr	115.7	8.4 AA	6.3 abcB	5.0 CB	5.7 a-dB	8.6 abA	5.7 CA	6.7 AA	2.7 cdB	9.0 AA	3.0 efBC	3.7 dB	1.0 eC
ACP 2100	60.0	9.0 AA	7.7 abAB	8.3 AA	6.6 abcB	9.0 AA	8.3 abA	8.3 AA	7.0 aB	9.0 AA	7.7 abA	7.0 abB	5.3 aC
ACP 2100	120.0	9.0 AA	8.0 AA	7.7 abA	4.7 cdB	9.0 AA	5.7 CB	8.0 AA	6.0 abB	9.0 AA	8.0 AA	7.3 aA	2.7 cdB
ACP 2100	180.0	9.0 AA	7.7 abCA	4.0 cdA	4.5 cdB	9.0 AA	2.2 dC	6.5 aB	2.3 cdC	9.0 AA	5.7 bodB	2.0 eC	1.0 eC
DPX L5300	10.0	9.0 AA	8.0 AA	6.0 bcB	8.3 abA	9.0 AA	6.0 CB	8.0 AA	6.0 abB	9.0 AA	7.3 abCA	4.7 cdB	4.0 BB
DPX L5300	20.0	9.0 AA	6.7 abCA	7.7 abA	6.0 abcA	9.0 AA	5.7 CAB	7.7 AA	5.0 bcB	9.0 AA	5.3 cdB	4.7 cdB	4.0 BB
DPX L5300	70.0	7.8 BA	5.3 bcA	8.0 abB	5.7 a-dA	7.9 BA	5.3 CA	6.7 AA	1.0 CB	8.3 AA	1.3 FC	3.7 dB	2.3 dB
Normowed	--	1.0 dA	1.0 dA	1.0 eA	1.0 eA	1.0 CA	1.0 eA	1.0 BA	1.0 CA	1.0 CA	1.0 FA	1.0 eA	1.0 eA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 38. Effects of one to four applications of PGR's on quality of 'KY 31' tall fescue^a.

Treatment	Quality								
	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulfuron	10.0	3.6 BA	1.0 eB	1.0 cB	1.0 dB	3.6 BA	1.0 eB	1.0 BB	1.0 dB
Chlorsulfuron	20.0	8.8 aA	1.0 eB	1.0 cB	1.0 dB	8.8 aA	1.0 eB	1.0 BB	1.0 dB
Imazethapyr & Imazapyr	67.5	2.5	8.9 aA	6.7 bcB	3.0 aC	3.3 cC	8.8 aA	6.7 bcB	3.0 aC
Imazethapyr & Imazapyr	96.4	3.6	8.9 aA	5.7 bcB	2.7 aC	1.7 dC	8.9 aA	5.7 bcB	2.7 aC
Imazethapyr & Imazapyr	115.7	4.3	8.9 aA	3.0 deB	1.2 bcB	1.0 dB	8.9 aA	3.0 deB	1.3 BB
ACP 2100	60.0	9.0 aA	7.7 aB	3.0 aD	6.0 aC	9.0 aA	7.7 aB	3.0 aD	6.0 aC
ACP 2100	120.0	9.0 aA	7.0 aBA	3.0 aB	3.7 cB	9.0 aA	7.0 aBA	3.0 aB	3.9 cB
ACP 2100	180.0	9.0 aA	5.0 cdB	1.0 cC	1.0 dC	9.0 aA	5.0 cdB	1.0 BC	1.0 dC
DPX L5300	10.0	9.0 aA	7.0 aBB	3.0 aD	5.0 cB	9.0 aA	7.0 aBB	3.0 aD	5.0 BC
DPX L5300	20.0	9.0 aA	5.7 bcB	3.0 aB	3.7 cB	9.0 aA	5.7 bcB	3.0 aB	3.7 cB
DPX L5300	70.0	8.6 aA	1.0 eB	1.7 bB	1.0 dA	8.6 aA	1.0 eA	1.2 BB	1.0 dB
Normowed	—	1.0 BA	1.0 eA	1.0 cA	1.0 dA	1.0 CA	1.0 eA	1.0 BA	1.0 dA

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 39. Phytotoxicity of one to four applications of PGR's on 7 month old 'KY 31' tall fescue.

Treatment (g/ha)	Phytotoxicity																
	Weeks After Initial Application				Application Schedule ^b												
	2(all)	4(all)	6(all)	8(1-3)	8(4)	10(1-3)	10(4)	12(1-2)	12(3)	12(4)	14(1-2)	14(3)	14(4)				
Metsulf	10.0	47 a	60 a	63 a	46 aA	80 aA	50 aA	80 aA	0 aB	97 aA	100 aA	0 aB	83 aA	97 aA			
Chlorsulf	20.0	43 a	53 ab	50 b	0 bB	67 bA	0 bB	67 bA	0 aB	60 abA	87 aA	0 aB	37 bAB	6 bA			
Imazeth & Imazapyr	67.5	2.5	10	ode	13 f	0 e	0 bA	13 fg	A	0 bA	13 fgA	0 aA	23 bCA	0 dA	0 aA	0 CA	0 dA
Imazeth & Imazapyr	96.4	3.6	23 b	20 ef	0 e	0 bB	30 deA	0 bB	30 deA	0 aA	0 CA	17 bcdA	0 aA	30 bA	30 CA		
Imazeth & Imazapyr	115.7	4.3	17 bc	43 c	27 c	0 bB	43 cA	0 bB	40 cA	0 aB	53 abA	30 bcAB	0 aB	63 aA	37 bcAB		
ACP 2100	60.0	0 f	0 g	0 e	0 bA	7 ghA	0 bA	0 gA	0 aA	17 bCA	7 cDA	0 aA	0 CA	17 cDA			
ACP 2100	120.0	7 def	27 de	3 de	0 bB	20 eFA	0 bB	20 eFA	0 aA	23 bCA	17 bcdA	0 aB	33 bA	17 cDAB			
ACP 2100	180.0	13 cd	43 c	27 c	7 bA	43 cA	7 bB	40 cA	0 aB	67 abA	33 bAB	0 aC	77 aA	43 bCB			
DPX L5300	10.0	3 ef	20 ef	0 e	0 bA	7 ghA	0 bA	0 gA	0 aA	0 CA	13 bcdA	0 aA	0 CA	0 dA			
DPX L5300	20.0	13 cd	33 d	10 d	0 bB	23 eFA	0 bB	20 eFA	0 aA	0 CA	13 bcdA	0 aA	0 CA	0 dA			
DPX L5300	70.0	13 cd	50 bc	43 b	0 bB	40 cDA	0 bB	40 cDA	0 aB	57 abA	23 bcdB	0 aA	27 bA	17 cDA			
Nonmowed	--	0 f	0 g	0 e	0 bA	0 hA	0 bA	0 gA	0 aA	0 CA	0 dA	0 aA	0 CA	0 dA			

