EXPERIMENTS IN CONTROL OF WEEDS IN GRASS SEED CROPS, 1971-1996

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INTRODUCTION

This report contains information on some of the research conducted from 1971 to 1996 on the control of weeds in forage grasses grown for seed at the Northern Agriculture Research Centre, Agriculture & Agri-Food Canada, Beaverlodge, Alberta. The purpose of the report is to provide background information to researchers and others planning future work in this area of research. It is not intended for purposes of presenting recommendations and should never be used as such.

Common names (CSA approved) for herbicides have been used throughout the report. All rates of herbicides are presented as active ingredients or acid equivalents. Expert Committee on Weeds, Western Canada Section rating scales have been used for visible evaluations. The scoring system is as follows:

Weed control	Crop tolerance
9 = complete control	9 = complete tolerance
8 = excellent control	8 = possible effect
7 = good control	7 = slight injury
6 = fair control	6 = definite effect
5 to 1 = poor control	5 to 1 = severe effect
0 - no effect	0 = complete kill

Ratings of 7 to 9 are considered as commercially acceptable.

SECTION I: EFFECT OF HERBICIDE RESIDUES ON FORAGE GRASSES

Response of five perennial forage crops to residues of metsulfuron methyl in northern Alberta[1]

Field studies have shown that metsulfuron methyl residues have little effect on forage crops seeded 1 year after spraying at Beaverlodge (soil pH 6.1) but at Fort Vermilion (soil pH 6.7) injury occurred among grasses seeded 1 year after spraying and among legumes seeded 2 years after spraying.

Metsulfuron methyl (Ally) has been used extensively in the Peace River region to control broadleaf weeds in cereal crops. Rates of use range up to 4.5 g (active ingredient) ha^{-1} (i.e., 3 g (product) per acre). While the herbicide has been successful in controlling weed, it can persist in the soil for periods of sufficient duration to cause injury to succeeding rotational crops. In Alberta, in black and grey wooded soil, an interval of 10 months between application of metsulfuron methyl and the seeding of most graminaceous crops is required while longer periods are required for broadleaved crops. Several soil and environment factors can influence the persistence of the herbicide. In general, high soil pH levels, low soil temperatures, low soil moisture content, intermittent water-logging of the soil and/or reduced water permeability increase persistence.

The production of forage crops for seed or herbage represents an important component of agriculture in the Peace River region of northern Alberta and British Columbia. Forage crops, particularly when produced for seed, are often grown in rotation with cereal crops where metsulfuron methyl has been used. Despite this practice, limited knowledge is available regarding the effect of metsulfuron methyl residues on forage crops, particularly under northern agriculture conditions. The purpose of this study was to determine the effect of metsulfuron methyl residues on the yield of five perennial forage crops (creeping red fescue, northern bromegrass, timothy, alfalfa and red clover) at two locations in northern Alberta.

Experiments were established in 1983, 1984, and 1985 at both Beaverlodge and Fort Vermilion, Alberta. Soil conditions for each location are described in Table 1. During the mid-May of the year of establishment of each experiment, barley was seeded and allowed to grow to the 3 to 6 leaf stage. At this time, metsulfuron methyl (60% dry flowable formulation) at 6, 9 and 18 g (active ingredient) ha^{-1} was applied with a bicycle sprayer set to deliver a spray volume of 168 L ha^{-1} at a pressure of 208 KPa. An unsprayed check was included in each experiment. Rates of metsulfuron methyl were selected in consultation with the manufacturer (DuPont Canada Inc.) and were the rates at which registrations of the product was expected. Each plot was 5.5 X 10 m in size. Individual dates of application are presented in Table 1. The treatments were arranged in a randomized complete block design with four replicates. All barley on the plots was harvested at maturity and the entire plot area was tilled with a tandem disc set to cut to a depth of 10 cm immediately after harvest.

In mid-May/early June of each of the years following herbicide application, the plot areas were cultivated, harrowed and packed (in the direction of herbicide application to avoid inter-plot contamination). Four rows (spaced 30 cm apart) of each of the following forage crops were seeded (see dates in Table 1) in a direction perpendicular to that of herbicide application: creeping red fescue (cv. Boreal), bromegrass (cv. Carlton), timothy (cv. Climax), alfalfa (cv. Peace) and red clover (cv. Altaswede). During the year of seeding, crop injury was evaluated approximately 6 weeks after seeding. In addition, herbage yields were obtained in August of the year following seeding, except when stand establishment failed (i.e. site 3, 1986 for grass species at Fort Vermilion). Since growth of the forage crops was insufficient to provide meaningful yields in the year of seeding, all yields reported are those obtained the year following seeding. Samples of the above ground parts from 2 m sections of the two middle rows of each crop, were harvested, oven dried and weighed. Weed growth in the plots was controlled by hand weeding or mowing. Two years after herbicide application the same forage species were again seeded (Table 1) in each plot in an area directly behind those seeded 1 year after spraying. Procedures for seeding, evaluation of crop injury and plot maintenance were the same as for those seedings made 1 year after spraying.

At Beaverlodge, metsulfuron methyl caused little or no visible injury or herbage yield reductions regardless of rate of application, site, the year after spraying when seeded or forage crop species, i.e. injury to forage crops seeded the year following application or later was not a problem.

[1]Conducted with G.W. Clayton.

At Fort Vermilion results were quite different from those at Beaverlodge. Residues from metsulfuron methyl caused moderate to severe visible injury to the three grass crops seeded 1 year after spraying and very severe injury to both legume crops seeded at the same time. Injury to the grasses increased as the rates of both herbicides increased while injury to the legumes was so severe that increasing the rate from 6 to 18 g ha^{-1} had little apparent effect. Visible injury ratings were not made for crops seeded 2 years after spraying.

Herbage yields of creeping red fescue and bromegrass were influenced by the site, year of seeding and the rate of metsulfuron methyl. Yield losses increased as the rate of metsulfuron methyl increased, i.e. yields, averaged across sites and years of seeding, decreased as rates of both herbicides increased (Table 2). Nearly all of the herbage yield losses caused by herbicide residue occurred among grasses seeded 1 year after spraying. Herbage yields of grasses seeded into plots where metsulfuron methyl had been applied 2 years previously generally were not significantly lower than those from the check plots. Differences between sites and years of seeding within sites occurred. Variation in weather conditions are probably responsible for these differences.

Herbage yields from some check plots were sometimes lower than expected. We are unable to clearly explain why this occurred. Differential weed competition may have been involved. Although the plots were handweeded in each of the years of seeding, delays sometimes occurred in performing this procedure. Thus, the effects of the herbicides in reducing weed populations combined with delays in handweeding may have resulted in greater weed pressure in check plots and a resultant reduction in check plot yields.

The herbage yields of timothy followed a similar pattern to those of creeping red fescue and bromegrass, although variability made the results less clear cut.

Herbage yields of red clover and alfalfa were drastically affected by residues from all metsulfuron methyl treatments (Table 2). With the exception of herbage yields in legumes seeded in 1986 at site 2 into plots where the lowest rates of metsulfuron methyl had been applied, residues from all treatments caused severe losses. Losses from legumes seeded 2 years after spraying tended to be less than those seeded 1 year after spraying, but they were still severe. Reductions in yield among legumes seeded 2 years after spraying increased as the rate of metsulfuron methyl increased.

The greater injury observed from metsulfuron methyl residues at Fort Vermilion than at Beaverlodge can be attributed to differences in soil pH. The low soil pH at Beaverlodge (Table 1) probably enhanced the rate of herbicide breakdown while at Fort Vermilion the relatively high pH probably promoted at lower rate of herbicide breakdown. Organic matter content of the soil probably had no effect on the level of crop injury. The organic matter content of the soil at Beaverlodge was higher than that of Fort Vermilion but crop injury from herbicide residues was greatest at the latter site. Soil temperatures also had little effect on the level of crop injury since they are generally higher at Fort Vermilion than Beaverlodge. The effect of soil moisture on the amount of crop injury from the herbicide residues is unclear.

Our results suggest that, under northern agricultural conditions, it is safe to seed any forage crops grown in this study into low pH soils (such as those at Beaverlodge) where metsulfuron methyl has been applied and the approved interval of time between spraying and seeding has elapsed. However, in some situations, where metsulfuron methyl has been applied to soils near pH 7.0 or higher (such as those at Fort Vermilion), a longer than recommended period between spraying and seeding of the forage crop may be required to ensure that injury does not occur.

Table 1: Location descriptions, dates of herbicides application, and dates of seeding of forage crops 1 and 2 years after metsulfuron methyl application.

	Location	
	Beaverlodge	Fort Vermilion
Site descriptions		
pH (1:1 slurry)	6.1	6.7
Soil texture	Silty clay	Loam
Organic matter	7.4%	4.6%
Dates of herbicide application		
Site 1	29/6/83	29/6/83
Site 2	13/6/84	5/6/85
Site 3	4/7/85	10/6/86
Dates of seeding 1 year after herbicide application		
Site 1	15/5/84	29/5/84
Site 2	6/6/85	5/6/85
Site 3	7/6/86	10/6/86
Dates of seeding 2 years after herbicide application		
Site 1	6/6/85	5/6/85
Site 2	5/6/86	10/6/86
Site 3	26/6/87	2/6/87

Table 2. Herbage yields of creeping red fescue, bromegrass, timothy, alfalfa and red clover 1 year after being seeded at Fort Vermilion into soils which had been sprayed with several rates of metsulfuron at 1 and 2 years prior to planting.

Rate of Metsulfuron	Site 1 Seeded 1984	Site 1 Seeded 1985	Site 2 Seeded 1985	Site 2 Seeded 1986	Site 3 Seeded 1987	Site 3 Seeded 1988	Mean
g ha^{-1}	kg ha^{-1}						
Creeping red fescue							
0	688†	415	1318	160	180	-	645
6	485	571	1015	200	298	-	568
9	535	552	845	368	360	-	575
18	72	605	472	538	280	-	422
Mean(Site x Years seeded)	445	536	913	316	532	-	
Mean(Site)	490		614		532		
Bromegrass							
0	610	562	730	355	265	-	564
6	342	902	663	225	422	-	538
9	482	1039	700	373	578	-	648
18	60	834	190	613	887	-	424
Mean(Site x Year seeded)	374	835	571	391	395	-	
Mean(Site)	604		481		395		
Timothy							
0	2248	511	480	315	140	-	780
6	1948	599	80	243	460	-	717
9	1765	620	105	443	600	-	733
18	607	526	268	760	755	-	540
Mean(Site x Year seeded)	1642	564	125	440	877	-	
Mean(Site)	1103		283		877		
Alfalfa							
0	4038†	1163	647	820	3285	1788	1957
6	423	527	235	845	663	415	460
9	50	0	122	663	0	40	146
18	0	0	21	415	0	0	73
Mean(Site x Year seeded)	1128	423	256	686	821	639	
Mean(site)	775		471		730		
Red clover							
0	2795	1145	160	1508	3133	1283	1903
6	52	182	94	848	0	220	373
9	0	16	1	530	0	0	93
18	0	0	0	207	0	0	35
Mean(Site x Year seeded)	713	336	636	773	783	364	
Mean(Site)	524		705		574		

' Years of application of herbicide treatments were 1983, 1984 and 1985 for sites 1, 2 and 3, respectively.

† Significant terms from analysis of variance with standard error of differences of means in parenthesis were:
Crf: Site(46); Year of seeding(46); Herbicide treatment(66); Year x Herbicide(93); and Site x Year(66).
Bro: Site(51); Year(51); Herbicide(72); Year x Herbicide(102); Site x Year(72).
Tim: Site(75); Year(75); Year x Herbicide(151); Site x Herbicide(151); Site x Year(107); and Site x Year x Herbicide(213).
Alf: Site(86); Herbicide(99); Year x Herbicide(140); Site x Herbicide(172); Site x Year(121); and Site x Herbicide x Year(243).
Red clover: Herbicide(178) and Year x Herbicide (251).

Effect of residues of ethalfluralin and trifluralin on succeeding crops

Creeping red fescue and timothy were injured by carryover from ethalfluralin and trifluralin. Injury from granular formulations tended to be greater than from emulsifiable concentrate formulations.

Introduction: Ethalfluralin and trifluralin are herbicides commonly used for the control of weeds in oilseed and legume crops. Creeping red fescue injury was reported from trifluralin carryover in the Sexsmith area in the late 1970's and on wheat in 1982 in the Grande Prairie area. In 1991, ehhalfluralin carryover caused serious wheat injury in the Dawson Creek area, as well as in other areas of the Peace River region. This experiment was conducted to determine the effect of carryover from two formulations of ethalfluralin and trifluralin on several crops.

Methods: Ethalfluralin and trifluralin (GR and EC formulations) were applied on May 27, 1988 to a silt loam soil (pH 6.1, O.M. 5%) at Beaverlodge. Immediately after application the herbicides were incorporated twice (at right angles) with a tandem disc set to cut to a depth of 10.0 cm. Granular formulations were applied with a granular applicator while emulsifiable concentrate formulations were sprayed on in a volume of 100 L/ha. Each treatment was replicated three times. On May 28, 1988 Tobin canola was seeded in all plots. On September 2, 1988 canola yields were obtained. Following harvest the entire plot area was cultivated with a toolbar cultivator to a depth of 15 cm. On May 11, 1989 the plot area was disced, harrowed, and packed. The following day Heartland barley, Neepawa wheat, Cascade oats, Boreal creeping red fescue (CRF), and Climax timothy (TIM) were seeded in rows spaced 23 cm apart and in a direction perpendicular to that of spraying. Eight rows of barley and wheat and 4 rows of the other crops were seeded. The plant density of all crops and the yield of barley, wheat, oats was measured on September 26 (Table 1). The entire plot area was maintained so as to prevent interference from weed competition. In 1988 moisture conditions were favourable for plant growth until mid-July but very dry after this date. In 1989 moisture conditions were at or above average throughout the growing season.

Results: Residues from ethalfluralin and trifluralin reduced yields of wheat and oats but not of barley. Similar residues reduced the density of the three cereal crops. Injury from granular formulations tended to be greater than from emulsifiable concentrate formulations. None of the treatments had any effect on canola yields in 1988.

Table 1. Density and yield of several crops grown 1 year after the application of ethalfluralin and trifluralin.

Herbicide	Formu-lation	Rate (kg/ha)	Density (plants/m)					Yield (g/m)		
			Barley	Wheat	Oats	CRF	TIM	Barley	Wheat	Oats
Check			107	132	164	67	128	327	340	644
Ethalfluralin	EC	1.0	130	134	118	29	22	328	265	171
Ethalfluralin	EC	2.0	89	112	110	9	7	224	191	21
Ethalfluralin	GR	1.0	138	112	151	16	3	366	170	33
Ethalfluralin	GR	2.0	89	97	116	3	1	206	50	8
Trifluralin	EC	1.0	119	121	135	43	39	315	214	183
Trifluralin	EC	2.0	113	129	110	6	4	303	151	26
Trifluralin	GR	1.0	157	121	105	22	12	333	246	126
Trifluralin	GR	2.0	102	90	96	1	7	228	118	10
Standard error differences			DNS	DNS	DNS	8	10	DNS	33	55

SECTION II: TOLERANCE OF SEEDLING GRASSES TO HERBICIDES

Effect of herbicides used for broadleaved weed control on subsequent seed yields of creeping red fescue

2,4-D ester, 2,4-D amine, MCPA amine, dicamba/2,4-D/mecoprop, and bromoxynil/MCPA applied to seedling creeping red fescue (3-leaf stage) at rates normally used to control annual broadleaved weeds, had no detrimental effect on subsequent seed yields.

Introduction: Stinkweed, lamb's-quarters, wild buckwheat, and a large number of other annual broadleaf weeds are troublesome in seedling fescue. Since herbicides that control these weeds in cereal crops are available for general use, a study was initiated to determine their effects on seedling fescue.

Methods: Boreal creeping red fescue was seeded in rows spaced 30 cm apart in 1971, 1972, and 1973. When the grasses reached the 3-leaf stage the herbicides (Table 1) were applied in a spray volume of 168 L/ha. Each herbicide treatment was replicated six times. Weeds were removed by tillage and hoeing to prevent their interference with crop yields. Seed yields were obtained one year after herbicide application.