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, and Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 40. Phytotoxicity of one to four applications of FGR's on 7 month old 'KY 31' tall fescue^a.

Treatment	Phytotoxicity																																		
	16(1) 16(2) 16(3) 16(4)			18(1) 18(2) 18(3) 18(4)			20(1) 20(2) 20(3) 20(4)			22(1) 22(2) 22(3) 22(4)																									
(g/ha)	Weeks After Initial Application (Application Schedule ^b)																																		
Metsulf	10.0	0	aC	27	abB	100	aA	100	aA	0	aB	93	aA	100	aA	100	aA	100	aA	100	aA	100	aA												
Chlorsulf	20.0	0	aA	13	abCA	33	bA	20	cdA	0	aB	73	abA	33	bB	0	bB	0	aB	97	aA	33	bA	13	cdB	0	aB	100	aA	80	abA	100	aA		
Imazeth & 67.5																																			
Imazapyr	2.5	0	aA	0	CA	0	CA	0	CA	0	DA	0	AB	40	cdA	0	CB	0	BB	0	AB	23	DA	0	CB	0	DB	0	AC	0	CC	20	efB	27	deA
Imazeth & 96.4																																			
Imazapyr	3.6	0	aA	0	CA	0	CA	7	DA	0	AB	43	cdA	0	CA	0	BA	0	AB	47	CA	0	CB	0	DB	0	AB	0	CB	23	defB	53	CA		
Imazeth & Imazapyr	115.7																																		
ACP 2100	60.0	0	aA	0	CA	0	CA	0	DA	0	AB	50	cdA	0	CB	0	BB	0	AB	70	BA	0	CB	7	cdB	0	AB	33	bB	13	efB	100	aA		
ACP 2100	120.0	0	aB	7	bcB	0	CB	33	CA	0	AB	30	deA	0	CB	0	BB	0	aA	0	EA	0	CA	0	DA	0	aA	0	CA	10	efA	13	efA		
ACP 2100	180.0	0	aB	10	abcB	0	CB	60	BA	0	AB	57	bCA	0	CB	0	BB	0	aC	73	BA	0	CC	20	bcB	0	aC	0	CC	57	bcB	97	aA		
DPX L5300	10.0	0	aA	3	bca	0	CA	7	DA	0	AB	30	deA	0	CB	0	BB	0	AB	7	deB	0	CB	30	BA	0	aC	0	CC	27	deB	37	cdA		
DPX L5300	20.0	0	aB	27	abA	0	CB	0	DB	0	AB	47	cdA	0	CB	0	BB	0	AB	13	deAB	0	CB	33	BA	0	aC	0	CC	30	deB	50	CA		
DPX L5300	70.0	0	aB	33	aA	0	CA	0	DA	0	AB	77	abA	0	CB	0	BB	0	aC	87	abA	0	CC	33	bB	0	aD	100	aA	47	cdc	77	BB		
Normowed	--	0	aA	0	CA	0	CA	0	DA	0	aA	0	fA	0	CA	0	BA	0	aA	0	EA	0	CA	0	DA	0	aA	0	CA	0	fA	0	fA		

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha^{-1} . All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 41. Phytotoxicity of one to four applications of FGR's on 7 month old 'KY 31' tall fescue^a.

Treatment	Phytotoxicity												
	Weeks After Initial Application (Application Schedule ^b)												
	24(1)	24(2)	24(3)	24(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulfuron	10.0	0 aB	100 aA	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA
Chlorsulfuron	20.0	0 aB	100 aA	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA
Imazethapyr & Imazapyr	67.5	2.5	0 aB	0 CB	27 CA	0 CB	0 aB	0 BB	50 CA	0 CB	0 aB	0 BB	43 dA
Imazethapyr & Imazapyr	96.4	3.6	0 aB	0 CB	30 CB	67 bA	0 aB	0 BB	50 CA	50 bA	0 aB	0 BB	40 cDA
Imazethapyr & Imazapyr	115.7	4.3	0 aC	33 BB	77 aB	100 aA	0 aB	0 BB	83 aBA	100 aA	0 aB	0 BB	80 aBA
ACP 2100	60.0	0 aA	0 CA	0 dA	0 aB	0 CA	0 aB	0 BB	50 CA	0 CB	0 aB	0 BB	50 cDA
ACP 2100	120.0	0 aA	0 CA	13 cDA	0 CA	0 aB	0 BB	50 CA	0 CB	0 aB	0 BB	50 cDA	0 CB
ACP 2100	180.0	0 aB	0 CB	100 aA	67 bA	0 aB	0 BB	100 aA	70 bA	0 aB	0 BB	100 aA	69 aBA
DPX I5300	10.0	0 aB	0 CB	27 CA	0 CB	0 aB	0 BB	50 CA	0 CB	0 aB	0 BB	50 cDA	0 CB
DPX I5300	20.0	0 aA	0 CA	30 CA	13 CA	0 aB	0 BB	50 CA	0 CB	0 aB	0 BB	50 cDA	0 CB
DPX I5300	70.0	0 aC	100 aA	57 bB	100 aA	0 aC	100 aA	67 bCB	100 aA	0 aB	100 aA	67 bCB	100 aA
Normowed	--	0 aA	0 CA	0 dA	0 CA	0 aA	0 BA	0 dA	0 CA	0 aA	0 BA	0 EA	0 CA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 42. Effects of one to four applications of FGR's on foliar height of 7 month old 'Rebel' tall fescue^a.

Treatment	Foliar Height (g/ha)										
	12(1-3)	12(4)	14(4)	18(4)	20(1)	20(2)	20(3)	24(4)			
Metsulfuron	10.0	11 aA	7 cdeA	4 c	0 d	13 deA	9 eA	0 dc	0 eC	0 f	
Chlorsulfuron	20.0	11 aA	12 abcA	10 b	0 d	13 deA	14 b-eA	5 dB	0 eC	0 f	
Imazethapyr & Imazapyr	67.5	2.5	14 aA	13 abcA	14 ab	11 b	14 cdeA	14 b-eA	18 abA	12 cA	15 bc
Imazethapyr & Imazapyr	96.4	3.6	12 aA	7 cdeA	3 c	0 d	19 bodA	14 b-eA	16 bcA	0 eB	0 f
Imazethapyr & Imazapyr	115.7	4.3	11 aA	3 eB	3 c	0 d	18 bodA	13 b-eA	0 dB	0 eB	0 f
ACP 2100	60.0	15 aA	9 b-eB	9 bc	6 c	20 bcA	14 b-eAB	19 abA	7 dB	7 de	
ACP 2100	120.0	15 aA	4 deB	3 c	0 d	16 b-eA	12 cdeA	15 bcAB	0 eC	3 ef	
ACP 2100	180.0	13 aA	4 deB	3 c	0 d	13 deA	13 b-eA	4 dB	0 eB	0 f	
DPX I5300	10.0	16 aA	15 abA	14 ab	12 b	21 bA	17 bcA	20 abA	17 bA	18 b	
DPX I5300	20.0	15 aA	13 abcA	12 ab	11 b	20 bcA	18 bA	22 aA	13 bcA	15 bc	
DPX I5300	70.0	15 aA	12 abcA	11 b	0 d	22 bA	16 bodB	17 abAB	0 eC	0 f	
Nonmowed	—	16 aA	17 aA	18 a	16 a	29 aA	25 aA	23 aA	23 aA	34 a	

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 43. Effects of one to four applications of FGR's on quality of 7 month old 'Rebel' tall fescue^a.

Treatment	Quality										
	12(1&2)	12(3)	Weeks After Initial Application		Application Schedule ^b				20(4)	24(4)	
(g/ha)	12(4)	14(4)	18(4)	20(1)	20(2)	20(3)	20(4)	24(4)	24(4)		
Metsulfuron	10.0	2.7 aA	1.3 bA	1.0 cA	1.0 b	1.0 c	2.6 bA	1.0 fB	1.0 fB	1.0 bB	1.0 c
Chlorsulfuron	20.0	4.7 aA	2.0 abA	1.7 cbA	1.0 b	1.0 c	5.5 aA	2.0 efB	1.3 efB	1.0 bB	1.0 c
Imazethapyr & Imazapyr	67.5	2.5	5.3 aA	4.0 abA	1.3 cB	2.0 b	6.0 aA	4.0 bodA	4.3 abCA	1.3 bB	2.0 b
Imazethapyr & Imazapyr	96.4	3.6	5.8 aA	2.9 abB	1.0 cB	2.3 b	6.0 aA	3.3 odeB	1.7 defB	1.3 bB	1.0 c
Imazethapyr & Imazapyr	115.7	4.3	4.3 aA	3.0 abA	1.0 cB	1.0 b	6.0 aA	2.7 defB	1.0 fB	1.0 bB	1.0 c
ACP 2100	60.0	4.1 aA	4.7 aA	1.0 cB	1.3 b	1.0 c	6.0 aA	5.0 abCA	5.3 abA	1.3 bB	1.3 bc
ACP 2100	120.0	6.0 aA	2.0 abAB	1.0 cB	1.0 b	1.0 c	6.2 aA	3.7 b-eB	2.7 c-fB	1.0 bB	1.0 c
ACP 2100	180.0	4.3 aA	2.7 abA	1.0 cB	1.0 b	1.0 c	6.1 aA	2.0 efB	1.3 efB	1.0 bB	1.0 c
DPX L5300	10.0	5.3 aA	3.0 abA	2.3 bA	4.0 a	3.0 b	6.3 aA	5.3 abA	5.7 aA	4.7 aA	4.3 ab
DPX L5300	20.0	3.1 aA	3.3 abA	1.0 cA	1.0 b	1.7 c	6.1 aA	6.0 abA	5.7 aA	1.7 bB	2.0 b
DPX L5300	70.0	4.3 aA	1.7 abA	1.0 cB	1.7 b	1.0 c	6.0 aA	5.0 abCA	3.3 b-eAB	1.3 bB	1.0 c
Nonmowed	—	5.0 aA	4.0 abA	5.3 aA	4.0 a	5.0 a	3.0 bA	3.2 cdeA	3.3 b-eA	3.6 abA	2.0 b

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 44. Phytotoxicity of one to four applications of FGR's on 7 month old 'Rebel' tall fescue in 1987a.