Results and Discussion: In 1972, 2,4-D ester at .56 kg/ha caused a small yield reduction while at 1.12 kg/ha it caused nearly a 50% reduction in seed yield (Table 1). Similarly 2,4-D amine and MCPA at .84 kg/ha caused small reduction and at 1.68 kg/ha both herbicides caused severe seed yield reduction. Dicamba/2,4-D/mecoprop reduced seed yields at 1.12 kg/ha but not at .56 kg/ha. Only the heaviest rates of bromoxynil/MCPA reduced seed yields. In 1973 and 1974 none of the herbicide treatment caused any seed yield reductions. Since the lowest rate of each herbicide or herbicide combination will give adequate broadleaf weed control, it would appear that there is minimal risk in treating seedling creeping red fescue at the 3-leaf stage.

Table 1. Effect of herbicides applied to seedling fescue on subsequent seed yields.				
		Fescue seed yields, kg/ha		
Herbicide	Rate, kg/ha	1972[1]	1973[2]	1974[3]
Check	0	226	999	943
2,4-D ester	.56	171	969	948
2,4-D ester	1.12	120	956	915
Check	0	158	977	1063
2,4-D amine	.84	142	1040	953
2,4-D amine	1.68	78	998	1090
Check	0	221	1150	1077
MCPA amine	.84	167	1108	1109
MCPA amine	1.68	121	1090	953
Check	0	212	1165	945
Dicamba/2,4-D/mecoprop	.56	207	1132	1025
Dicamba/2,4-D/mecoprop	1.12	153	1055	852
Check	0	174	1096	1084
Bromoxynil/MCPA	.84	196	1170	1205
Bromoxynil/MCPA	1.68	134	1082	1030

[1] Herbicides applied July 8, 1971. Seed harvested July 1972.
[2] Herbicides applied July 11, 1972. Seed harvested July 1973.
[3] Herbicides applied July 27, 1973. Seed harvested July 1974.

Tolerance of seedling creeping red fescue, bromegrass, and timothy to herbicides used for broadleaved weed control[2]

Seedling creeping red fescue, timothy, and bromegrass exhibited good tolerance to bromoxynil/MCPA, Linuron/MCPA, clopyralid, clopyralid/2,4-D, clopyralid/MCPA, and dicamba/mecoprop/MCPA when these herbicides were applied at rates normally used in cereal crops. Similarly creeping red fescue and bromegrass seedlings exhibited excellent tolerance to cyanazine/MCPA but timothy seedlings were sometimes injured.

Introduction: Common chickweed, hemp nettle, corn spurry, cleavers, and several other weeds which are resistant to herbicides developed prior to the mid-seventies, have recently become problems in seedling stands of grasses. Several herbicides, developed to control these weeds in cereal crops, appear to have promise in seedling grasses. Therefore, a study was initiated to determine the tolerance of seedling grasses to herbicides for broadleaved weed control.

Methods: Boreal creeping red fescue, Carlton bromegrass and Climax timothy were seeded annually in rows spaced 30cm apart from 1978 to 1983. When the grasses developed to the 3-leaf stage herbicide treatments (Tables 1, 2 and 3) were applied. Plots on which the herbicides were applied consisted of 3 rows of each grass. The plots were 9 m in length. The herbicides were applied to the front two-thirds of the plot leaving the remaining one-third as an untreated check. Each herbicide treatment was replicated at least twice. Weed populations were kept at a low level by tillage or hoeing. Crop tolerance ratings were obtained from 3 to 9 weeks after application of the herbicides.

In 1984, 1985 and 1986 the design of the plots was modified from that of previous years. Four rows of each grass were sown in each plot. The rows were 3 m in length and spaced 30 cm apart. Herbicide treatments were applied perpendicular to the direction the grasses were seeded. Untreated check strips, 1.5 m in width, were left adjacent to each plot. All treatments were replicated three times each year. Tolerance of the grasses was evaluated as in previous years. All trials were conducted at the Beaverlodge Research Station, except for 1980 and 1982 when they were also conducted at Fort Vermilion and Barrhead, respectively.

Results: All three grasses exhibited good tolerance to the following herbicides: bromoxynil, bromoxynil/MCPA, linuron/MCPA, clopyralid, clopyralid/2,4-D, clopyralid/MCPA and dicamba/mecoprop/ MCPA. Creeping red fescue and bromegrass also showed good tolerance to cyanazine/MCPA but timothy was injured in some years by this treatment. Metribuzin caused injury to the grasses in most years with timothy appearing most susceptible. Injury symptoms included leaf burn, retardation of growth and some grass mortality, particularly at the highest rates. Bromoxynil/diclofop methyl injured timothy but neither of the other two grasses.

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[2] Funds from the Agricultural Research Council of Alberta, Farming for the Future (Project Number 79-0083), supported this project during 1980, 1981, and 1982.

Table 1. The tolerance of seedling stands of creeping red fescue to herbicides for broadleaved weed control.				
Herbicide	Rate (kg/ha)	Mean tolerance	Range in tolerance	No. of station years evaluated
Metribuzin	0.14	7.3	5.0 - 8.5	5
Metribuzin	0.21	6.5	3.0 - 8.0	5
Metribuzin	0.28	6.9	5.5 - 8.0	4
Metribuzin	0.42	6.0	4.0 - 8.0	4
Metribuzin + MCPA	0.21 + .56	7.5	6.0 - 9.0	4
Linuron + MCPA	0.21 + .42	8.6	8.0 - 9.0	10
Linuron + MCPA	0.28 + .56	8.6	8.0 - 9.0	9
Bromoxynil	0.28	8.8	8.0 - 9.0	5
Bromoxynil	0.42	8.5	8.0 - 9.0	4
Bromoxynil	0.56	8.7	8.0 - 9.0	3
Bromoxynil/MCPA	0.28 + .28	9.0	9.0 - 9.0	3
Bromoxynil/diclofop methyl (1:2.9)	1.08	9.0	9.0 - 9.0	3
Metsulfuron methyl	0.003	9.0	-	1
Metsulfuron methyl	0.01	3.0	-	1
Clopyralid	0.10	9.0	9.0 - 9.0	3
Clopyralid	0.30	8.8	8.0 - 9.0	6
Clopyralid + 2,4-D	0.15 + .42	9.0	9.0 - 9.0	5
Clopyralid + 2,4-D	0.30 + .56	9.0	9.0 - 9.0	4
Clopyralid/MCPA (1:5.6)	0.66	9.0	9.0 - 9.0	2
Dicamba/mecoprop/MCPA (1:1:4.4)	0.60	9.0	9.0 - 9.0	3

\+ 0 = complete kill, 9 = no effect.

++ Metsulfuron methyl applied with a surfactant, Cittowett Plus, at 0.1% (V/V) of spray volume.

Table 2. The tolerance of seedling stands of bromegrass to herbicides for broadleaved weed control.				
Herbicide	Rate (kg/ha)	Mean tolerance	Range in tolerance	No. of station years evaluated
Metribuzin	0.14	7.6	6.0 - 8.5	6
Metribuzin	0.21	7.1	5.0 - 8.0	6
Metribuzin	0.28	6.9	6.0 - 8.5	4
Metribuzin	0.42	5.8	5.0 - 6.0	4
Metribuzin + MCPA	0.21 + .56	7.9	7.0 - 8.5	4
Linuron + MCPA	0.21 + .42	8.8	8.0 - 9.0	11
Linuron + MCPA	0.28 + .56	8.6	8.0 - 9.0	10
Bromoxynil	0.28	8.9	8.0 - 9.0	7
Bromoxynil	0.42	8.5	8.0 - 9.0	4
Bromoxynil	0.56	8.7	8.0 - 9.0	3
Bromoxynil/MCPA	0.28 + .28	9.0	9.0 - 9.0	4
Bromoxynil/diclofop methyl (1:2.9)	1.08	8.7	8.0 - 9.0	3
Metsulfuron methyl	0.003	9.0	-	1
Metsulfuron methyl	0.006	8.0	-	1
Metsulfuron methyl	0.01	6.0	-	1
Clopyralid	0.10	8.7	8.0 - 9.0	4
Clopyralid	0.30	8.5	8.0 - 9.0	7
Clopyralid + 2,4-D	0.15 + .42	8.3	8.0 - 9.0	3
Clopyralid + 2,4-D	0.30 + .56	8.8	8.0 - 9.0	6
Clopyralid/MCPA (1:5.6)	0.66	9.0	-	2
Dicamba/mecoprop/MCPA (1:1:4.4)	0.60	9.0	-	3

\+ 0 = complete kill, 9 = no effect.

++ Metsulfuron methyl applied with a surfactant, Cittowett Plus, at 0.1% (V/V) of spray volume.

Table 3. The tolerance of seedling stands of timothy to herbicides for broadleaved weed control.				
Herbicide	Rate (kg/ha)	Mean tolerance	Range in tolerance	No. of station years evaluated
Metribuzin	0.14	6.8	4.0 - 9.0	4
Metribuzin	0.21	5.5	2.0 - 8.0	4
Metribuzin	0.28	6.0	6.0 - 6.0	2
Metribuzin	0.42	5.0	4.0 - 6.0	2
Metribuzin + MCPA	0.21 + .56	6.0	5.0 - 7.0	2
Linuron + MCPA	0.21 + .42	8.3	7.0 - 9.0	9
Linuron + MCPA	0.28 + .56	7.8	6.0 - 9.0	8
Bromoxynil	0.28	9.0	-	7
Bromoxynil	0.42	8.6	8.0 - 9.0	5
Bromoxynil	0.56	9.0	-	3
Bromoxynil/MCPA	0.28 + .28	8.3	8.0 - 9.0	3
Bromoxynil/diclofop methyl (1:2.9)	1.08	4.3	3.0 - 6.0	3
Metsulfuron methyl	0.003	6.0	-	1
Metsulfuron methyl	0.006	6.0	-	1
Metsulfuron methyl	0.01	4.0	-	1
Clopyralid	0.10	9.0	-	2
Clopyralid	0.30	8.5	8.0 - 9.0	6
Clopyralid + 2,4-D	0.15 + .42	8.5	8.0 - 9.0	2
Clopyralid + 2,4-D	0.30 + .56	8.7	8.0 - 9.0	4
Clopyralid/MCPA (1:5.6)	0.66	9.0	-	2
Dicamba/mecoprop/MCPA (1:1:4.4)	0.60	9.0	-	3

\+ 0 = complete kill, 9 = no effect.

++ Metsulfuron methyl applied with a surfactant, Cittowett Plus, at 0.1% (V/V) of spray volume.

The tolerance of several seedling grasses to barban, difenzoquat, diclofop methyl, and flamprop methyl

Creeping red fescue, crested wheatgrass, intermediate wheatgrass, and Russian wild ryegrass were generally tolerant to dicofop methyl (without Renex 36) at rates that gave satisfactory control (.85 to 1.40 kg/ha). Warm, humid conditions combined with early treatment resulted in injury to creeping red fescue in one of the years. Bromegrass varied from year to year in its tolerance to diclofop methyl. Injury occurred in one year but not in the two other years. All other chaffy grasses were severely injured by diclofop methyl. Applications of the herbicide to wild oats in the 1.5 to 2 leaf stage generally provided better control than applications to wild oats in the 4 to 5 leaf stage. All chaffy grasses, except possibly reed canarygrass and Kentucky bluegrass were tolerant to barban at .35 kg/ha. Barban gave good wild oat control in 2 out of 3 years. Increasing the rate from .35 to .70 kg/ha did not produce a major improvement in wild oat control. The tolerance of all chaffy grasses to difenzoquat was good. Wild oat control from applications of this herbicide ranged between poor and fair. All chaffy grasses, except reed canarygrass and possibly Kentucky bluegrass and timothy were tolerant to flamprop methyl treatments. A rate of .85 kg/ha was required to give good, consistent wild oat control.

Introduction: The use of herbicides to control wild oats in seedling chaffy grass crops has been limited because of a lack of information on crop tolerance to support product registration. When these crops are underseeded in an annual cereal or oilseed crop, herbicides frequently cannot be applied because of the grass crop. The objective of this study was to determine the tolerance of several chaffy grasses to barban, difenzoquat, flamprop methyl, and diclofop methyl.

Methods: Experiments were conducted in the field from 1974 to 1978. Unless otherwise specified creeping red fescue (CRF-cv. Boreal), crested wheatgrass (CW-cv. Fairway), meadow fescue (MF-cf. Mimer), bromegrass (B-cv. CarLton), intermediate wheatgrass (IWG-cv. Chief), timothy (T-cv. Climax), reed canarygrass (RCG-cv. Castor), Kentucky bluegrass (KB-cv. Parkland), and Russian wild ryegrass (RWR-cv. Sawki) were used in each experiment. Wild oat control was also evaluated in each experiment.

Experiment 1. On June 4, 1974 all of the chaffy grasses plus wild oats were seeded in the field. Each grass was seeded in a 10.7 m long row. The rows were spaced 30 cm apart. Barban and diclofop methyl (without Renex 36) were applied on July 3 when the wild oat plants, crested wheatgrass, and Kentucky bluegrass were in the 2-leaf stage and all other grasses in the 3-leaf stage. Flamprop methyl and difenzoquat were applied on July 18 when the wild oat plants were in the 4-leaf to tillering stage. On this date the other grasses ranged between the 3-leaf and tillering stages. Barban and difenzoquat were applied in a spray volume of 56 L/ha while the other treatments were applied in a spray volume of 168 L/ha. The treatments were arranged in a randomized complete block design with four replications. The plots were hand-weeded. Chaffy grass tolerance to the herbicides was evaluated on September 25 while wild oat density and dry weight of shoots was obtained two weeks later. Results from this experiment are presented in Table 1.

Experiment 2. On June 4, 1975 all chaffy grasses, plus the wild oat, were seeded in the field in rows 9.1 m long and spaced 45 cm apart. All plots contained a single row of each chaffy grass plus a row of wild oat plants. Three herbicides were evaluated: barban, difenzoquat, and flamprop methyl. Barban treatments were applied on July 7 when the wild oat plants were in the 1.5- to 2-leaf stage, and the chaffy grasses in the 1- to 1.5-leaf stage. Difenzoquat and flamprop methyl treatments were applied on July 21 when the wild oat plants were in the 4- to 5-leaf stage. Russian wild ryegrass, timothy, intermediate wheatgrass, and reed canarygrass were in the 2- to 4-leaf stage on this date, while the other grasses were in the 3-leaf stage. Barban and difenzoquat were applied in a spray volume of 56 L/ha while flamprop methyl was applied in a spray volume of 168 L/ha. The plots were arranged in a randomized block design with four replicates. The plots were hand-weeded. Wild oat plant density and shoot dry weights were obtained in early October while crop tolerance was evaluated on October 10. The experiment was repeated in 1976. The chaffy grasses and wild oats were seeded on June 4. Barban treatments were applied on June 21 when the wild oat plants were in the 2-leaf stage and the chaffy grasses in the l-to 1.5-leaf stage. Difenzoquat and flamprop methyl treatments were applied on July 5 when the wild oat plants were in the 4-to 5-leaf stage. On this date, Kentucky bluegrass, crested wheatgrass, bromegrass, and intermediate wheatgrass were in the 3- to 4-leaf stage. Russian wild ryegrass and reed canarygrass were in the 3-leaf stage, timothy was in the 3- to 5-leaf stage, meadow fescue was in the 4-leaf stage and creeping red fescue was in the 6-leaf stage. Wild oat shoot dry weights and crop tolerance evaluations were obtained in mid-September. Results from this experiment are presented in Table 2.

Experiment 3. On June 4, 1975 crested wheatgrass, creeping red fescue, Russian wild ryegrass, bromegrass, intermediate wheatgrass and wild oats were seeded in the field in rows 9.1 m long and spaced 45 cm apart. All plots contained a single row of each chaffy grass plus a row of wild oats. Diclofop methyl (with Renex 36) at several rates was applied to one set of plots on July 7 when the wild oat plants and chaffy grasses were in the 1.5- to 2-leaf stage (stage 1) and another set of plots on July 21 when the wild oat plants were in the 4- to 5-leaf stage (stage 2). On July 21 Russian wild ryegrass and intermediate wheatgrass were in the 2- to 4-leaf stage and the other chaffy grasses in the 3- leaf stage. All treatments were applied in a spray volume of 168 L/ha. The plots were arranged in a randomized complete block design with four replicates. The plots were hand-weeded. Wild oat plant density and shoot dry weights were obtained in early October while crop tolerance evaluations were made on October 17.

The experiment was repeated in 1976. The grasses, plus the wild oat were seeded on June 4. Stage 1 diclofop methyl treatments were applied on June 21 when the wild oat plants were in the 1.5- to 2-leaf stage and the chaffy grasses in the 1- to 1.5-leaf stage. Stage 2 treatments were applied on July 5 when the wild oat plants were in the 4- to 5-leaf stage. On this date crested wheatgrass, bromegrass, and intermediate wheatgrass were in the 3- to 4-leaf stage, Russian wild ryegrass was in the 3-leaf stage and creeping red fescue was in the 6-leaf stage. Wild oat plant density and shoot dry weights were obtained in mid-September. Crop tolerance evaluations were also made in mid-September. Results from this experiment are presented in Table 3.

Results and Discussion:

a. *Weather Conditions*: The 1974 growing season was characterized by below average monthly air temperatures, a dry June but above normal precipitation in July, August and September. In 1975 air temperatures were generally near or above average. However, moisture conditions were generally dry during the spring and summer of 1975. In 1976, moisture conditions were excellent during the spring and early summer. However, above average precipitation in late July and in August produced excessively wet soil moisture conditions. Temperatures in June and July were cool but near or above normal during the other months. The 1977 growing season was characterized by excessive rainfall and below average temperatures.

b. *Crop Growth in the Field*: Grass emergence varied from year to year. In 1974 and 1975 emergence was irregular mainly because of an inadequate or irregular rainfall pattern. In 1976, emergence of all grasses, except bromegrass, was satisfactory. Improvements in the soil moisture situation in the latter parts of the growing seasons of 1974 and 1975, as well as continued adequate soil moisture in the latter part of the 1976 growing season, resulted in good stands of all grasses, except bromegrass, by the end of the season of seeding.

c. *Wild Oat Control*: In all experiments the wild oats were grown without crop competition. In fields where chaffy grasses are established without a companion crop the control ratings are probably good indicators of what can be expected. However, where the chaffy grasses are seeded with a companion crop, competition from the latter can be expected to improve the performance of many of the herbicides.

Barban at .35 kg/ha provided good wild oat control in 1975 and 1976 (Table 2) but poor control in 1974 (Table 1). Increasing the rate of barban to .70 kg/ha did not produce a significant increase in wild oat control.

Difenzoquat did not provide satisfactory wild oat control (Tables 1 and 2). Reductions in wild oat shoot dry weight were generally less than 50%. Presumably this poor control can be attributed to the lack of crop competition.

Flamprop methyl at 1.68 kg/ha provided good to excellent control in all field experiments (Table 1 and 2). At .84 kg/ha the herbicide provided good control in 1975 and 1976 but only fair control in 1974. Control with flamprop methyl at .42 kg/ha was inadequate.

Diclofop methyl at 1.12 kg/ha or more provided good to excellent wild oat control in all experiments (Table 1 and 3). At rates below 1.12 kg/ha control varied from fair to excellent. Applications made to wild oat plants in the 1.5- to 2-leaf stage were generally better than those made to plants in the 4- to 5-leaf stage.

d. *Tolerance of Grasses*:

Creeping red fescue - Creeping red fescue exhibited no injury symptoms from treatments of barban, difenzoquat or flamprop methyl (Tables 1 and 2). In 1974 and 1975 the crop also exhibited good tolerance to all diclofop methyl treatments (Tables 1 and 3). However, in 1976 diclofop methyl at 1.40 kg/ha or more applied to creeping red fescue in the 1- to 1.5-leaf stage caused serious injury (Table 3). At a rate of .84 kg/ha injury was less. Only major injury occurred from applications at the older stage in 1976. Warm, moist weather at the time of treatment may have contributed to the crop injury at stage 1.

Crested wheatgrass - Crested wheatgrass exhibited good tolerance to all barban, difenzoquat, diclofop methyl and flamprop methyl treatments (Tables 1, 2 and 3).

Meadow fescue - Meadow fescue exhibited good tolerance to barban, difenzoquat and flamprop methyl (Tables 1 and 2) but was severely injured by diclofop methyl treatments (Table 1).

Bromegrass - Bromegrass was tolerant to all barban, difenzoquat and flamprop methyl treatments (Tables 1 and 2). However, its tolerance to diclofop methyl varied from year to year. In 1974, injury was minor (Table 1). In 1975, very little injury was apparent but in 1976 severe injury occurred (Table 3).

Intermediate wheatgrass - Intermediate wheatgrass exhibited good tolerance to all barban, difenzoquat, diclofop methyl and flamprop methyl treatments (Tables 1, 2 and 3).

Timothy - Timothy exhibited good tolerance to barban at .35 kg/ha to all difenzoquat treatments and to flamprop methyl at .42 or .84 kg/ha (Tables 1 and 2). However, barban at .70 kg/ha and flamprop methyl at 1.68 kg/ha caused slight to moderate injury to the crop in some of the years. Diclofop methyl treatments severely injured timothy (Table 1).

Reed canarygrass - Reed canarygrass was tolerant in all years to barban at .35 kg/ha, difenzoquat at .84 or 1.12 kg/ha and flamprop methyl at .42 kg/ha (Tables 1 and 2). Barban at .70 kg/ha and flamprop methyl at .84 and 1.12 kg/ha caused injury to the crop which ranged from moderate to severe. Diclofop methyl treatments severely injured reed canarygrass (Table 1).

Kentucky bluegrass - In the field, injury from all treatments ranged from slight to severe (Table 1 and 2).

Russian wild ryegrass - Russian wild ryegrass exhibited good tolerance to all barban, difenzoquat, diclofop methyl and flamprop methyl treatments (Tables 1, 2 and 3).

Table 1. Crop tolerance and wild oat control in several seedling grass crops with barban, difenzoquat, diclofop methyl and flamprop methyl (Experiment 1).

Treatment	Rate kg/ha	Crop tolerance (0-9) [1] CRF	C W	MF	B	IWG	T	RCG	KB	RWR	Dry weight of wild oats g/m²
Check		9	9	9	9	9	9	9	9	9	261 a[2]
Barban	.35	9	9	9	9	9	9	9	8	8	163 b
Barban	.70	8	8	7	7	8	7	7	5	9	147 bc
Difenzoquat	.56	9	9	9	8	8	9	9	-	9	125 bcd
Difenzoquat	.84	9	9	9	8	8	8	9	7	9	168 b
Difenzoquat	1.12	8	8	9	9	9	8	9	7	9	179 b
Diclofop methyl	.56	9	9	2	8	9	5	2	2	9	81 cd
Diclofop methyl	1.12	9	8	2	7	8	1	2	1	8	65 de
Diclofop methyl	2.24	9	8	0	7	8	0	0	0	8	11 e
Flamprop methyl	.42	9	9	9	9	9	9	9	9	9	157 bc
Flamprop methyl	.84	9	9	9	9	9	9	9	8	8	174 b
Flamprop methyl	1.68	9	9	9	8	9	7	8	7	8	54 de

[1] Rating scale: 9 - no damage; 7-8 slight damage; 4-6 moderate damage; 1-3 severe damage; O - complete kill.
[2] Means within the column followed by the same letter are not significantly different at p = .05

Treatment	Rate kg/ha	Crop tolerance (0 - 9) [1]									Dry weight of wild oats, g/m²	
		CRF	CW	MF	B	IWG	T	RCG	KBG	RWR	1975	1976
Check		9	9	9	9	9	9	9	9	9	380 a[2]	635 ab
Barban	.35	9	8	9	8	9	8	8	8	9	38 c	76 d
Barban	.70	8	8	8	8	8	8	6	7	9	33 c	27 d
Difenzoquat	.84	9	9	8	9	9	9	9	8	9	206 b	510 b
Difenzoquat	1.12	8	9	8	9	8	9	9	8	8	168 b	705 a
Flamprop methyl	.42	9	9	9	8	9	9	8	9	9	244 b	331 c
Flamprop methyl	.84	8	8	8	8	8	8	6	8	8	60 c	54 d
Flamprop methyl	1.68	8	8	8	8	8	8	4	8	8	11 c	5 d

Table 2. Crop tolerance and wild oat control in several seedling grass crops with barban, difenzoquat, and flamprop methyl (Experiment 2).

[1] Tolerance ratings averaged for 1975 and 1976. Rating scale: 9 - no damage; 7-8 slight damage; 4-6 moderate damage; 1-3 severe damage; 0 - complete kill.
[2] Means within each column followed by the same letter are not significantly different at P = .05.

Table 3. Crop tolerance and wild oat control in several seedling grass crops with diclofop methyl (Experiment 3).

Rate of diclofop methyl (kg/ha)	Stage	Crop tolerance (0 - 9)[1]										Dry weight of wild oats g/m²	
		CRF		CW		IWG		B		RWR			
		1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
0	1	9	9	9	9	9	9	9	9	9	9	196 a[2]	695 a
0.84		9	8	9	9	9	8	9	8	8	8	109 b	0 b
1.40		9	6	9	8	9	8	9	2	9	7	16 c	0 b
2.24		9	5	9	7	9	8	9	2	8	7	5 c	0 b
0	2	9	9	9	9	9	9	9	9	9	9	240 a	456 a
0.84		9	9	9	9	9	9	9	7	8	9	60 a	32 b
1.40		9	9	9	9	9	8	9	4	9	8	49 b	5 b
2.24		9	9	9	9	9	9	9	4	8	9	38 b	5 b

[1] Rating scale: 9 - no damage; 7-8 slight damage; 4-6 moderate damage; 1-3 severe damage; 0 - complete kill.
[2] Means within each column and within each stage followed by the same letter are not significantly different at P = .05.

Tolerance of seedling creeping red fescue, bromegrass, and timothy to sethoxydim, fluazifop-p-butyl, clethodim, and quizalofop ethyl

Creeping red fescue was tolerant to all herbicides while bromegrass and timothy were severely injured by all herbicides.

Introduction: Sethoxydim, fluazifop-p-butyl, clethodim, and quizalofop are herbicides which have either recently been developed for the control of grassy weeds in broadleaved crops. The purpose of this research was to determine the tolerance of seedling creeping red fescue, bromegrass and timothy to these herbicides.

Methods: Procedures described previously were used in this study.

Results: Creeping red fescue exhibited excellent tolerance to all herbicide treatments (Table 1). Bromegrass and timothy were severely injured by all of the herbicide treatments.

Table 1. The tolerance of seedling stands of creeping red fescue, timothy, and bromegrass to herbicides for grassy weed control.

Herbicide	Rate of herbicide (kg/ha)	Mean tolerance*	Range	Number of sites
		Creeping red fescue		
Sethoxydim**	0.25	8.3	8.0 - 9.0	5
Sethoxydim	0.30	8.2	8.9 - 9.0	4
Sethoxydim	.80	9.0	-	1
Fluazifop-p-butyl	0.25	8.0	-	2
Fluazifop-p-butyl	0.35	8.0	-	2
Fluazifop-p-butyl	0.70	8.0	-	1
Clethodim	0.045	8.5	-	2
Clethodim	0.090	8.5	-	2
Quizalofop ethyl	0.10	8.5	-	1
		Bromegrass		
Sethoxydim	0.25	4.8	0 - 8.0	0
Sethoxydim	0.30	5.3	4.0 - 6.0	5
Sethoxydim	0.80	0.0	-	1
Fluazifop-p-butyl	0.25	0.0	-	1
Fluazifop-p-butyl	0.35	0.6	0 - 2.0	3
Fluazifop-p-butyl	0.70	0.0	-	2
		Timothy		
Sethoxydim	0.25	1.7	0 - 4.0	3
Sethoxydim	0.30	1.7	0 - 4.0	3
Sethoxydim	0.80	0.0	-	1
Fluazifop-p-butyl	0.25	0.5	0 - 1.0	2
Fluazifop-p-butyl	0.35	0.3	0 - 1.0	3
Fluazifop-p-butyl	0.70	0.5	0 -1.0	2
Clethodim	0.045	0.5	-	1
Clethodim	0.090	0.5	-	1

* 0 = complete kill; 9 = no effect.

** Sethoxydim applied with Assist Oil Concentrate (0.5% V/V spray volume), Fluazifop-p-butyl applied with Agral 90 (0.1% V/V spray volume), and Clethodim applied with CC-16255 (0.5% V/V spray volume.

SECTION III: TOLERANCE OF ESTABLISHED GRASSES TO HERBICIDES

Tolerance of established creeping red fescue to 2,4-D and dicamba

The tolerance of established creeping red fescue to 2,4-D ester may be summarized as follows:

			Reduction in yield First crop after treatment		
Year No.	*Date*	*Stage of crop*	*2,4-D .56 kg/ha*	*2,4-D .70 kg/ha*	*2,4-D 1.12 kg/ha*
1	*June*	*Crop planted*	-	-	-
	July	*3-leaf*	*Nil*		*Very little*
	August				
	September	*Vegetative*	*25-50%*		*50%*
	October				
2	*May*	*Before stem elongation*	*5-10%*		*15-20%*
		Shot-blade			
	June	*Early heading*			
		Flowering		*50-70%*	
	July	*Hard dough*		*Nil*	
	August	*After harvest*	*Nil*		*Nil*
	September				

Established creeping red fescue exhibited good tolerance to dicamba. When applied at rates up to .56 kg/ha in the fall of the year of seeding or during the spring (before stem elongation, shot-blade or early heading stages) to 1-year-old stands, the herbicide did not reduce seed yields of this crop.

Introduction: The use of herbicides in established stands of grasses for seed has received minimal attention from researchers in western Canada. In Europe, most workers feel that considerable care is required when applying any herbicide to seed-producing grasses. Work by Elliott at our Station, as well as by Gallagher and Vanden Born at the University of Alberta, would indicate the need for care under Alberta conditions. Table 1 shows work carried out by Elliott in 1968 on the effect of 2,4-D ester on seed production in creeping red fescue. Seed yield reductions occurred from treatment at all stages prior to the hard dough stage. Similar results were obtained by Gallagher and Vanden Born at the University of Alberta. They also observed that dicamba at more than .56 kg/ha reduced seed yields. In 1973 studies were initiated to obtain more information on the tolerance of creeping red fescue to fall and spring applications of 2,4-D and dicamba.

Methods: Creeping red fescue (cv. Boreal) was seeded in rows spaced 30 cm apart in June of 1972, 1973 and 1974. 2,4-D and dicamba were applied at several rates in September to 3.5 month-old-stands or in the spring to 1-year-old stands. Spring applications of the herbicides were made prior to stem elongation, at the shot-blade stage or at the early heading stage (the first two weeks in May, late May and late May to early June, respectively). The herbicide treatments were applied in a spray volume of 168 L/ha. Each treatment was replicated six times. The fescue was maintained in a generally weed-free condition by hoeing and cultivation. Fescue seed was harvested in late July or early August of the year after applications in the fall or during the same year after applications in the spring.

Results and Discussion: When applied in September of the year of seeding, 2,4-D at .56 or 1.12 kg/ha severely reduced seed yields the following year (Table 2). However, dicamba at rates up to .56 kg/ha did not have any effect on seed yields. The effect of spring applications of 2,4-D on creeping red fescue seed yield is shown in Table 3. When applied at .56 kg/ha, 2,4-D ester caused yield reductions in 1974 but not in

1973 or 1975. Applications of 1.12 kg/ha of the herbicide caused yield reductions in all three years. The stage of the fescue at the time of herbicide application did not appear to have a significant influence on the amount of the seed yield reduction.

Dicamba applied in the spring at rates up to .56 kg/ha did not reduce the seed yields of fescue. The stage of the fescue at the time of herbicide application had little influence on the seed yield. The results of these experiments clearly show that considerable care is required when applying herbicides to creeping red fescue that is grown for seed production. 2,4-D should not be applied in the fall of the year of seeding. It would appear that not more than .56 kg/ha of 2,4-D ester should be applied in the spring to established creeping red fescue. It would also appear that creeping red fescue is more tolerant to dicamba than 2,4-D when these herbicides are applied at rates that give equivalent weed control.