Treatment	Phytotoxicity												
	Weeks After Initial Application				(Application Schedule ^b)								
(g/ha)	4 (all)	8 (all)	12 (1&2)	12 (3)	12 (4)	14 (1&2)	14 (3)	14 (4)	18 (1)	18 (2)	18 (3)	18 (4)	
Metsulfuron	10.0	23 a	57 a	0 aB	90 aA	90 aBA	0 aB	100 aA	100 aA	0 aC	35 aB	100 aA	100 aA
Chlorsulfuron	20.0	20 a	27 b	0 aB	43 aBA	43 bDA	0 aC	70 bA	30 cDB	0 aC	30 aB	100 aA	100 aA
Imazethapyr & Imazapyr	67.5	2.5	0 b	10 bc	0 aB	20 bA	33 cDA	0 aB	32 deA	17 cdAB	0 aC	0 bC	10 cB
Imazethapyr & Imazapyr	96.4	3.6	0 b	10 bc	0 aC	27 bB	90 aBA	0 aC	41 cDB	93 aA	0 aB	0 bB	7 cB
Imazethapyr & Imazapyr	115.7	4.3	0 b	20 bc	0 aC	33 bB	97 aA	0 aC	80 bA	97 aA	0 aB	0 bB	100 aA
ACP 2100	60.0	0 b	17 bc	0 aB	0 bB	57 abCA	0 aB	12 eFB	53 bcA	0 aA	0 bA	3 cA	0 cA
ACP 2100	120.0	0 b	20 bc	0 aB	13 bB	97 aA	0 aB	23 eB	100 aA	0 aB	0 bB	13 cB	100 aA
ACP 2100	180.0	0 b	30 b	0 aB	19 bB	93 aA	0 aC	50 cB	97 aA	0 aC	33 aB	80 bA	100 aA
DPX I5300	10.0	0 b	0 c	0 aB	10 bB	30 cDA	0 aA	16 eFA	17 cDA	0 aA	0 bA	0 cA	0 cA
DPX I5300	20.0	0 b	10 bc	0 aB	27 bB	80 aBA	0 aC	23 eB	90 aBA	0 aA	0 bA	0 cA	0 cA
DPX I5300	70.0	3 b	13 bc	0 aB	43 aBA	57 abCA	0 aC	30 deB	70 aBA	0 aB	0 bB	7 cB	100 aA
Not mowed	—	0 b	0 c	0 aA	0 bA	0 dA	0 aA	0 fA	0 dA	0 aA	0 bA	0 cA	0 cA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no injury.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 45. Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1987a.

Treatment	Phytotoxicity							
	20(1)	20(2)	20(3)	20(4)	24(1)	24(2)	24(3)	24(4)
(g/ha)	Weeks After Initial Application (Application Schedule ^b)							
Metsulfuron	10.0	0 ac	87 ab	100 aA	100 aA	0 ab	100 aA	100 aA
Chlorsulfuron	20.0	0 ac	60 bb	100 aA	100 aA	0 ab	0 cb	100 aA
Imazethapyr & Imazapyr	67.5	2.5	0 ab	13 fb	0 cb	30 ba	0 ab	0 cb
Imazethapyr & Imazapyr	96.4	3.6	0 ac	33 deb	33 bb	100 aA	0 ac	0 cc
Imazethapyr & Imazapyr	115.7	4.3	0 ac	53 bcb	100 aA	100 aA	0 ab	0 cb
ACP 2100	60.0	0 aA	17 efa	0 ca	0 ca	0 ca	0 aA	0 ca
ACP 2100	120.0	0 ac	37 cdb	0 cc	100 aA	0 ac	0 cc	37 bb
ACP 2100	180.0	0 ab	80 aA	100 aA	100 aA	0 ac	33 bb	100 aA
DPX L5300	10.0	0 aA	0 fa	0 ca	0 ca	0 aA	0 ca	23 bca
DPX L5300	20.0	0 aA	0 fa	0 ca	0 ca	0 aA	0 ca	7 bca
DPX L5300	70.0	0 ab	0 fb	0 cb	100 aA	0 ac	0 cc	33 bb
Notmowed	--	0 aA	0 fa	0 ca	0 ca	0 aA	0 ca	0 ca

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no injury.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 46. Effects of one to four applications of FGR's on foliar height of 7 month old 'Rebel' tall fescue in 1988^a.

Treatment	(g/ha)	Foliar Height											
		Weeks After Initial Application		(Application Schedule) ^b									
		2(all)	6(all)	10(1)	10(2)	10(3)	12(1)	12(2)	12(3)	12(4)	14(4)		
Metsulf	10.0	20 c	18 e	27 dA	29 fA	34 cdeA	19 gB	29 aA	30 aA	34 cdeA	13 eB	9 gB	
Chlorsulf	20.0	20 c	19 e	41 abCA	34 defA	32 deA	19 gB	35 aA	30 aA	32 deA	18 deB	16 cdeA	
Imazeth & Imazapyr	67.5	2.5	23 bc	25 de	42 abA	35 cdeA	41 abA	31 dA	35 aA	31 aA	41 abCA	33 bA	22 bA
Imazeth & Imazapyr	96.4	3.6	20 c	19 e	38 bcA	38 a-dA	38 a-eA	25 efB	33 aA	30 aAB	38 a-eA	26 cB	21 bcA
Imazeth & Imazapyr	115.7	4.3	20 c	21 de	38 bcA	37 a-eA	38 a-eA	22 fgB	33 aA	30 aA	38 a-eA	22 cdB	15 deA
ACP 2100	60.0	26 ab	28 cd	46 aA	42 abA	38 a-eA	37 bcA	41 aA	33 aA	42 abA	40 aA	19 bcDA	
ACP 2100	120.0	20 c	24 de	40 abCA	36 b-eA	42 abA	28 deB	35 aA	33 aA	37 b-eA	30 bcA	20 bcDA	
ACP 2100	180.0	20 c	23 de	35 cA	32 eFA	37 b-eA	18 gB	30 aA	30 aA	31 eA	20 dB	19 bcDA	
DPX L5300	10.0	26 ab	37 b	46 aA	43 abCA	31 eA	40 bA	41 aA	30 aA	45 aA	35 abA	21 bcD	
DPX L5300	20.0	20 c	34 bc	41 abCA	41 abCA	45 aA	37 bcA	36 aA	30 aA	40 abCA	35 abA	22 bA	
DPX L5300	70.0	20 c	24 de	39 bcA	38 a-dA	39 a-dA	33 cdA	34 aA	29 aA	39 a-dA	33 bA	22 bA	
Nonmowed	--	29 a	48 a	41 abCA	39 a-dA	39 a-dA	47 aA	39 aA	40 aA	39 a-dA	35 abA	38 aA	

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr, Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 47. Effects of one to four applications of PGR's on foliar height of 7 month old 'Rebel' tall fescue in 1988^a.

Treatment (g/ha)	Foliar Height Weeks After Initial Application (Application Schedule ^b)												
	16(1)	16(2)	16(3)	16(4)	18(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)
Metsulf	10.0	21 dA	19 cDA	0 eB	7 fB	8 g	26 dA	0 eB	0 fB	27 dA	0 fB	0 dB	0 eB
Chlorsulf	20.0	21 dA	22 bDA	20 bcAB	16 eB	14 efg	28 bDA	20 cA	25 cDA	13 deB	27 dA	26 deA	27 bA
Imazeth & Imazapyr	2.5	23 cDA	24 bA	19 bDA	21 bDA	27 bc	29 bcA	19 cB	26 bDA	26 bcA	31 bcA	30 bDA	31 bA
Imazeth & Imazapyr	96.4	3.6	22 cDA	20 bDA	17 cDA	20 b-eA	26 bc	28 bDA	19 cB	27 bDA	26 bcAB	28 cDA	26 deA
Imazeth & Imazapyr	115.7	4.3	22 cDA	21 bDA	16 cDA	18 cDA	21 b-e	28 bDA	20 cB	28 bDA	19 cdeB	28 cDA	26 deA
ACP 2100	60.0	23 cDA	20 bDA	19 bDA	22 bDA	23 b-e	30 bA	21 cA	28 bDA	21 bDA	31 bcA	30 bDA	30 bA
ACP 2100	120.0	23 cDA	19 cDA	17 cDA	20 b-eA	19 cde	27 cDA	20 cA	27 bDA	22 bDA	27 dA	26 deA	28 bA
ACP 2100	180.0	22 cDA	21 bDA	14 deA	17 deA	18 def	27 cDA	20 cB	27 bDA	19 cdeB	29 bDA	24 eAB	30 bA
DPX L5300	10.0	25 bcA	23 bcA	24 bA	23 bcA	25 bcd	30 bA	25 bA	30 bA	26 bcA	32 bA	32 bcA	29 bA
DPX L5300	20.0	26 bA	21 bDA	21 bcA	24 bA	28 bc	30 bA	22 bcA	29 bcA	27 bcA	33 bA	34 bA	30 bAB
DPX L5300	70.0	23 cDA	18 dAB	17 cdB	23 bcA	29 b	27 cDA	21 cB	24 dAB	30 bA	31 bcA	28 cDA	26 bA
Normowed	--	41 aA	42 aA	44 aA	42 aA	44 a	43 aA	42 aA	43 aA	42 aA	44 aA	42 aA	48 aA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 48. Effects of one to four applications of PGR's on foliar height of 7 month old 'Rebel' tall fescue in 1988^a.

Treatment	(g/ha)	Foliar Height									
		Weeks After Initial Application		Application Schedule ^b							
		24(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)	
Metsulfuron	10.0	0 f	28 cA	0 gB	0 cB	0 fB	28 cA	0 fB	0 cB	0 dB	
Chlorsulfuron	20.0	0 f	29 cA	22 fA	28 bA	0 fB	28 cA	23 eA	27 bA	0 dB	
Imazethapyr & Imazapyr	67.5	2.5	23 cD	33 bCA	32 bDA	32 bA	24 dB	32 bCA	33 bDA	31 bA	25 bCB
Imazethapyr & Imazapyr	96.4	3.6	22 d	30 bCA	26 eFAB	24 bAB	23 dB	30 bCA	28 deA	24 bB	24 bCB
Imazethapyr & Imazapyr	115.7	4.3	0 f	30 bCA	31 b-eA	31 bA	0 fB	29 cA	32 bDA	30 bA	0 dB
ACP 2100	60.0	24 cD	34 bA	32 bDA	31 bA	24 cDA	34 bA	33 bDA	30 bA	26 bA	
ACP 2100	120.0	22 d	33 bCA	32 bDA	25 bAB	22 dB	32 bCAB	34 bCA	25 bBC	24 bCC	
ACP 2100	180.0	15 e	33 bCA	34 bA	31 bA	15 eB	30 bCA	36 bA	31 bA	16 cDB	
DPX I5300	10.0	28 bc	34 bA	32 bCA	29 bA	28 bCA	34 bA	34 bCA	29 bA	26 bA	
DPX I5300	20.0	23 cD	34 bA	27 deFAB	30 bAB	24 cDB	33 bCA	29 cDAB	30 bAB	25 bCA	
DPX I5300	70.0	30 b	33 bCA	29 cdeAB	25 bB	31 bA	30 bCA	30 bDA	26 bA	31 bA	
Nonmowed	--	40 a	44 aA	42 aA	48 aA	40 aA	45 aA	42 aA	47 aA	42 aA	

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = Imazethapyr, Metsulf = metsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 49. Effects of one to four applications of PGR's on quality of 7 month old 'Rebel' tall fescue in 1988^a.