Table 1. Effect of 2,4-D ester at .70 kg/ha on seed production of creeping red fescue.

Date of treatment	Stage of plant development	Seed yield, kg/ha
Not treated		1001
June 2	2% heading	683
June 6	100% heading	706
June 11	5% flowering	701
June 13	50% flowering	587
June 19	90% flowering	444
June 23	50% flowering	533
June 25	20% soft dough	656
July 2	25% hard dough	1060
July 4	50% hard dough	1012
	L.S.D. (P = .05)	113

Table 2. Yields of 1-yr-old creeping red fescue seed produced during growing season following September applications of herbicides.

		Seed yield[1], kg/ha	
Herbicide	Rate, kg/ha	1974	1975
Control	-	735 a	708 a
2,4-D	.56	365 bc	503 b
2,4-D	1.12	253 c	309 c
Dicamba	.14	670 a	780 a
Dicamba	.28	516 ab	774 a
Dicamba	.56	668 a	786 a

[1] Means within each column followed by the same letter are not significantly different at P = .05.

Table 3. Effect of 2,4-D ester on seed yield of creeping red fescue.					
Rate of 2,4-D kg/ha	Stage of application	Seed yield, kg/ha			
		1973	1974	1975	Average
0	-	580 a	1052 a	694 a	775 a
0.56	Before stem elongation	570 a	773 b	629 ab	684 a
0.56	Shot-blade	574 a	839 b	535 b	649 a
0.56	Early heading	588 a	867 b	675 ab	710 a
0	-	622 a	967 a	730 a	787 a
1.12	Before stem elongation	555 a	861 b	591 b	649 b
1.12	Shot-blade	564 a	762 b	538 b	621 b
1.12	Early heading	499 a	837 b	507 b	614 b

Tolerance of established timothy to 2,4-D and dicamba

Established timothy exhibited limited tolerance to 2,4-D ester and very poor tolerance to dicamba. 2,4-D applied in the fall at .56 kg/ha to 3.5-month-old stands severely reduced seed yields the following year. Applications of 2,4-D at .56 kg/ha in the spring prior to stem elongation reduced yields by as much as 25%. However, little or no injury occurred when similar applications were made at the shot-blade or early heading stages. Applications of dicamba at times similar to those for 2,4-D resulted in serious seed yield reductions.

Introduction: The use of herbicides such as dicamba and 2,4-D, in established stands of timothy has occasionally resulted in severe seed yield losses. Therefore, a study to examine the effects of 2,4-D and dicamba on timothy seed yields was conducted.

Methods: A procedure similar to that used in the previous experiment was employed. Timothy (cv. Climax) was seeded in rows spaced 30 cm apart in June 1977 and again in June 1978. 2,4-D and dicamba were appLied at several rates in September to 3.5 month-old-stands or in the spring to l-year-old stands. Spring applications of the herbicides were made prior to stem elongation, at the shot-blade stage or at the early heading state (May 4, 1978 or May 14, 1979; May 31, 1978 or June 7, 1979; June 13, 1978 or June 28, 1979). The herbicide treatments were applied in a spray volume of 168 L/ha. The timothy was maintained in a generally weed-free condition by hoeing and cultivation. Each treatment was replicated five times. Timothy seed was harvested in September of the year after applications in the fall or the year of application in the spring. Seed weight and seed germination were determined the winter following harvest.

Results and Discussion: Fall applications of 2,4-D ester caused severe seed yield reductions (Table 1). Early spring treatments (before stem elongation) were less injurious than those in the fall. Yield reductions from 2,4-D at .56 kg/ha were 16% in 1978 and 25% in 1979. Little or no injury occurred from 2,4-D at .56 kg/ha applied at the shot-blade and early heading stages. Spring treatments of 2,4-D at 1.12 kg/ha reduced yields from 15 to 32%. None of the 2,4-D treatments affected seed weight or seed germination.

All treatments of dicamba caused seed yield reductions in timothy (Table 1). Seed germination was also reduced by dicamba, particularly when applied at the shot-blade and early heading stages.

The results clearly show extreme care is required when applying herbicides to timothy. The use of dicamba appears inadvisable. If 2,4-D is used, only applications of less than .56 kg/ha in late May (just prior to the shot-blade stage) appear possible without injury and subsequent yield loss.

Table 1. Effect of 2,4-D ester and dicamba on the seed yield of timothy.

Herbicide	Rate kg/ha	Stage of application	1978 Seed yield kg/ha	1978 % Reduction	1978 % Germination	1979 Seed yield kg/ha	1979 % Reduction	1979 % Germination
2,4-D	0	---	360 a[1]	-	95 a	332 a	-	94 a
	0.56	Fall	195 ab	46	94 a	172 dc	48	94 a
	0.56	Before stem elongation	304 a	16	95 a	250 bc	25	93 a
	0.56	Shot-blade	366 a	0	96 a	310 ab	6	94 a
	0.56	Early heading	363 a	0	97 a	332 a	0	95 a
	1.12	Fall	108 b	70	93 a	124 c	62	92 a
	1.12	Before stem elongation	259 ab	28	95 a	224 dc	32	96 a
	1.12	Shot-blade	276 ab	24	95 a	243 bc	27	94 a
	1.12	Early heading	269 ab	25	94 a	281 abc	15	96 a
Dicamba	0	---	276 b	-	95 a	349 a	-	92 a
	0.14	Fall	319 a	0	91 abc	272 b	22	86 a
	0.14	Before stem elongation	209 bcd	24	88 abcd	170 cd	51	87 a
	0.14	Shot-blade	186 cde	33	85 bcde	93 ef	73	65 c
	0.14	Early heading	131 efg	52	79 ef	-	-	-
	0.28	Fall	227 bc	17	93 abc	269 b	23	89 a
	0.28	Before stem elongation	159 def	42	84 cde	109 e	69	76 b
	0.28	Shot-blade	87 ghi	68	80 def	47 fg	86	61 cd
	0.28	Early heading	82 ghi	70	75 fg	-	-	-
	0.56	Fall	115 fgh	58	93 ab	164 d	53	84 b
	0.56	Before stem elongation	115 fgh	58	84 bcde	69 efg	80	82 ab
	0.56	Shot-blade	48 hi	82	70 g	31 g	91	55 d
	0.56	Early heading	44 I	84	76 efg	-	-	-

[1] Means within each herbicide and column followed by the same letter are not significantly different at P = .05.

Tolerance of established bromegrass to 2,4-D and dicamba

Established bromegrass exhibited adequate tolerance to 2,4-D amine applied at rates to 1.0 kg/ha in the fall or spring prior to stem elongation. However, applications of 2,4-D at 1.0 kg/ha in the spring at the shot-blade stage of development reduced yields. Dicamba at 0.15 to 0.60 kg/ha caused seed yield losses when applied in the spring prior to stem elongation or at the shot-blade stage. Fall applications of dicamba did not reduce seed yields the following year.

Introduction: The yield and/or quality of bromegrass seed produced in northern Alberta and British Columbia is frequently reduced by the presence of perennial weeds such as alsike clover (Trifolium hybridum L.) and Canada thistle (Cirsium arvense L.). While chemical weed control has been used in seedling stands and in established herbage-producing stands of bromegrass, its use in established seed-producing stands has been restricted by limited information on the effect of selective herbicides on seed production. In Germany 2,4-D can be used for weed control in bromegrass during the year of seed harvest but timing is critical; the herbicide must be applied after floral initiation but before emergence of the inflorescences to avoid crop injury. In Washington, good bromegrass tolerance to April and September applications of 2,4-D at rates up to 1.1 kg a.i./ha has been observed. Dicamba, a herbicide used for the control of alsike clover and Canada thistle in seed-producing stands of creeping red fescue, may also have a potential for use in bromegrass although injury may occur if applied at an improper stage of crop development. In Germany, seed yield reductions have been observed from applications of dicamba plus MCPA applied to bromegrass in the reproductive stage. In Washington, no seed yield reductions were obtained from applications of dicamba at 0.6 kg a.i./ha or less to bromegrass in September prior to the first or second seed crop but severe seed yield reductions occurred from application of the herbicide at 0.3 kg a.i./ha or more in April to similar stands. The purpose of this study was to elucidate the effects of 2,4-D and dicamba, applied at several rates and stages of crop development, on the seed production of bromegrass.

Methods: In June 1982, two experiments were established adjacent to each other. In both experiments, bromegrass 'Carlton' was seeded at a depth of 2.5 cm and in rows spaced 30 cm apart. In one of the experiments the dimethylamine salt of 2,4-D was applied at 0.5 and 1.0 kg a.i./ha on 20 September 1982 when the crop was 15 cm high. The following spring the same 2,4-D treatments were applied at two growth stages of the crop: on 10 May before stem elongation and on 8 June at the shot-blade stage. In the other experiment, the dimethylamine salt of dicamba was applied at 0.15, 0.3 and 0.6 kg a.i./ha at the same dates and at the same stages as the 2,4-D treatments. All herbicides were applied with a bicycle-type sprayer using a spray volume of 168 L/ha at 207 kPa pressure. In each experiment the herbicide treatments, along with a control treatment, were arranged in a randomized complete block design with five replications. All plots were 1.8 x 7.6 m in size. To prevent the interference of weeds with crop yields the plots were weeded by rotovating or hand pulling and maintained in a generally weed-free condition throughout the duration of the experiment.

The two experiments were repeated in 1983-84 on seedings of bromegrass established in early June 1983 and again in 1984-85 on seedings of bromegrass established in early June 1984. 2,4-D and dicamba were applied at the same rates and stages as given above. In the 1983-84 experiments, applications were made in 1983, when the bromegrass was 12 cm high (22 Sept.) and in 1984 prior to stem elongation (18 May) and at the shot-blade stage (12 June). Dates of application for the 1984-85 experiments were 24 Sept. 1984, 8 May and 17 June 1985 for the above stages, respectively.

In all experiments, seed yields were obtained by hand-harvesting all mature culms of bromegrass from a 0.6 x 6.1 m strip situated in the middle of each plot. The harvested samples were bagged, air-dried and threshed. Following threshing the seed was cleaned to remove chaff and inert material and weighed. A subsample of 100 seeds was taken from each sample, weighed to determine average seed weight and then subjected to a routine germination test.

Results: Seed yields, 1 year after seeding, were not significantly reduced by any of the herbicide treatments applied in September or by any of the 2,4-D treatments applied before stem elongation (Table 1). However, similar seed yields, averaged across the 3 years of the study, were significantly reduced by applications of 2,4-D at 1.0 kg/ha at the shot-blade stage and by all spring applications of dicamba, except the 0.15 kg/ha rate applied before stem elongation. Fall applications of dicamba did not reduce seed yields. Weight per 100 seeds and percent germination were not affected by any of the herbicide treatments.

Table 1. Yield of bromegrass seed harvested following the application of 2,4-D or dicamba in the autumn or in the spring before stem elongation or at the shot-blade stage.

Herbicide	Rate (kg/ha)	Stage at time of application	Seed yield (kg/ha)			
			1983	1984	1985	Mean
2,4-D	0	---	290	411	612	438
	0.5	Fall	241	440	568	416
		Before stem elongation	227	442	601	424
		Shot-blade	271	348	522	380
	1.0	Fall	266	393	564	408
		Before stem elongation	238	341	608	396
		Shot-blade	156	354	534	348**
S.E.M.			50	51	34	26
Dicamba	0	---	322	605	571	500
	0.15	Fall	292	549	502	448
		Before stem elongation	364	477	451	431
		Shot-blade	253	437	389**	360**
	0.30	Fall	356	455	492	434
		Before stem elongation	413	500	236**	383*
		Shot-blade	376	386*	302**	355*
	0.60	Fall	385	471	482	446
		Before stem elongation	245	391*	122**	253**
		Shot-blade	211	216**	198**	208**
S.E.M.			71	69	47	37

*, ** Means significantly different from control plots at the 0.05 and 0.01 levels of probability. Significance of difference determined by Dunnett's procedure.

S.E.M. Standard error of the treatment means.

Tolerance of established grasses to metsulfuron methyl

Metsulfuron methyl caused visual injury to smooth bromegrass in 2 of 4 trials but had no effect on seed yields. Seed yields of intermediate wheatgrass and creeping red fescue were not affected by metsulfuron methyl. Crested wheatgrass seed yields were not affected by metsulfuron methyl applied at the 3 to 4 leaf stage. Timothy seed yields were reduced by metsulfuron methyl.

Experiment 1. Smooth bromegrass and creeping red fescue.

Methods: Plots, 2 x 10 m in size, were established on a 3-year-old stand of Carlton bromegrass and a 2-year-old stand of Boreal creeping red fescue near Beaverlodge, Alberta. On May 25, 1989, metsulfuron methyl at 3 and 6 g/ha was applied to the creeping red fescue when it was 10 cm in height and just prior to the shot-blade stage. The herbicide treatments were applied in a spray volume of 100 L/ha. The treatments were arranged in a randomized block design with 3 replicates per grass. Moisture conditions were generally favourable throughout the growing season. Weed control and bromegrass and creeping red fescue injury ratings were taken on June 24, 1989. Seed was harvested from creeping red fescue on July 24, 1989, while that from bromegrass was harvested on August 14, 1989. Weight per 100 seeds and % germination were determined 3 months after harvest.

Results: Metsulfuron methyl at 4.5 g/ha caused moderate injury to the bromegrass (height reduction and apparent seed head reduction). Severe bromegrass injury occurred from the 9.0 g/ha rate. However, seed yields were not significantly reduced. Weight per 100 seeds and % germination of bromegrass were not affected by the herbicide treatments. The metsulfuron methyl treatments had no effect on creeping red fescue seed yields, weight per 100 seeds or % germination. (Research Station, Beaverlodge, Alberta).

Rate of metsulfuron (g/ha)	Bromegrass	
	Inj. Ind. (0 - 9)	Seed yield (g/m^{-2})
0	9.0	85
4.5	6.0	100
9.0	4.0	64

Experiment 2. Smooth bromegrass, intermediate wheatgrass, crested wheatgrass.

Methods: Crop - other crop #1; Planted - 20/06/89, 2 kg/ha, 3 cm deep, 30 cm row width; Planting method - belt planter; Fert. broadcast on 20/10/89 at 110 kg/ha product with 34-00-00.; Prev. crops - grass, brome (89); Field Expt. - Expt design R.C. Block; Reps - 04; Plot size - 8 x 1.5 m; Plot area - 12 sq. m; Crop zone - 27; Expt Locn - Beaverlodge, AB; Weather Stn. - Beaverlodge CD; PPT in mm actual (30 yr norm) - Apr. 13 (19.3), May 67 (39), Jun. 190 (68.4), Jul. 59 (64), Aug. 38 (63.8); Temp in C actual (30 yr norm) - Apr. 3 (2.6), May 10 (9.4), Jun. 13 (13.1), Jul. 16 (15.2), Aug. 16 (14.2); Grass, Brome (Carlton) emerged on 27/06/89. Grass, crested wheat (Parkway) emerged on 27/06/89. Grass, intermediate wheat (Chief) emerged on 27/06/89.

Treatments were applied on June 3, 1990 when grasses were in the 3 - 4 leaf stage.

Results: 2,4-D alone or with metsulfuron methyl reduced the seed yield of crested wheatgrass (Table 1). Other treatments had no effect on crested wheatgrass yields. None of the treatments had any effect on bromegrass or intermediate wheatgrass yields. Seed weight or % germination of the three forage species were not affected by any of the treatments.

Experiment 3. Smooth bromegrass, intermediate wheatgrass, and crested wheatgrass.