Treatment	Quality																				
	2 (all) 6 (all)		10 (1)			10 (2)			10 (3)			10 (4)			12 (1)		12 (2)		12 (3)		12 (4)
Metsulfuron	10.0	4.0 b	2.0 de	4.5 CA	4.0 eA	4.3 CA	1.5 deB	4.7 CAB	6.0 CA	1.0 CC	3.0 CBC										
Chlorsulfuron	20.0	4.0 b	2.0 de	8.0 abA	8.0 bA	7.7 abA	1.3 deB	7.4 abA	7.3 abCA	6.7 abCA	5.3 bA										
Imazethapyr & Imazapyr	67.5	2.5	8.0 a	7.0 a	8.0 abA	7.7 bcA	6.0 aA	9.0 aA	9.0 aA	8.3 abA	8.3 aA										
Imazethapyr & Imazapyr	96.4	3.6	8.0 a	5.0 b	9.0 aA	8.0 bA	5.7 aA	8.8 aA	8.7 abA	9.0 aA	8.0 aA										
Imazethapyr & Imazapyr	115.7	4.3	7.5 a	4.5 bc	8.0 abA	8.3 aA	1.7 deB	9.0 aA	9.0 aA	8.0 abA	9.0 aA										
ACP 2100	60.0	9.0 a	5.0 b	5.0 bcA	5.0 dA	5.0 CA	6.7 aA	7.0 bA	6.7 bcA	8.0 abA	8.7 aA										
ACP 2100	120.0	9.0 a	7.0 a	8.0 abA	8.0 bA	7.7 abA	6.0 aB	9.0 aA	8.0 abCA	8.0 abA	9.0 aA										
ACP 2100	180.0	9.0 a	5.0 b	8.0 abA	7.7 bcAB	7.0 BB	5.0 abCC	9.0 aA	9.0 aA	9.0 aA	8.0 aA										
DPX L5300	10.0	9.0 a	2.0 de	2.5 cdA	3.0 fA	3.0 dA	3.0 cdeA	6.4 bcA	7.3 abCA	6.3 abCA	7.3 abA										
DPX L5300	20.0	9.0 a	3.0 cd	5.0 bcA	4.3 deA	4.0 CA	3.3 bcDA	7.0 bA	8.3 abA	6.3 abCA	9.0 aA										
DPX L5300	70.0	9.0 a	4.0 bc	4.0 cdA	7.0 CA	5.3 CA	5.3 abA	7.4 abA	8.0 abCA	6.0 bcA	8.3 aA										
Not mowed	--	9.0 a	1.0 e	1.0 dA	1.0 gA	1.0 eA	1.0 eA	1.0 dA	1.0 dA	1.0 dA	1.0 CA										

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 50. Effects of one to four applications of PCR's on quality of 7 month old 'Rebel' tall fescue in 1988^a.

Treatment (g/ha)	Quality													
	16(1)	16(2)	16(3)	16(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)		
Metsulfuron	10.0	6.0 bA	6.0 cdA	2.0 cB	1.5 cdB	5.5 bA	1.0 cB	3.0 cB	1.0 fB	5.0 bA	1.0 eB	1.0 eB	1.0 fB	
Chlorsulfuron	20.0	7.8 abA	6.0 cdA	7.0 bA	3.0 cB	7.5 abA	2.3 bB	6.7 abA	2.0 eFB	7.4 bA	1.3 eC	5.7 bcB	1.3 fC	
Imazethapyr & Imazapyr	67.5	2.5	9.0 aA	8.0 abA	8.7 aA	8.0 abA	9.0 aA	4.3 aB	6.7 abAB	6.7 aAB	8.7 abA	6.3 bcA	6.7 abCA	6.3 aA
Imazethapyr & Imazapyr	96.4	3.6	9.0 aA	8.3 abA	9.0 aA	7.3 bcA	9.0 aA	3.7 aB	8.0 aA	6.3 abAB	9.0 aA	5.3 cdBC	6.0 bcB	2.7 deC
Imazethapyr & Imazapyr	115.7	4.3	9.0 aA	8.0 abA	8.3 abA	7.3 bcA	8.5 aA	3.7 aB	6.0 bAB	3.3 deB	9.0 aA	4.7 cdB	6.0 bcB	1.7 eF
ACP 2100	60.0	8.8 aA	8.0 abA	8.7 aA	8.3 abA	9.0 aA	4.3 aB	7.3 abAB	6.3 abAB	8.7 abA	8.0 abA	5.3 bcB	4.7 bB	
ACP 2100	120.0	9.0 aA	9.0 aA	8.7 aA	8.0 abA	9.0 aA	4.3 aB	8.0 aA	4.7 cdB	9.0 aA	8.3 aA	7.0 aA	3.3 cdB	
ACP 2100	180.0	9.0 aA	8.7 abA	8.3 abA	9.0 aA	9.0 aA	4.0 aB	8.0 aA	4.0 cdC	9.0 aA	8.0 abA	6.0 bcB	2.7 deC	
DPX L5300	10.0	9.0 aA	7.7 abA	8.0 abA	7.7 abA	9.0 aA	4.0 aB	7.0 abAB	5.0 bcBC	8.4 abA	8.0 abA	5.0 bodB	4.0 bcB	
DPX L5300	20.0	9.0 aA	7.3 bcB	8.3 abA	7.7 abAB	9.0 aA	4.0 aB	6.7 abAB	5.0 bcBC	8.4 abA	6.3 bcAB	4.7 cdB	4.0 bcB	
DPX L5300	70.0	9.0 aA	5.7 dB	7.0 bAB	8.0 abAB	8.5 aA	2.7 bB	5.7 bB	5.3 abcB	9.0 aA	3.3 deB	3.0 deB	3.7 bcB	
Nonmowed	--	1.0 cA	1.0 eA	1.0 cA	1.0 dA	1.0 cA	1.0 cA	1.0 cA	1.0 cA	1.0 dA	1.0 eA	1.0 eA	1.0 fA	

^aMetsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality is based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 51. Effects of one to four applications of FGR's on quality of 7 month old 'Rebel' tall fescue^a.