Methods: Crop - other crop #1; Planted - 20/06/89, 2 kg/ha, 3 cm deep, 30 cm row width; Planting method - belt planter; Fert. broadcast on 20/10/90 at 110 kg/ha product with 34-00-00.; Prev. crops - grass, brome (89); Field Expt. - Expt design R.C. Block; Reps - 04; Plot size - 8 x 1.5 m; Plot area - 12 sq. m Crop zone - 27; Expt Locn - Beaverlodge, AB; Weather Stn. - Beaverlodge CD; PPT in mm actual (30 yr norm) - Apr. 15 (19.3), May 44 (39), Jun. 90 (68.4), Jul. 28 (64), Aug. 39 (63.8); Temp in C actual (30 yr norm) - Apr. 6 (2.6), May 11 (9.4), Jun. 13 (13.1), Jul. 15 (15.2), Aug. 17 (14.2); Grass, brome (Carlton) emerged on 27/06/89. Grass, crested wheat (Parkway) emerged on 27/06/89. Grass, intermediate wheat (Chief) emerged on 27/06/89.

Treatments were applied on stage 1 - May 8, 1991 when the grasses were in the 3 to 4 leaf-stage; and stage 2 - June 5, 1991 when the grasses were in the 5-leaf stage to shot-blade stage.

Results: Seed yield, seed weight, and % germination of bromegrass, intermediate wheatgrass, and crested wheatgrass were not reduced by any of the metsulfuron treatments (Table 2). However, all metsulfuron treatments applied at stage 2 plus the highest rate at stage 1 caused visible bromegrass injury. Both height and the number of heads were reduced by these treatments. There was no apparent visible injury to crested wheatgrass or intermediate wheatgrass.

Experiment 4. Bromegrass, intermediate wheatgrass, and timothy.

Methods: Crop - other crop #1; Planted - 20/06/89, 2 kg/ha, 3 cm deep, 30 cm row width; Planting method - belt planter;

Fert. broadcast on 20/10/91 at 110 kg/ha product with 34-00-00.; Prev. crops - grass, brome (89); Field Expt. - Expt design R.C. Block; Reps - 04; Plot size - 8 x 1.5 m; Plot area - 12 sq. m; Crop zone - 27; Expt Locn - Beaverlodge, AB; Weather Stn. - Beaverlodge CD; PPT in mm actual (30 yr norm) - Apr. 22 (19.3), May 32 (39), Jun. 45 (68.4), Jul. 58 (64), Aug. 50 (63.8); Temp in C actual (30 yr norm) - Apr. 5 (2.6), May 9 (9.4), Jun. 16 (13.1), Jul. 16 (15.2), Aug. 15 (14.2); Grass, brome (Carlton) emerged on 27/06/89. Grass, intermediate wheat (Chief) emerged on 27/06/89. Timothy (Climax) emerged on 27/06/91.

Treatments were applied on May 15, 1992 when the grasses were in the 3 to 4-leaf stage and on June 6, 1992 when the grasses were in the 5-leaf to shot-blade stage.

Results: Seed yield, seed weight, and % germination of bromegrass and intermediate wheatgrass were not reduced by any of the metsulfuron treatments (Table 3). However, the seed yield and wt/1000 seeds of timothy were reduced by the two highest rates of metsulfuron. Timothy germination was not affected by any of the treatments. Serious reductions in the height of timothy were observed from all metsulfuron treatments.

Table 1. Experiment #2 - Smooth bromegrass, intermediate wheatgrass, crested wheatgrass.

Herbicide	Rate (g/ha)	Bromegrass			Intermediate wheatgrass			Crested wheatgrass		
		Yield (g/m^2)	Seed weight (g/1000 seeds)	Germ (%)	Yield (g/m^2)	Seed weight (g/1000 seeds)	Germ. (%)	Yield (g/m^2)	Seed weight (g/1000 seeds)	Germ. (%)
Check, weed free		64	4.2	85	173	5.9	94	56	1.9	83
Metsulfuron met	3	50	4.2	85	159	5.5	87	52	1.8	80
Agral 90	.2%									
Metsulfuron met	4.5	60	4.1	84	180	5.7	94	58	1.8	76
Agral 90	.2%									
Metsulfuron met	9	62	4.1	86	175	5.8	89	50	1.9	83
Agral 90	.2%									
Metsulfuron met	4.5	54	4.1	85	137	5.8	93	38	1.8	80
2,4-D amine	550									
Agral 90	.2%									
Metsulfuron met	4.5	55	4.1	86	137	5.5	94	47	1.8	75
MCPA amine	550									
Agral 90	.2%									
2,4-D amine	550	53	4.2	87	436	5.9	95	43	1.9	84
		NSF	NSF	NSF	NSF	NSF	NSF	6.0SE	NSF	NSF

Table 2. Experiment #3 - Smooth bromegrass, intermediate wheatgrass, and crested whetgrass.													
			Bromegrass					Intermediate wheatgrass			Crested wheatgrass		
Stage	Herbicide	Rate (g/ha) (AI)	Yield (g/m²)	Seed weight (g/1000 seeds)	Germ. (%)	Head Red[a] (%)	Height (cm)	Yield (g/m²)	Seed weight (g/1000 seeds)	Germ. (%)	Yield (g/m²)	Seed weight (g/1000 seeds)	Germ. (%)
-	Check, weed free		28	3.6	90	0	110	29	3.0	94	12	1.5	90
1	Metsulfuron met	3	21	3.4	82	0	110	31	3.1	91	12	1.5	84
	Agral 90	.2%											
1	Metsulfuron met	4.5	25	3.4	88	2	105	41	3.0	90	11	1.5	88
	Agral 90	.2%											
1	Metsulfuron met	9	23	3.5	84	10	96	33	2.9	91	11	1.5	88
	Agral 90	.2%											
2	Metsulfuron met	3	22	3.5	90	11	98	29	3.0	93	16	1.5	88
	Agral 90	.2%											
2	Metsulfuron met	4.5	29	3.4	92	9	100	31	2.9	95	12	1.5	88
	Agral 90	.2%											
2	Metsulfuron met	9	20	3.3	92	42	80	26	2.8	93	13	1.5	88
	Agral 90	.2%											
			NSF	NSF	NSF			NSF	NSF	NSF	NSF	NSF	NSF

Table 3. Experiment #4 - Bromegrass, intermediate wheatgrass, and timothy.

			Bromegrass			Intermediate wheatgrass			Timothy		
Stage	Herbicide	Rate (g/ha) (AI)	Yield (g/m^2)	Seed weight (g/1000 seeds)	Germ. (%)	Yield (g/m^2)	Seed weight (g/1000 seeds)	Germ. (%)	Yield (g/m^2)	Seed weight (g/1000 seeds)	Germ. (%)
	Check, weed free		10	3.7	96	13.8	6.0	92	31.7	.54	98
1	Metsulfuron met	3	9.0	3.8	95	12	6.2	92	31.1	.54	99
	Agral 90	.2%									
1	Metsulfuron met	4.5	8.0	3.7	94	16.2	5.9	96	28.5	.53	99
	Agral 90	.2%									
1	Metsulfuron met	9	9.0	3.8	96	20.1	6.3	91	18.4	.55	98
	Agral 90	.2%									
2	Metsulfuron met	3	9.0	3.8	94	10	5.8	90	23.4	.54	98
	Agral 90	.2%									
2	Metsulfuron met	4.5	9.0	3.8	92	14.7	6.0	89	24.6	.58	100
	Agral 90	.2%									
2	Metsulfuron met	9	10	3.7	94	10.9	6.0	94	18.3	.56	100
	Agral 90	.2%									
			NSF	NSF	NSF	NSF	NSF	NSF	6.6SE	.02SE	NSF

SECTION IV: CONTROL OF SPECIFIC WEEDS

Wild Oat Control in Seedling Smooth Bromegrass with Clodinafop-propargyl, Fenoxaprop-p-ethyl/modifier and Tralkoxydim (Preliminary Report)

Wild oat control was generally similar from all three graminicides. Wild oat control was better with a wheat companion crop present than where the bromegrass was seeded alone. Tank mixing with a herbicide for broadleaf weed control sometimes reduced wild oat control. However, wild oat dockage in the first seed crop was greater where the bromegrass was seeded with wheat than where it was established alone. There were little or no wild oat in the second seed crop.

Methods: Carlton smooth bromegrass was seeded alone or with Neepawa spring wheat on June 24, 1991, May 25, 1992 and May 10, 1993. The following graminicide (herbicides for grassy weed control) treatments were applied: Clodinafop-prop at 60 g/ha + cloquintocet-mx at 0.15% + Score at 1%; Fenoxaprop-p-ethyl/Modifier at 92 g/ha; and tralkoxydim at 250 g/ha + Superior Oil Concentrate at 1%. Each graminicide was applied with the following herbicides for broadleaf weed control: MCPA (amine in 1991, ester in other years) at 420 g/ha; Bromoxynil + MCPA (1:1) at 560 g/ha; and MCPA at 420 g/ha + Thifensulfuron at 15 g/ha. A weedy check, a handweed check and a treatment where the wild oat were mowed at time of heading were included each year. The treatments were applied on July 21, 1991, June 16, 1992 and June 4, 1993 when the wild oat were in the 2- to 4-leaf stage, the bromegrass in the 2- to 4- leaf stage and the wheat in the 4-leaf stage. Wild oat shoot dry weight was determined shortly before harvest. Bromegrass was harvested at 1 and 2 years after each seeding. Wild oat dockage was determined for each seed crop.

Results: Wild oat control was generally similar from all three graminicides. Therefore, only averages for these herbicides are presented in Table 1. In all three experiments, wild oat shoot dry weight in the year of herbicide application was greater where bromegrass was seeded alone than where it was seeded with wheat. Where bromegrass was seeded alone the graminicides (alone) reduced wild oat shoot dry weight below the level in the weedy checks by 63, 69 and 43% in 1991, 1992 and 1993, respectively. However, where bromegrass was seeded with wheat the reductions were 92, 94 and 68% for the same years. Tank mixing with a broadleaf herbicide resulted in reduced wild oat control in 1991 and 1992 but not in 1993.

Wild oat in bromegrass seed from the first seed crop was greater where the crop was seeded with wheat than where it was seeded alone in the first two experiments. However, in the 1993-95 experiment wild oat contamination was so slow that method of establishment had little effect.

First crop bromegrass seed yields were greater where it was established alone than with wheat. This trend continued into the second crop year in the 1991-93 and 1993-95 experiments but in the 1992-94 experiment yields were low and method of establishment had little effect.

Table 1. Wild oat shoot dry weight, wild oat seed contamination in first seed crop, and bromegrass seed yield 1 and 2 years after establishment with or without a wheat companion crop and the application of herbicide treatments.

	Wild oats, first year (Dry wt g/m²)		Wild oats, second year (Seed g/m²)		First seed crop yield (g/m²)		Second seed crop yield (g/m²)	
Treatment	Without wheat	With wheat	Without wheat	With wheat	Without wheat	With wheat	Without wheat	With wheat
				1991 - 1993				
Check (weedy)	357.7	121.0	1.6	7.6	23.5	12.0	24.6	26.1
Check (handweed)	0	0	0.4	1.1	48.9	13.8	30.6	27.5
Graminicides (alone)	130.7	9.6	0.5	1.1	37.2	13.6	34.0	25.4
Graminicides + MCPA	325.3	40.2	1.0	1.5	35.7	15.6	32.7	28.1
Graminicides + Buctril M	249.9	45.9	1.1	1.9	38.1	12.0	34.3	23.6
Graminicides + Refine + MCPA	311.3	43.2	1.4	4.8	41.5	11.7	32.7	29.2
Mowing	0	0	0.5	0.3	37.0	23.5	38.7	29.5
Mean	234.6	24.2	1.0	2.4	37.7	13.9	33.1	26.7
				1992 - 1994				
Check (weedy)	1491.0	318.0	17.9	72.8	7.2	3.9	12.4	16.2
Check (handweed)	0	0	5.3	58.4	31.6	6.0	9.4	7.2
Graminicides (alone)	457.0	20.0	11.0	29.5	18.6	7.6	8.6	13.3
Graminicides + MCPA	733.0	51.0	14.0	57.4	24.6	11.6	9.4	11.8
Graminicides + Buctril M	612.0	53.0	11.1	46.9	27.1	6.6	9.8	10.7
Graminicides + Refine + MCPA	723.0	38.0	15.5	43.8	30.1	10.6	10.4	10.4
Mowing	0	0	27.0	57.4	11.5	5.2	9.2	9.6
Mean	633.0	63.0	13.5	47.2	23.1	8.2	9.4	11.1
				1993 - 1995				
Check (weedy)	530.0	54.0	0.1	0.9	22.8	2.1	119.3	39.2
Check (handweed)	0	0	0.3	0.1	42.4	24.0	90.8	72.3
Graminicides (alone)	274.0	17.0	0.4	0.1	17.2	4.6	95.3	54.9
Graminicides + MCPA	300.0	17.0	0.3	0.1	32.3	5.1	108.4	65.6
Graminicides + Buctril M	347.0	45.0	0.1	0.1	32.3	7.7	97.4	83.3
Graminicides + Refine + MCPA	236.0	15.0	0.2	0.1	36.5	5.8	93.5	63.0
Mowing	0	0	0	0.2	24.9	12.5	95.3	59.1
Mean	288.0	20.0	0.2	0.3	26.8	8.8	99.2	63.7

Chemical control of dandelions[3]

Improved dandelion control has been achieved with the addition of dicamba to 2,4-D. However, creeping red fescue seed yield increases have not been obtained until the second growing season after treatment.

Introduction: Dandelions are probably the number one weed problem in creeping red fescue grown for seed. In regions with a warmer or more humid climate than northern Alberta 2,4-D has generally given good dandelion control. In northern Alberta, dandelions, particularly well established plants, are quite tolerant to 2,4-D. Because of the dandelion problem in fescue fields, studies were initiated in 1969 to find improved methods for their control.

Methods: The studies consisted of herbicide trials conducted in dandelion infested, commercial fields of creeping red fescue. In all trials the herbicide treatments were applied with experimental sprayers. All evaluations of herbicide effectiveness were made during the first growing season after treatment, i.e. treatments applied in the fall (early to mid-September) or in the spring (early to mid-May) were evaluated in the following June, July or August. All trials were located in the Beaverlodge area.

Results: Dandelion control was poor from both fall and spring treatments of 2,4-D (Table 1). Fall treatments appeared to be slightly more effective than spring treatments. Within all treatments, large variations in percent dandelion control occurred from year-to-year. For example, control with 2,4-D applied at .56 kg/ha in the fall ranged from 0 to 66%. There is no good explanation for this variability at present. However, unfavourable soil moisture conditions before and after treatment may account for some of the poor dandelion control.

Combinations of dicamba plus 2,4-D have also given improved dandelion control in comparison with 2,4-D alone (Table 2). In terms of crop tolerance, cost and effective dandelion control the combination of dicamba plus 2,4-D at .28 + .56 kg/ha appears to be optimum. A combination of dicamba plus 2,4-D at .42 + 1.12 kg/ha gave good dandelion control but caused considerable fescue injury.

In addition to the herbicides or herbicide combinations mentioned above we have examined a combination of dichloroprop plus 2,4-D. This combination has given good dandelion control but severe fescue injury. Another combination, clopyralid plus 2,4-D has given excellent control without causing fescue injury.

In most trials we have applied 56 to 67 kg/ha of N fertilizer in the fall to one-half of each plot. This fertilization has resulted in a positive herbicide-fertilizer effect on dandelion control in 2 of the 9 trials. In addition, in most trials we have obtained a beneficial fertilizer effect on seed yields.

Consistent increases in seed yield from treatments applied in the above trials have not been obtained. Seed yield data from some of the most promising treatments are shown in Table 3. With the possible exception of fall applied 2,4-D plus dicamba, none of the herbicides produced increased yields during the growing season following treatment.

In six trials seed yields were obtained in the second year following herbicide treatment. In three of the six trials large increases in yield (33 to 70%) were obtained. In the other three trials only small seed yield increases occurred.

[3] Work on these trials was conducted in cooperation with W. Yarish, Plant Industry Division, Alberta Agriculture, Edmonton.

Table 1. Percent control of dandelions with 2,4-D amine in seed-producing stands of creeping red fescue.

		Rate of 2,4-D, kg/ha			
		Fall applied		Spring applied	
Year	Location	.56	1.12	.56	1.12
1969	1	-	-	11	17
1970	1	0	11	-	-
1973	1	-	-	60	60
1974	1	49	58	59	65
	2	66	66	49	50
1975	1	45	54	31	39
	2	52	68	0	17
1976	1	0	30	21	26
Average		35	48	33	37

Table 2. Percent control of dandelions with dicamba plus 2,4-D in seed-producing stands of creeping red fescue.

		Rate of Dicamba + 2,4-D, kg/ha					
		Fall applied			Spring applied		
Year	Location	.28 + .56	.28 + .84	.42 + 1.12	.28 + .56	.28 + .84	.42 + 1.12
1971	1	-	-	-	-	-	81
1972	1	-	-	76	-	-	-
1973	1	-	-	-	-	-	99
	2	-	-	-	-	-	94
1974	1	-	-	65	57	-	-
	2	-	-	92	65	-	-
1975	1	78	93	78	43	62	-
	2	80	83	86	51	74	-
1976	1	78	89	96	56	50	-
Average		79	88	82	54	62	91

Table 3. Seed yields (kg/ha) of creeping red fescue in the growing season following treatment with herbicides.				
Herbicide treatment	Site years	Herbicide applied in fall	Site years	Herbicide applied in spring
Check	3	410	5	340
2,4-D, 1.12 kg/ha		380		349
Check	3	410	3	420
2,4-D + dicamba, .56 + .28 kg/ha		480		400

Crop competition for dandelion control

The size and density of dandelions can be manipulated by grass species and row spacing. The size of dandelions growing in intermediate wheatgrass, bromegrass, meadow fescue, creeping red fescue, and timothy was effectively reduced by decreasing the row spacing of each grass from 100 to 30 cm. Russian wild ryegrass had only a minor effect on dandelion size regardless of the row spacing at which it was seeded. Within any given row spacing between 30 and 100 cm, dandelion density was not affected by grass species. However, as the row spacing decreased the average density of dandelions growing in the six grass species also decreased.

Introduction: Crop competition is a major tool in suppressing weed growth and invasion. A study was conducted in cooperation with Dr. C.R. Elliott to determine the effectiveness of six grass species, each growing at varying row spacings, in reducing the establishment and growth of dandelions.

Method: Intermediate wheatgrass (cv. Chief), bromegrass (cv. Carlton), meadow fescue (cv. Mimer), Russian wild ryegrass (cv. Sawki), creeping red fescue (cv. Boreal) and timothy (cv. Climax) were each seeded in seven-row plots. The rows were arranged in a fan-shaped design so that the spacing between rows was 10 cm at one end and 100 cm at the other end. Two seedings were made: one in 1972 and the other in 1973. Dandelions were allowed to infest the grasses. Annual measurements of dandelion density and canopy diameter (the average distance between leaf tips in east-west and north-south directions) were made at row spacings of 30, 50, 70 and 90cm for 3 years following the year of seeding.

Results and Discussion: Both grass species and row spacing had a significant effect on dandelion growth. At narrow row spacings (30 cm) the size of dandelions growing in vigorous, aggressive grasses such as intermediate wheatgrass, bromegrass, meadow fescue, creeping red fescue and timothy was much smaller than the size of dandelions growing in the slow growing, low yielding Russian wild ryegrass (Figure 1). At row spacings greater than 30 cm grass species had very little effect on the size of the dandelions.

Dandelion density between the rows of all grass species was similar when comparisons were made within each of the selected row spacings. However, dandelion density between rows, averaged over all grasses, declined as row spacing declined. In 1976, the density of dandelions growing amongst grasses seeded in 1973 was approximately 40% less in row spacings of 30 cm than in row spacings of 90 cm.

These results have demonstrated several important features relating to the control of dandelions and presumably many other weeds. Intermediate wheatgrass, bromegrass, meadow fescue, creeping red fescue when seeded in narrow rows (30 cm or less), were able to compete vigorously with dandelions. In these grasses, row spacing can be considered as an important method of weed control. Russian wild ryegrass, on the other hand, had only a minor effect on the dandelion, regardless of row spacing. For this grass under northern conditions, as well as for the other grasses seeded in row spacings greater than 30 cm, tillage and other methods of control appear more important than crop competition.

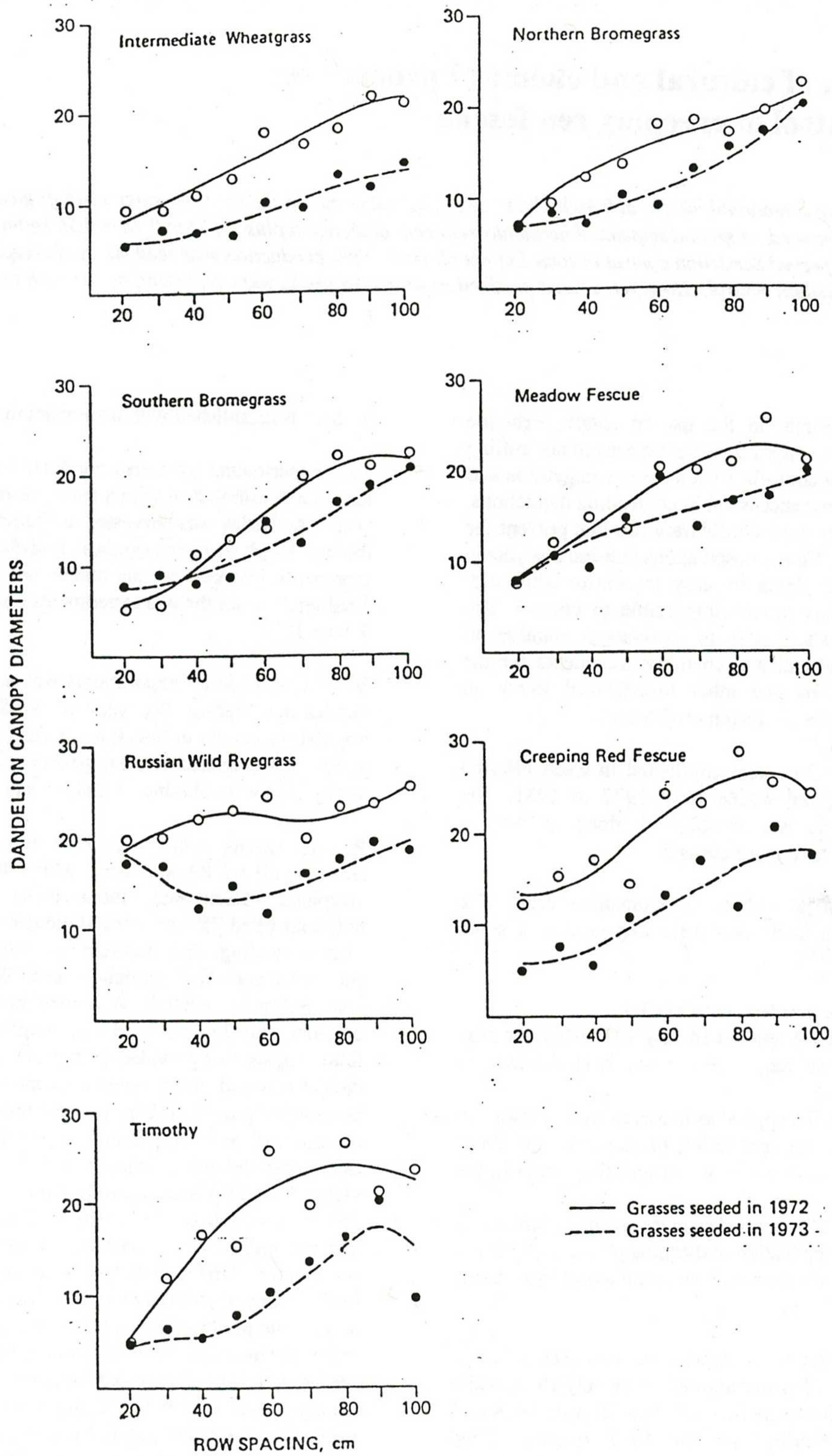

Figure 1. Effect of grass species and row spacing on the canopy diameter (cm) of dandelions. Dandelion canopy diameters from grasses seeded in 1972 are the average from samplings made in 1973, 1974 and 1975 while those from grasses seeded in 1973 are the average made in 1975 and 1976.

Combination of cultural and chemical procedures for weed control in creeping red fescue

A single application of bromoxynil/MCPA at 0.56 kg/ha to creeping red fescue in the seedling stage (3-leaf) gave substantial (65% or more) control of the seed. A second sequential herbicide treatment of dicamba plus 2,4-D at 0.28 + 0.56 kg/ha in May of the year following seeding improved dandelion control in some but not all tests. First production year seed yields of creeping red fescue were not improved by dandelion control. However, second production year seed yields were increased by as much as 25% as a result of dandelion control.

Introduction: Research on the use of single herbicide treatments has not provided a consistent means of controlling dandelions. Cultural controls, such as crop competition and row spacing, have been successful in controlling dandelions. However, other agronomic considerations often prevent the use of such methods. Casual observations indicate that young, immature dandelion plants are easy to control while old, established plants are almost impossible to control. The objective of this study was to evaluate a number of combinations of cultural and chemical treatments for the control of dandelions and other broadleaved weeds in seed-producing stands of creeping red fescue.

Methods: Field studies were conducted in weed infested stands of creeping red fescue from 1977 to 1981. The creeping red fescue was established alone or with a companion crop of barley or rapeseed.

a) Stands established without a companion crop. The following herbicide treatments were imposed on a stand seeded on 7 May 1977:

(1) Weedy check - no weed control (CK).
(2) Bromoxynil/MCPA applied 14 July 1977 when the crop was in the three-leaf stage and the weeds in the two- to four-leaf stage (BM).
(3) Bromoxynil/MCPA applied as in treatment 2 followed on 15 August 1977 by an application of dicamba plus 2,4-D when the crop was 10 cm in height and the weeds in the rosette stage (BM-D2A).
(4) Bromoxynil/MCPA applied as in treatment 2 followed on 5 May 1978 by an application of dicamba plus 2,4-D prior to stem elongation of the crop and when the weeds were in the rosette stage (BM-D2S).

On 7 June 1978, the entire experiment was seeded again. Bromoxynil plus MCPA was applied on 16 July 1978, while dicamba plus 2,4-D was applied on either 28 Aug. 1978 or 7 June 1979, as described for the 1977 seeding. Weed population counts in the weedy check plots were obtained on 14 July 1978 and 6 July 1979. In other plots weed population counts were made on 12 July 1979.

b) Stands established with a companion crop.

Two experiments were also conducted where creeping red fescue was established with a barley or rapeseed companion crop. The barley was harvested as fodder in early August in the soft dough stage or as grain in mid-September. Herbicide treatments imposed on the stands are shown in Table 1. Seeding dates for the two experiments were 22 May 1977 and 4 June 1979.

Weed control in all experiments was determined by visual evaluations during the year of seeding and by weed population counts in late June or early July of each of the years following that of establishment. Creeping red fescue seed yields were obtained 1 and 2 years after seeding.

Results: Results of the research are shown in Tables 2 and 3. Bromoxynil/MCPA applied at 0.28 + 0.28 kg/ha when the creeping red fescue was in the three-leaf stage (and 1-2 month old) controlled 75% or more of the annual weeds during the year of seeding. This herbicide combination also provided substantial control of dandelions and other weeds during the year following seeding. A second herbicide treatment of dicamba plus 2,4-D at 0.28 + 0.56 kg/ha in May of the year following seeding provided an improvement in the control of dandelions and other weeds over the single application of bromoxynil plus MCPA in some but not all seedings. The use of rapeseed as a companion crop without any herbicide treatments did not provide consistent weed control. Seed yields during the second production year were increased by 25% or more from the use of herbicide treatments when creeping red fescue was seeded alone or with barley harvested for fodder. First production year seed yields were not increased by any of the herbicide treatments. Similarly, first and second production year seed yields were not increased by any of the herbicide treatments when creeping red fescue was seeded with barley harvested for grain. Harvesting barley as fodder rather than grain produced marginally higher first production year creeping red fescue seed yields but had no effect on second production year seed yields.

Table 1. Description of treatments imposed on creeping red fescue seeded with a companion crop.

Treatment code	Companion crop	Method of harvest of companion crop	Herbicide treatments and dates of application: 1977 seeding: Bromoxynil + MCPA	Dicamba + 2,4-D	2,4-D	1979 seeding: Bromoxynil + MCPA	Dicamba + 2,4-D	2,4-D
F-CK	Barley	Fodder	-	-	-	-	-	-
F-BM	Barley	Fodder	24/6/77	-	-	29/6/79	-	-
F-BM-D2A	Barley	Fodder	24/6/77	15/8/7	-	29/6/79	22/7/79	-
F-BM-D2S	Barley	Fodder	24/6/77	5/8/79	-	29/6/79	18/6/80	-
G-CK	Barley	Grain	-	-	-	-	-	-
G-BM	Barley	Grain	24/6/77	-	-	29/6/79	-	-
G-BM-D2S	Barley	Grain	24/6/77	29/9/77	-	29/6/79	13/6/80	-
G-MOW+	Barley	Grain	-	-	-	-	-	-
RAP	Rapeseed	Grain	-	-	31/5/78	-	-	13/6/80

+ Treatment was clipped at a height of 10 cm during the second growing season to control weeds. Dates of clipping were 14 July 1979 for the 1977 seeding and 13 June 1980 for the 1979 seeding.

Table 2. Effect of herbicide treatments on the seed yield of creeping red fescue and the density of dandelions and the total weed populations in stands seeded without a companion crop.

Treatment code	Seeded in 1977: First production year (1978)	Seeded in 1977: Second production year (1979)	Seeded in 1978: First production year (1979)	Mean of two seedings: First production year
		Creeping red fescue seed yield (kg/ha)		
CK	518	368	893	705
BM	518	536	947	733
BM-D2A	460	648	638	549
BM-D2S	548	549	869	709
S.E.M.	75	44	61	48
		Dandelion density (plants/m^2)		
CK	27	31	10	19
BM	4	5	4	4
BM-D2A	0	1	2	1
BM-D2S	2	4	1	2
S.E.M.	2	3	2	1
		Total weed density (plants/m^2)		
CK	32	31	42	37
BM	5	5	17	11
BM-D2A	1	1	11	6
BM-D2S	2	4	4	3
S.E.M.	1	3	5	3

S.E.M. Standard error of the treatment mean.

Table 3. The effect of several cultural-chemical weed control procedures on the seed yield of creeping red fescue, the density of dandelions and the density of all weeds following establishment of the forage grass with a companion crop.

Treatment code	Seeded in 1977		Seeded in 1979		Mean of two seedings	
	First production year (1978)	Second production year (1979)	First production year (1980	Second production year (1981)	First production year	Second production year
	Creeping red fescue seed yield (kg/ha)					
F-CK	134	657	-	592	-	625
F-BM	108	866	-	844	-	855
F-BM-D2A	28	895	-	888	-	892
F-BM-D2S	98	855	-	902	-	879
G-CK	9	699	-	760	-	730
G-BM	7	854	-	772	-	813
G-BM-D2S	4	778	-	739	-	759
G-MOW	0	801	-	830	-	816
RAP	54	769	-	811	-	790
S.E.M.	24	53	-	57	-	38
	Dandelion density (plants/m^2)					
F-CK	36	26	7	7	22	17
F-BM	10	12	2	2	6	7
F-BM-D2A	1	4	1	3	1	4
F-BM-D2S	2	4	1	2	2	3
G-CK	22	16	6	7	14	12
G-BM	12	11	1	2	7	7
G-BM-D2S	4	5	1	3	3	4
G-MOW	16	9	1	2	9	6
RAP	13	11	3	4	8	8
S.E.M.	4	2	1	1	2	1
	Total weed density (plants/m^2)					
F-CK	43	26	57	8	50	17
F-BM	11	14	11	3	11	9
F-BM-D2A	3	4	21	5	12	5
F-BM-D2S	2	4	3	2	3	3
G-CK	24	18	43	8	34	13
G-BM	14	11	9	3	12	7
G-BM-D2S	4	6	21	4	13	5
G-MOW	18	10	12	2	15	6
RAP	16	12	24	5	20	9
S.E.M.	4	3	5	2	3	2

S.E.M. Standard error of the treatment mean.