Treatment	Quality							
	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)
Metsulfuron	10.0	5.0 CA	1.0 dB	1.0 CB	5.5 CA	1.0 dB	1.0 CB	1.0 BB
Chlorsulfuron	20.0	7.0 bcA	1.3 dC	3.0 aB	8.0 abA	1.3 dC	3.0 aB	1.0 BB
Imazethapyr & Imazapyr	67.5	2.5	7.0 bcAB	8.0 aA	3.0 aC	4.3 abB	7.5 bcA	8.0 aA
Imazethapyr & Imazapyr	96.4	3.6	8.0 abA	7.7 aA	3.0 aB	2.3 abB	9.0 aA	7.7 aA
Imazethapyr & Imazapyr	115.7	4.3	8.5 aA	7.3 abA	3.0 aB	1.0 dB	8.5 abA	7.3 abA
ACP 2100	60.0	8.0 abA	8.0 aA	3.0 aB	3.0 aB	5.7 aB	8.0 aA	8.0 aA
ACP 2100	120.0	8.0 abA	8.0 aA	3.0 aB	3.0 aB	3.7 abB	8.5 abA	8.0 aA
ACP 2100	180.0	8.0 abA	8.0 aA	3.0 aB	3.0 aB	3.3 abB	9.0 aA	8.0 aA
DPX I5300	10.0	7.0 bcA	7.3 abA	3.0 aB	5.7 aA	7.0 bcA	7.3 abA	3.0 aB
DPX I5300	20.0	7.0 bcA	5.7 bcA	3.0 aB	3.7 abB	7.0 bcA	5.7 bcAB	3.0 aB
DPX I5300	70.0	8.5 aA	4.0 CB	2.3 BB	2.3 abB	8.5 abA	4.0 CB	2.0 BB
Nonmowed	--	1.0 dA	1.0 dA	1.0 CA	1.0 BA	1.0 dA	1.0 CA	1.0 BA

^aMetsulfuron, chlorsulfuron, and DPX I5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Quality was based on a scale from 1 to 9, where 6 = acceptable, 9 = excellent.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = application at week 0, 6, 12, and 18.

Appendix Table 52. Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1988^a.

Treatment (g/ha)	Phytotoxicity												
	Weeks After Initial Application				(Application Schedule ^b)								
	2(all)	4(all)	6(all)	8(1-3)	8(4)	10(1-3)	10(4)	12(1-2)	12(3)	12(4)	14(1-2)	14(3)	14(4)
Metsulf	10.0	55 a	75 a	43 aB	90 aA	0 aB	85 aA	0 aA	33 aA	0 aA	0 aB	60 aA	70 aA
Chlorsulf	20.0	50 a	70 a	0 bB	73 bA	0 aB	83 aA	0 aA	0 aA	0 aA	0 aB	37 bCA	37 bA
Imazeth & Imazapyr	67.5	2.5	10 bc	0 c	0 c	0 bA	13 efgA	0 aA	20 cdeA	0 aA	0 aA	7 eFA	0 dA
Imazeth & Imazapyr	96.4	3.6	10 bc	0 c	0 c	0 bB	37 cdA	0 aB	37 bCA	0 aA	0 aA	17 deFA	0 dA
Imazeth & Imazapyr	115.7	4.3	25 b	0 c	0 c	0 bB	47 cA	0 aB	80 aA	0 aA	0 aB	27 cDA	17 cAB
ACP 2100	60.0	0 c	0 c	0 c	0 bA	6 fgA	0 aA	10 deA	0 aA	0 aA	0 aA	0 fA	0 dA
ACP 2100	120.0	0 c	0 c	0 c	0 bB	23 deA	0 aA	30 bcdA	0 aA	0 aA	0 aA	17 deFA	13 cda
ACP 2100	180.0	0 c	20 b	25 b	0 bB	43 cA	0 aB	33 bCA	0 aA	0 aA	0 aA	23 cdeA	0 dA
DPX L5300	10.0	0 c	0 c	0 c	0 bA	3 gA	0 aA	7 eA	0 aA	0 aA	0 aA	10 deFA	0 dA
DPX L5300	20.0	0 c	0 c	0 c	0 bB	23 deA	0 aB	17 cdeA	0 aA	0 aA	0 aB	27 cDA	0 dB
DPX L5300	70.0	0 c	30 b	35 b	0 bB	20 eFA	0 aB	43 bA	0 aA	0 aA	0 aB	50 abA	0 dB
Notmowed	---	0 c	0 c	0 c	0 bA	0 gA	0 aA	0 eA	0 aA	0 aA	0 aA	0 fA	0 dB

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 53. Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue in 1988^a.