Control of narrow-leaved hawk's-beard in established creeping red fescue

Fall application (early to mid-October) of 2,4-DB at 1.40 or more kg/ha, 2,4-D ester at 1.12 kg/ha, and dicamba/2,4-D/mecoprop at .56 kg/ha have given good control of narrow-leaved hawk's-beard.

Introduction: Narrow-leaved hawk's-beard is a slender, yellow flowered annual or winter annual species which is a member of the composite family. In recent years this weed has been rapidly invading seed-producing fields of creeping red fescue in the Peace River region of Alberta and British Columbia. Work at the University of Alberta by Vanden Born and Shraa has shown that 2,4-DB applied at 1.12 to 1.68 kg/ha in late September or early October will give effective control of hawk's-beard in alfalfa. Since information on the control of this weed in fescue was lacking we conducted a study to evaluate the effect of several chemicals for hawk's-beard control.

Methods: The study was conducted in a commercial field of creeping red fescue seeded in 1970. Herbicide treatments were applied either in the fall (October 5 to 16) or in the spring (May 12 to 17). The hawk's-beard was in the rosette stage at all times of application. Fall treatments were repeated for each of 3 years while spring treatments were repeated for each of 2 years. Each year the herbicide treatments were replicated 5 times. All treatments were applied in a spray volume of 168 L/ha. Weed harvests were made in late June or in July each year.

Results and Discussion: The major findings of this work are:

a) Applications of 2,4-DB at 1.40 kg/ha or more and of 2,4-D ester at 1.12 kg/ha in the fall (early to mid-October) consistently provided good hawk's-beard control over the 3.5 year period (Table 1). A combination of 2,4-D/dicamba/mecoprop at .56 kg/ha provided good control in 2 out of 3 years. With these treatments the hawk's-beard plants were not immediately killed but became distorted in the fall and died during the following spring.

b) Spring applications (early to mid-May) of 2,4-DB at 1.40 kg/ha, 2,4-D ester at 1.12 kg/ha and dicamba plus 2,4-D plus mecoprop at .56 kg/ha provided good hawk's-beard control. However, control tended to be poorer than from fall applied treatments.

c) Bromoxynil plus MCPA (Buctril M or Brominal M) at .56 and .84 kg/ha, MCPB/MCPA(15:1) at 1.12 or 1.68 kg/ha and MCPA at .56 and 1.12 kg/ha were each evaluated for one year. None of these treatments provided adequate hawk's-beard control.

Table 1. Effect of several herbicides on narrow-leaved hawk's-beard growing in an established stand of creeping red fescue.

Herbicide	Rate, kg/ha	Hawk's-beard dry weight, kg/ha 1971-72	1972-73	1973-74	Average
		Fall-applied treatments			
Check	0	300	486	233	340
2,4-DB	1.12	129	46	3	59
2,4-DB	1.40	13	34	4	17
2,4-DB	1.68	13	16	29	19
2,4-D ester	.56	40	41	4	29
2,4-D ester	1.12	19	26	24	22
Dicamba/2,4-D/ mecoprop	.28	96	136	32	88
Dicamba/2,4-D/ mecoprop	.56	4	68	13	29
		Spring-applied treatments			
Check	0	-	315	170	242
2,4-DB	1.40	-	22	12	18
2,4-D ester	1.12	-	31	18	25
Dicamba/2,4-D/ mecoprop	.56	-	44	4	24

Control of alsike clover in established timothy, bromegrass, and creeping red fescue

Clopyralid alone at .2 kg/ha or at .1 kg/ha in combination with 2,4-D at .4 kg/ha gave good alsike clover control without crop injury. Picloram/2,4-D at .426 kg/ha gave good control in 2 of 3 years without crop injury. Alsike clover control with 2,4-D alone was poor in all years.

Introduction: Alsike clover is a common weed in forage grass seed fields in the Peace River region. It competes with the grasses reducing yields, and, in the case of timothy, contaminating the seed. Separation of timothy and alsike clover seeds is very difficult. Dicamba has provided effective control of alsike clover in creeping red fescue but there are no controls available for the weed in bromegrass or timothy.

Methods: The experiments were established annually in June of 1981, 1982 and 1983 on the Beaverlodge Research Station. Climax timothy, Carlton bromegrass and Boreal creeping red fescue were seeded in rows spaced 30 cm apart on a silt loam to clay loam soil (pH 6.1, O.M.5-6z) that had been summerfallowed the previous year. Four rows of each grass were seeded in each plot. The plots were 9 m long. Alsike clover was seeded in a direction perpendicular to the rows of grass on the back 3 m of each plot. The alsike clover was also seeded in rows spaced 30 cm apart. The grasses and the alsike clover were allowed to grow for 1 year in each experiment. Applications of several herbicides (see Table 1) were made in the spring to the l-year old grass and alsike clover stands. In 1982, applications were made on June 9 when the timothy was 15 cm high, the bromegrass in the shot-blade stage, the fescue was in the heading stage and the alsike clover 10 cm high. In 1983, applications were made on June 8 when the grasses and alsike clover were in stages similar to those in 1982 while in 1984, applications were made on May 25 when the timothy was 25 cm high, the bromegrass 20 cm high, the fescue in the shot-blade stage and the alsike clover 7.5 cm high. All of the treatments were applied in a spray volume of 168 L/ha and replicated 4 times. The front two-thirds of each plot was maintained in a relatively weed-free condition throughout the life of each stand. Grass tolerance and alsike clover control ratings were obtained between 2 and 3 months after application of the treatments. The grasses were harvested at maturity while the height, number of flowers/m2 and dry weight of shoots of alsike clover was obtained in September.

Results:

1. Clopyralid at .2 kg/ha alone or at .1 kg/ha in combination with 2,4-D at .4 kg/ha gave acceptable alsike clover control in all years (Table 1). Clopyralid at .1 kg/ha, alone, and picloram/2,4-D at .426 kg/ha gave acceptable control in 2 of the 3 years. 2,4-D did not give adequate control in any of the years.

2. Under weed-free conditions none of the herbicide treatments reduced the seed yields of timothy, bromegrass or creeping red fescue in 1983 or 1984 (Table 2). There was insufficient seed produced in 1981 to permit harvest of any of the grasses.

3. Where alsike clover was present, the seed yield of timothy in 1983 was increased in plots where the legume was controlled (Table 2). In 1984, the yield of creeping red fescue was increased where alsike clover was controlled. In other situations, grass seed yield increases were not observed.

4. In untreated check plots yields of bromegrass and creeping red fescue were higher under weed-free conditions than where alsike clover was present. Similarly, in 1983 timothy yields were higher under weedfree conditions than where alsike clover was present. In 1984, timothy yields were the same under both conditions presumably because of the sparse alsike clover population. In all plots, yields under weed-free conditions were generally higher than those where alsike clover was present. This probably indicates the importance of controlling alsike clover in the year of establishment rather than in the year of seed production.

CONCLUSIONS:

1. Clopyralid at .2 kg/ha alone or with 2,4-D at .4 kg/ha provided acceptable alsike clover control without reducing seed yields.

2. Picloram/2,4-D(1:16) at .426 kg/ha effectively reduced alsike clover flower production in all years and provided acceptable reductions in alsike clover dry weight in 2 of the 3 years.

3. Yield responses in weedy and weed-free plots suggests that early treatment (i.e. the year of establishment) is required to obtain maximum benefits from controlling alsike clover.

Table 1. Control of alsike clover in established grasses with several herbicide treatments.

Treatment	Rate (kg/ha)	0 - 9 rating			No. of flowers/m^2			Height of clover (cm)			Dry weight (g/m^2)		
		1982	1983	1984	1982	1983	1984	1982	1983	1984	1982	1983	1984
Check	-	0	0	0	166	83	762	50	69	44	251	865	232
Clopyralid	.1	4.0	6.9	7.2	40	0	28	41	38	12	176	86	11
Clopyralid + 2,4-D	.1 + .4	5.2	6.1	7.3	15	0	0	28	37	6	51	107	0
Clopyralid	.2	7.5	7.9	7.5	0	0	0	8	16	0	6	7	0
Clopyralid + 2. 4-D	.2 + .4	7.5	8.2	8.1	0	0	0	8	16	0	10	12	0
Clopyralid	.3	7.8	8.5	8.0	1	0	0	10	0	0	2	0	0
2,4-D	.4	1.0	2.2	3.0	184	83	895	48	66	42	212	861	233
Picloram/2,4-D	.426	5.0	6.5	7.6	19	0	7	26	43	13	115	163	12
S.E.M.		0.5	0.5	0.2	15	9	82	3	5	3	23	56	16

S.E.M. Standard error of the treatment mean.

Table 2. Timothy, bromegrass, and creeping red fescue seed yields (g/m²) from weedfree stands or stands infested with alsike clover following the application of several herbicide treatments.

		Timothy				Bromegrass				Creeping red fescue	
		Weedfree		Alsike present		Weedfree		Alsike present		Weedfree	Alsike present
Treatment	Rate (kg/ha)	1983	1984	1983	1984	1983	1984	1983	1984	1984	1984
Check	-	29	29	12	30	11	40	1	24	125	59
Clopyralid	.1	25	28	19	31	9	40	4	29	119	81
Clopyralid + 2,4-D	.1 + .4	28	22	20	30	15	38	3	29	121	100
Clopyralid	.2	32	31	23	30	10	56	3	29	113	73
Clopyralid + 2,4-D	.2 + .4	31	25	19	31	11	38	2	26	114	85
Clopyralid	.3	29	34	19	33	7	58	3	33	143	104
2,4-D	.4	35	29	16	27	9	32	1	27	105	67
Picloram/2,4-D	.426	37	25	23	25	8	31	4	33	100	76
S.E.M.		4	3	3	4	3	8	1	6	15	12

S.E.M. Standard error of treatment mean.

Table 3. Effect of several herbicide treatments on the weight and germination of seeds of timothy, bromegrass, and creeping red fescue.

		Timothy				Bromegrass				Creeping red fescue	
		Seedweight (g/100)		Germination (%)		Seed weight (g/100)		Germination (%)		Seed weight (g/100)	Germination (%)
Treatment	Rate (kg/ha)	1983	1984	1983	1984	1983	1984	1983	1984	1984	1984
Check	-	.050	.037	83	97	.444	.356	82	92	.140	92
Clopyralid	.1	.053	.036	85	91	.428	.368	84	93	.136	89
Clopyralid + 2,4-D	.1 + .4	.051	.036	86	91	.422	.382	82	90	.134	92
Clopyralid	.2	.054	.036	88	96	.446	.366	83	90	.136	92
Clopyralid + 2,4-D	.2 + .4	.049	.037	85	96	.433	.375	82	92	.141	91
Clopyralid	.3	.053	.034	90	93	.438	.374	82	91	.132	87
2,4-D	.4	.048	.034	86	93	.415	.366	77	92	.140	94
Picloram/2,4-D	.426	.053	.039	83	93	.426	.362	79	89	.152	95
S.E.M.		.002	.001	2	2	.012	.009	2	2	.005	2

S.E.M. Standard error of treatment mean.

Control of Foxtail Barley, Volunteer Bromegrass, Dandelions, and Volunteer Alsike Clover in Creeping Red Fescue grown for seed

Spring applications of sethoxydim at 500 g/ha and fluazifop-P at 250 g/ha consistently reduced the heading, and consequently the seed production, of foxtail barley and volunteer bromegrass by ≥ 90% without affecting crop seed yield, 100-seed wt or germination. The effectiveness of sethoxydim at 500 g/ha and fluazifop-P at 250 g/ha to reduce heading of grass weeds was not affected by tank mixing with metsulfuron at 4.5 g/ha but was reduced when tank mixed with either dicamba plus 2,4-D at 280 plus 560 g/ha or 2,4-D alone at 560 g/ha. Metsulfuron alone, or in tank mixtures with sethoxydim (500 g/ha) or fluazifop-P (250 g/ha), effectively controlled dandelion and volunteer alsike clover (probability of ≥80% control was 0.94 or more). Dicamba plus 2,4-D provided a similar level of volunteer alsike clover control but was less effective on dandelion, while 2,4-D was ineffective on both weeds. Treatments containing dicamba plus 2,4-D reduced crop seed yield and germination, and increased seed weight.

Introduction: The most effective time to control weeds in seed-producing stands of creeping red fescue is before or during establishment. However, weeds, particularly perennials, often invade after stand establishment. Chemical control of some weeds is possible. Sethoxydim and fluazifop-P are labelled in Canada for the control of quackgrass and several annual grass weeds while dicamba plus 2,4-D, metsulfuron, clopyralid, 2,4-D, and MCPA are labelled for the control of many broadleaf weeds. While these herbicides are effective against a wide range of weeds, there are no herbicides labelled for the control of foxtail barley and volunteer bromegrass.

An additional problem with current product labels is that herbicides for grass and broadleaf weed control can not be tank-mixed; they must be applied in separate operations. Tank mixtures of herbicides save time and costs. However, tank-mixing herbicides can alter their efficacy on weeds and crops. Limited information is available on the effects of combining sethoxydim or fluazifop-P with herbicides for broadleaf weed control in creeping red fescue. In other crops, no detrimental effects have been observed from tank-mixing sethoxydim with chlorsulfuron or ethametasulfuron. Similarly, the activity of fluazifop-P was not altered when tank-mixed with chlorsulfuron, but when tank-mixed with ethametasulfuron, crop (i.e. canola) injury occurred. Sethoxydim activity was reduced when tank-mixed with MCPA. In general, growth regulator type herbicides, such as 2,4-D and dicamba, reduce the activity of foliarly applied herbicides for wild oat control, with amine formulations causing greater reductions than ester formulations.

The purposes of this research were twofold: a) to evaluate foxtail barley and volunteer bromegrass control from sethoxydim and fluazifop-P applied alone or in combination with metsulfuron, 2,4-D, and dicamba plus 2,4-D, and b) to evaluate dandelion and volunteer alsike clover control from each of the latter herbicide treatments applied alone or in combination with sethoxydim or fluazifop-P.

Methods: Six experiments were conducted from 1989 to 1992 in well-established, commercial seed-producing fields of creeping red fescue located within a 15 km radius of the Agriculture and Agri-Food Canada Norther Agriculture Research Centre, Beaverlodge, Alberta. At all sites, except site 1, four graminicide treatments: sethoxydim at 200 and 500 g/ha and fluazifop-P at 125 and 250 g/ha; and three herbicides for broadleaf weed control: metsulfuron at 4.5 g/ha, dicamba at 280 g/ha plus the alkanolamine salt of 2,4-D at 560 g/ha, and the same salt of 2,4-D alone at 560 g/ha, were applied. The highest rate of each graminicide was applied as a tank-mix with each herbicide for broadleaf weed control at all sites, except site 1. At that site, treatments containing sethoxydim, fluazifop-P plus 2,4-D, and 2,4-D alone were not applied. A weedy check was included at all sites. All treatments containing sethoxydim were applied with Merge at 1.0% of spray volume while fluazifop-P formulation contained Agral 90. Herbicides were applied between May 12 and 25. At the time of application, crop and weed growth stages were as follows: creeping red fescue, prior to shot-blade and 15 to 25 cm tall; foxtail barley, 3- to 4-leaf stage and 10 to 15 cm tall; volunteer bromegrass, 3- to 4-leaf stage and 20 to 25 cm tall; dandelion, bud to early flower; and volunteer alsike clover, vegetative stage and 10 cm tall. All treatments were applied with a compressed air-charged, bicycle-type experimental sprayer delivering 100 L/ha at 210 kPa. The herbicide treatments were arranged in a randomized complete lock design with four replicates. Individual plot size was 2 by 10 m.

Weed control was evaluated 6 to 8 wk after herbicide application. Control of foxtail barley and volunteer bromegrass was evaluated by visually estimating the percent reduction in heading. Percent dandelion and volunteer alsike clover control (percent reduction in biomass) was evaluated according to the Expert Committee on Weeds, Western Canada Section accepted rating scale. Crop yields were obtained when the crop matured in late July to early August by harvesting three quadrats, each 1.0 m^2 in size, from each plot. Following threshing, two sub-samples of 100 seeds were counted from each plot of cleaned seed, weighed, and subjected to a routine germination test.