Treatment (g/ha)	Phytotoxicity																	
	Weeks After Initial Application (Application Schedule ^b)																	
	16(1)	16(2)	16(3)	16(4)	18(1)	18(2)	18(3)	18(4)	20(1)	20(2)	20(3)	20(4)	22(1)	22(2)	22(3)	22(4)		
Metsulf	10.0	0 aB	27 abB	100 aA	0 aB	83 aA	100 aA	50 aAB	0 aB	100 aA	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA		
Chlorsulf	20.0	0 aB	20 abAB	0 cB	50 aA	0 aB	60 bA	0 bB	33 aAB	0 aB	70 bA	0 bB	43 bA	0 aB	23 bB	13 cB	80 bA	
Imazeth & Imazapyr	67.5	2.5	0 aA	0 cA	0 aB	0 bA	0 aB	33 cDA	0 bB	0 bB	0 aB	30 eA	0 bB	0 dB	0 aA	0 bA	23 cA	13 eFA
Imazeth & Imazapyr	96.4	3.6	0 aA	0 cA	0 aB	10 bA	0 aB	33 cDA	0 bB	0 bB	0 aB	43 dA	0 bB	0 dB	0 aA	7 bA	20 cA	30 deA
Imazeth & Imazapyr	115.7	4.3	0 aA	10 bCA	0 cA	13 bA	0 aB	40 cA	0 bB	10 bB	0 aB	50 cDA	0 bB	3 cdB	0 aA	30 bA	23 cA	27 deA
ACP 2100	60.0	0 aA	0 cA	0 cA	0 bA	0 aB	17 eA	0 bB	0 bB	0 aB	20 fA	0 bB	0 dB	0 aA	0 bA	10 cA	0 fA	
ACP 2100	120.0	0 aA	0 cA	0 cA	0 bA	0 aB	30 dA	0 bB	0 bB	0 aB	30 eA	0 bB	10 cDA	0 aA	0 bA	17 cA	7 fA	
ACP 2100	180.0	0 aA	0 cA	0 cA	10 bA	0 aB	33 cDA	0 bB	10 bB	0 aB	43 dA	0 bB	7 cdB	0 aB	0 bB	20 cA	30 deA	
DPX I5300	10.0	0 aA	7 bCA	30 bA	0 bA	0 aB	27 dA	0 bB	0 bB	0 aB	27 eFA	0 bB	23 bCA	0 aB	0 bB	27 bCA	30 deA	
DPX I5300	20.0	0 aA	13 abCA	0 cA	0 bA	0 aB	33 bCA	0 bB	7 bB	0 aB	33 eA	0 bB	30 bCA	0 aB	0 bB	30 bCA	40 dA	
DPX I5300	70.0	0 aB	33 aA	0 bB	0 bB	0 aB	57 bA	0 bB	0 bB	0 aC	53 cA	0 bC	23 bcB	0 aC	33 bB	60 bA	60 cA	
Normowed	—	0 aA	0 cA	0 bA	0 bA	0 aB	0 fA	0 bA	0 aA	0 gA	0 bA	0 dB	0 aA	0 aA	0 bA	0 cA	0 fA	

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX I5300 all contained mefluidide at 140 g ha⁻¹. All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

Appendix Table 54. Phytotoxicity of one to four applications of PGR's on 7 month old 'Rebel' tall fescue^a.

Treatment (g/ha)	Phytotoxicity											
	Weeks After Initial Application (Application Schedule ^b)											
	24(1)	24(2)	24(3)	24(4)	26(1)	26(2)	26(3)	26(4)	28(1)	28(2)	28(3)	28(4)
Metsulf	10.0	0 aB	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA	0 aB	100 aA	100 aA	100 aA
Chlorsulf	20.0	0 aC	0 cA	43 cB	100 aA	0 aC	0 cB	50 cB	100 aA	0 aC	0 cC	50 cB
Imazeth & Imazapyr	2.5	0 aA	0 cA	10 deA	0 dA	0 aB	0 cB	50 cA	0 bB	0 aB	0 cB	50 cA
Imazeth & Imazapyr	3.6	0 aA	0 cA	20 deA	13 dA	0 aB	0 cB	50 cA	0 bB	0 aB	0 cB	50 cA
Imazeth & Imazapyr	4.3	0 aB	0 cB	17 deB	100 aA	0 aC	0 cC	50 cB	100 aA	0 aC	0 cC	50 cB
ACP 2100	60.0	0 aA	0 cA	0 eA	0 dA	0 aB	0 cB	50 cA	0 bB	0 aB	0 cB	50 cA
ACP 2100	120.0	0 aA	0 cA	7 eA	0 dA	0 aB	0 cB	50 cA	0 bB	0 aB	0 cB	50 cA
ACP 2100	180.0	0 aA	0 cA	13 deA	0 dA	0 aB	0 cB	50 cA	0 bB	0 aB	0 cB	50 cA
DPX L5300	10.0	0 aA	0 cA	20 deA	7 dA	0 aB	0 cB	50 cA	0 bB	0 aB	0 cB	50 cA
DPX L5300	20.0	0 aB	0 cB	30 cDA	47 cA	0 aB	0 cB	50 cA	0 bB	0 aB	0 cB	50 cA
DPX L5300	70.0	0 aC	33 bB	70 bA	70 bA	0 aC	33 bB	67 bA	0 bC	0 aC	33 bB	70 bA
Notmowed	—	0 aA	0 cA	0 eA	0 dA	0 aA	0 cA	0 dA	0 bA	0 aA	0 cA	0 dA

^aMetsulf = metsulfuron, Chlorsulf = chlorsulfuron, Imazeth = imazethapyr. Metsulfuron, chlorsulfuron, and DPX L5300 treatments all contained mefluidide at 140 g ha^{-1} . All chemical treatments contained a nonionic surfactant at 0.25% v/v. Means within a column followed by the same small letter and means within a row and within the same week followed by the same capital letter are not significantly different at the 5% level according to a Waller-Duncan K-ratio t-test. Phytotoxicity is based on a scale from 0 to 100, where 0 = no phytotoxicity.

^bApplication schedule 1 = one application at week 0; 2 = application at week 0 and 14; 3 = application at week 0, 10, and 20; 4 = four application at weeks 0, 6, 12, and 18.

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