Results and Discussion: When averaged over sites, sethoxydim alone at 500 g/ha and fluazifop-P alone at 125 or 250 g/ha effectively reduced foxtail barley heading compared to the weedy check (Table 1). The probability of these treatments preventing 90% or more heading was 1.0. Reducing the rate of sethoxydim to 200 g/ha decreased effectiveness and increased site-to-site variation. The addition of metsulfuron had no effect on the efficacy of either graminicide. However, when tank-mixed with either dicamba plus 2,4-D or 2,4-D alone, the efficacy of both herbicides was reduced, with 2,4-D alone causing a greater reduction that dicamba plus 2,4-D.

The highest rate of both sethoxydim and fluazifop-P prevented volunteer bromegrass heading when applied alone (Table 2). Reducing the rate of both graminicides resulted in an increase in volunteer bromegrass heading with the low rate of sethoxydim being less effective that the low rate of fluazifop-P. The addition of metsulfuron dicamba plus 2,4-D, or 2,4-D alone to sethoxydim or fluazifop-P decreased the efficacy of the latter herbicides to reduce volunteer bromegrass heading in some, but not all cases.

Metsulfuron alone consistently provided ≥80% dandelion control (Table 3). Tank- mixing sethoxydim or fluazifop-P did not reduce the efficacy of metsulfuron to control dandelion. Dicamba plus 2,4-D, without sethoxydim or fluazifop-P, was less effective than metsulfuron in controlling dandelion. The addition of sethoxydim or fluazifop-P improved the efficacy of dicamba plus 2,4-D on dandelion. Control from 2,4-D, alone or with sethoxydim or fluazifop-P was unacceptable.

Metsulfuron and dicamba plus 2,4-D, alone or with a graminicide, consistently controlled volunteer alsike clover by ≥80% (Table 4). The probability of metsulfuron treatments to control volunteer alsike clover by ≥ 90% tended to be greater than that of the dicamba plus 2,4-D treatments. The site-to-site variability was higher from dicamba plus 2,4-D than from metsulfuron. The effect of tank-mixing metsulfuron or dicamba plus 2,4-D with sethoxydim or fluazifop-P tended to be similar to that observed for dandelion control. Volunteer alsike clover control from 2,4-D alone, or with sethoxydim or fluazifop-P was unacceptable.

Sethoxydim and fluazifop-P, alone or tank-mixed with metsulfuron or 2,4-D, had little or no effect on creeping red fescue seed yield, 100-seed wt, or seed germination (Table 5). However treatments containing dicamba plus 2,4-D reduced seed yields and germination and increased 100-seed wt. The average seed yield from the group of treatments containing dicamba plus 2,4-D was 723 ± 41 kg/ha while the average seed yield from the group of treatments including the check, sethoxydim at 500 g/ha, and fluazifop-P at 250 g/ha was 904 ± 50 kg/ha. Average seed yields from the other two groups, those with treatments containing metsulfuron or 2,4-D, but not dicamba, were similar to the average for the group without herbicides for broadleaf weed control. Average seed germination and 100-seed wt for the above four groups of treatments were 88 ± 0.4, 91 ± 0.3, 93 ± 0.3, 91 ± 0.4% and 125 ± 0.8, 119 ± 0.8, 121 ± 0.8, 123 ±0.8 mg, respectively. Mean site seed yield, 100-seed wt, and germination ranged from 233 ± 14 to 1227 ±67 kg/ha, 113 ± 0.9 to 130 ± 1.0 mg, and 88 ± 0.6 to 95 ± 0.4% respectively.

The enhanced dandelion and volunteer alsike clover control which occurred when dicamba plus 2,4-D were combined with sethoxydim and fluazifop-P can probably be attributed to the effect of the surfactants. Merge and Agral 90, which were included when the latter herbicides were applied. Surfactants have been shown to enhance activity of 2,4-D and dicamba. However, increased crop injury has also been reported from the addition of surfactants on dicamba plus 2,4-D also probably contributed to the detrimental effects of these combinations on yield and seed quality.

The results of this study indicate that sethoxydim and fluazifop-P can be used effectively to reduce heading, and the subsequent seed production, of foxtail barley and volunteer bromegrass growing in creeping red fescue seed production fields. A sethoxydim rate of 500 g/ha appears necessary to reduce grass weed heading satisfactorily while fluazifop-P at 125 or 250 g/ha appears adequate. Metsulfuron can be tank-mixed with sethoxydim or fluazifop-P without loss of efficacy on either grass weed head reduction or broadleaf weed control. However, mixtures of dicamba plus 2,4-D with either sethoxydim or fluazifop-P are inadvisable because the efficacy of the latter herbicides to reduce grass weed heading decreases and crop yield and quality are reduced.

Table 1. Probability of graminicides, alone or in combination with herbicides for broadleaf weed control, to reduce the heading of foxtail barley infesting stands of creeping red fescue at sites 1 to 5.

Herbicide	Rate (g/ha)	Probability of 100% reduction in heading[a]	
		Mean of all sites	Range among site means
Sethoxydim	200	0.56 (0.08)	0.25 - 1.00
Sethoxydim	500	0.88 (0.03)	0.75 - 1.00
Sethoxydim + metsulfuron	500 + 4.5	0.94 (0.03)	0.75 - 1.00
Sethoxydim + dicamba + 2,4-D	500 + 280 + 560	0.75 (0.08)	0.25 - 1.00
Sethoxydim + 2,4-D	500 + 560	0.50 (0.09)	0.25 - 0.75
Fluazifop-P	125	0.89 (0.05)	0.75 - 1.00
Fluazifop-P	250	0.94 (0.03)	0.75 - 1.00
Fluazifop-P + metsulfuron	250 + 4.5	0.94 (0.03)	0.75 - 1.00
Fluazifop-P + dicamba + 2,4-D	250 + 280 + 560	0.86 (0.03)	0.75 - 1.00
Fluazifop-P + 2,4-D	250 + 560	0.69 (0.08)	0.25 - 1.00

[a] Numbers in parentheses are standard errors. A value of 0 indicates a standard error of < 0.01.

Table 2. Probability of graminicides, alone or in combination with herbicides for broadleaf weed control, to reduce the heading of volunteer bromegrass infesting stands of creeping red fescue at sites 4 and 5.

Herbicide	Rate (g/ha)	Probability of 100% reduction in heading[a]	
		Mean of all sites	Range among site means
Sethoxydim	200	0.62 (0.01)	0.50 - 0.75
Sethoxydim	500	1.00 (0)	-
Sethoxydim + metsulfuron	500 + 4.5	0.87 (0.01)	0.75 - 1.00
Sethoxydim + dicamba + 2,4-D	500 + 280 + 560	0.75 (0.01)	0.50 - 1.00
Sethoxydim + 2,4-D	500 + 560	1.00 (0)	-
Fluazifop-P	125	0.75 (0.01)	-
Fluazifop-P	250	1.00 (0)	-
Fluazifop-P + metsulfuron	250 + 4.5	1.00 (0)	-
Fluazifop-P + dicamba + 2,4-D	250 + 280 + 560	0.87 (0.01)	0.75 - 1.00
Fluazifop-P + 2,4-D	250 + 560	0.87 (0.01)	0.75 - 1.00

[a] Numbers in parentheses are standard errors. A value of 0 indicates a standard error of < 0.01.

Table 3. Probability of metsulfuron, dicamba + 2,4-D, and 2,4-D, each alone or in combination with a graminicide to provide ≥80% control of dandelion infesting stands of creeping red fescue at sites 1, 3, 4, 5 and 6.

		Probability of ≥80% control[a]	
Herbicide	Rate (g/ha)	Mean of all sites	Range among site means
Metsulfuron	4.5	0.94 (0.04)	0.75 - 1.00
Metsulfuron + sethoxydim	4.5 + 500	0.94 (0.04)	0.75 - 1.00
Metsulfuron + fluazifop-P	4.5 + 250	1.00 (0)	-
Dicamba + 2,4-D	280 + 560	0.25 (0.04)	0.00 - 0.75
Dicamba + 2,4-D + sethoxydim	280 + 560 + 500	0.62 (0.05)	0.25 - 1.00
Dicamba + 2,4-D + fluazifop-P	280 + 560 + 250	0.71 (0.01)	0.25 - 1.00
2,4-D	560	0.06 (0.04)	0.00 - 0.25
2,4-D + sethoxydim	560 + 500	0 (0)	-
2,4-D + fluazifop-P	560 + 250	0.06 (0.04)	0.00 - 0.25

[a] Numbers in parentheses are standard errors. A value of 0 indicates a standard error of < 0.01.

Table 4. Probability of metsulfuron, dicamba + 2,4-D, and 2,4-, each alone or in combination with a graminicide to provide ≥90% control of volunteer alsike clover infesting stands of creeping red fescue at sites 1, 4, and 5.

		Probability of ≥90% control[a]	
Herbicide	Rate (g/ha)	Mean of all sites	Range among site means
Metsulfuron	4.5	0.96 (0.01)	0.75 - 1.00
Metsulfuron + sethoxydim	4.5 + 500	1.00 (0)	-
Metsulfuron + fluazifop-P	4.5 + 250	0.96 (0.01)	0.75 - 1.00
Dicamba + 2,4-D	280 + 560	0.63 (0.01)	0.25 - 1.00
Dicamba + 2,4-D + sethoxydim	280 + 560 + 500	1.00 (0)	-
Dicamba + 2,4-D + fluazifop-P	280 + 560 + 250	0.79 (0.01)	0.50 - 1.00
2,4-D	560	0 (0)	-
2,4-D + sethoxydim	560 + 500	0 (0)	-
2,4-D + fluazifop-P	560 + 250	0 (0)	-

[a] Numbers in parentheses are standard errors. A value of 0 indicates a standard error of < 0.01.

Table 5. Seed yield, 100-seed wt and germination of creeping red fescue following the application of graminicides alone or combined with herbicides for broadleaf weed control.				
Herbicide	Rate (g/ha)	Seed yield (kg/ha)	100 Seed wt (mg)	Seed germination (%)
Check, weedy	-	904 (86)[a]	119 (1.3)	92 (0.6)
Sethoxydim	200	904 (88)	121 (1.6)	92 (0.6)
Sethoxydim	500	969 (91)	118 (1.4)	91 (0.6)
Sethoxydim + metsulfuron	500 + 4.5	911 (91)	123 (1.5)	93 (0.6)
Sethoxydim + dicamba + 2,4-D	500 + 280 + 560	714 (73)	124 (1.5)	87 (0.7)
Sethoxydim + 2,4-D	500 + 560	824 (83)	126 (1.5)	91 (0.6)
Fluazifop-P	125	935 (90)	117 (1.5)	91 (0.6)
Fluazifop-P	250	853 (83)	119 (1.3)	91 (0.6)
Fluazifop-P + metsulfuron	250 + 4.5	904 (87)	120 (1.4)	92 (0.6)
Fluazifop-P + dicamba + 2,4-D	250 + 280 + 560	679 (65)	127 (1.4)	87 (0.7)
Fluazifop-P + 2,4-D	250 + 560	891 (88)	126 (1.5)	89 (0.7)
Metsulfuron	4.5	933 (90)	121 (1.4)	94 (0.5)
Dicamba + 2,4-D	280 + 560	780 (80)	124 (1.5)	90 (0.7)
2,4-D	560	860 (88)	120 (1.4)	92 (0.6)

[a] Numbers in parentheses are standard errors. A value of 0 indicates a standard error of < 0.01.

APPENDIX

Trade names, CSA accepted names, and rates in kg/ha are in active ingredients or acid equivalent. Rates per acre are in product per acre (as usually presented in the *Alberta Agriculture Crop Protection with Chemicals* manual or in the *British Columbia Guide to Weed, Disease, Insect, Bird, and Rodent Control for Commercial Growers*).

Trade Name	Herbicide Name	Rate (kg/ha)*	Rate per acre*
2,4-D Amine	2,4-D Amine	0.25-0.55	0.20-0.47 L
2,4-D Ester	2,4-D Ester	0.25-0.55	0.20-0.47 L
Achieve	tralkoxydim	0.25	0.40 kg
Afolan/Lorox	linuron	0.20-0.26	0.43-1.90 L
Ally/Escort	metsulfuron methyl	0.0045	0.003/0.0012 kg
Assure	quizalofop ethyl	0.09-0.14	0.40-0.60 L
Avadex BW	triallate	1.1-2.2	1.20-1.70 L
Avenge 200-C	difenzoquat	0.7-0.85	1.40-1.70 L
Banvel	dicamba	0.1-0.3	0.095-0.245 L
Bladex	cyanazine	1.4-2.7	1.20-2.30 L
Buctril M	bromoxynil+MPCA	0.28+0.28	0.40 L
Carbyne	barban	no longer available	
Champion Plus	fenoxaprop-p-ethyl+MCPA+2,4-D+ trifensulfuron methyl	0.277+1.292+0.431+ 0.015	0.81 L+0.0081 kg
DyVel	dicamba-MCPA-K	0.10-0.42	0.50 L
Edge	ethalfuralin	0.8-1.4	0.69-1.13 L
Embutox	2,4-DB	1.0-1.4	0.70-1.10 L
Estaprop	2,4-D+dichlorprop	0.49+0.53	0.71 L
Fusilade II/Venture	fluazifop-p-butyl	0.07-0.12	0.24-0.80 L
Fusion	fenoxaprop-p-ethyl+fluazifop-p-butyl	0.006+0.0164	0.185 L+0.325 L
Glean	chlorsulfuron	no longer available	
Hoe-Grass II	diclofop-methyl+bromoxynil	0.80+0.28	1.40 L
Hoe-Grass 284	diclofop-methyl	0.7-0.8	1.00-1.13 L
Horizon	clodinafop-propargyl	0.08	0.072 L
Kil-Mor/DyVel DS	2,4-D+mecoprop+ dicamba	0.25-0.52+0.67-0.14+ 0.09-0.19	0.34-1.30 L
Laser	fenoxaprop-p-ethyl+bromoxynil+MCPA	0.19+0.69+0.12	1.00 L
Laser DF	fenoxaprop-p-ethyl+ MCPA+thifensulfuron	0.035+ 0.42+0.015	0.008 kg
Lontrel	clopyralid	0.14-0.30	0.20-0.60 L

Trade Name	Herbicide Name	Rate (kg/ha)*	Rate per acre*
Matavan L	flamprop-methyl	0.25-0.40	2.00-3.00 L
MCPA Amine	MCPA Amine	0.34-0.55	0.20-1.70 L
MCPA Ester	MCPA Ester	0.34-0.55	0.20-1.70 L
MCPA-K	MCPA-K	0.34-0.55	0.20-0.85 L
MCPA-Na	MCPA-Na	0.34-0.55	0.20-1.70 L
Mecoprop	Mecoprop	0.825-1.275	2.20-3.80 L
Muster	ethametsulfuron-methyl	0.015-0.002	0.008-0.012 kg
Pardner	bromoxynil	0.015-0.022	0.41-0.49 L
Poast	sethoxydim	0.14-0.26	0.33-1.09 L
Prevail	tralkoxydim+clopyralid+MCPA	0.20+0.099+0.561	0.20 kg + 0.80 L
Puma	fenoxaprop-p-ethyl+modifier	0.092	0.40 L
Refine	thifensulfuron-methyl	0.025-0.050	0.085 L
Refine Extra	thifensulfuron-methyl+tribenuron-methyl	0.010+0.005	0.008 kg
Roundup	glyphosate	0.4-0.9	0.91-4.90 L
Rustler	glyphosate+dicamba	0.33+0.15-0.43+0.19	1.00-1.30 L
Select	clethodim	0.05	0.076 L
Sencor/Lexone	metribuzin	0.42-1.12	0.91 L
Target/Mirage	MCPA+mecoprop+dicamba	0.275-0.041+0.0625-0.094+0.0625-0.094	0.41-0.61 L
Tordon 202C	picloram+2,4-D	0.024+0.40	0.81 L
Treflan/Rival	trifluralin	0.82-1.60	0.45-0.81 L
Triumph Plus	fenoxaprop-p-ethyl+MCPA+thifensulfuron	0.092+0.42+0.015	0.67 L+0.008 kg