Cocksfoot Seed Crop Tolerance to Herbicides Applied to Seedling and Established Stands

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ABSTRACT

The herbicide tolerance of two seedling and five established crops of cocksfoot (orchardgrass, *Dactylis glomerata* L.) was studied. Control of weeds, especially *Poa annua* in seedling stands, resulted in large seed yield increases. The highest seed yield was 1310 kg ha^{-1} for ethofumesate at 1.5 kg ha^{-1} compared with 170 kg ha^{-1} for the untreated check. A mixture of ethofumesate and methabenzthiazuron generally gave higher yields than either product alone. Simazine, atrazine, diuron, terbicil and metribuzin applied to established crops of two cultivars, 'Grasslands Wana' and 'Grasslands Kara', often caused necrosis and retarded early spring growth, but did not cause a reduction in seed yield. Seed yield increases of 25 and 36% occurred from herbicide treatment in two trials, and were associated with the control of inter-row volunteer cocksfoot seedlings.

Several herbicide treatments can be recommended for use in established cocksfoot; diuron at 2.0 to 4.0 kg ha^{-1}; terbicil plus diuron at 0.5 plus 2.0 kg ha^{-1}; simazine or atrazine at 2.0 to 4.0 kg ha^{-1}; and metribuzin at 1.4 kg ha^{-1}. Higher rates of the terbicil plus diuron mixture or metribuzin were associated with severe necrosis and reduced yields in some trials.

Additional index words: Dactylis glomerata, **orchardgrass, seed yield, weed control, atrazine, diuron, ethofumesate, methabenzthiazuron, simazine, terbicil.**

INTRODUCTION

Herbicides are used in forage seed crops to improve seed quality through reduced weed seed contamination, reduced seed cleaning losses and seed processing costs, and reduced competition from weeds including intra-specific competition from volunteer seedlings in established crops. In established cocksfoot (orchardgrass, *Dactylis glomerata* L.), various herbicides, particularly diuron and simazine, have been widely used in Oregon (Lee and Whitesides, 1979; Mueller-Warrant and Mellbye, 1991). However, the use of older herbicide products that have no patent protection (e.g. simazine) is being restricted as companies withdraw their registrations for use in minor crops such as forage seed, particularly in the USA (Mueller-Warrant and Mellbye, 1991). There is a need to develop information on other herbicides suitable for use in established cocksfoot seed crops. There is little information on herbicides for seedling cocksfoot stands, particularly for grass weed control. Rolston and Hare (1986) reported large seed yield reductions in first-year crops of cocksfoot, phalaris (*Phalaris aquatica* L.) and browntop (*Agrostis capillaris* L.) when high weed cover occurred.

The primary objective of this research was to examine the tolerance of seedling and established cocksfoot to various herbicides able to control weeds or seedling volunteer cocksfoot. Weed control and the indirect effects of altered competition on cocksfoot seed yield were also studied.

METHODS

General

The experiments were conducted at DSIR Aorangi Research Farm, near Palmerston North (latitude 40°S), on a Holocene siliceous sandy alluvium soil (Kairanga silt loam). Herbicide treatments were applied by knapsack sprayer with a 1.5 m boom width, using 250 to 300 litres per hectare of water and 220 kPa pressure with 73.154 nozzles. Seedling crops were not grazed, while established crops were grazed three times between autumn and closing in late August. Nitrogen fertiliser (urea) was applied to plots in mid September at 60 to 80 kg N ha^{-1}. Weed cover and crop damage were assessed visually. Seedling and fertile tiller density were determined from two row counts of one metre. Seed yield was determined by cutting heads from 1.8 to 2.4 m^2 at 40% seed moisture, air drying the sample in jute sacks, threshing with a belt-thresher, and cleaning the samples. Seed purity and germination for each treatment were determined by the NZ Official Seed Testing Station. Seed yields are expressed as pure live seed at 14% seed moisture content.

Seedling Cocksfoot

Experiment 1

'Grasslands Wana' plots were sown on 3 April 1981 in 60 cm rows at 1.1 kg seed ha^{-1} and sprayed on 15 May 1981, when the cocksfoot had two to three leaves and was

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3 cm tall. The weeds (predominantly *Poa annua* and twin cress *Coronopus didymus*) also had two to three leaves. The herbicides and rates applied are listed in Table 1. In addition to the treatments listed diclofop (diclofop-methyl) was also applied at higher rates of 0.8 and 1.2 kg ha^{-1}. Plots were 7 m^2, with three replications per treatment.

Experiment 2

'Grasslands Wana' plots were sown in 60 cm rows in March 1983 and sprayed on 13 July 1983, when the cocksfoot had four leaves and was 5 cm tall. The weeds included *Poa annua* (3-5 cm tall and tillering) and *Coronopus didymus* (up to 10 cm diameter). The herbicides and rates are listed in Table 2. Plots were 8 m^2, with four replications per treatment.

Established Cocksfoot cv 'Grasslands Kara'

Experiment 3

An 18-month-old crop in 60 cm rows was sprayed on 27 May 1982, with the herbicides listed in Table 3. The cocksfoot was 5-10 cm tall, and had been grazed three days previously. Plots were 7.5 m^2 with four replications per treatment.

Experiment 4

The same field crop as Experiment 3 was used with this trial adjacent to the previous trial. Treatments were sprayed on 12 July 1983 with the herbicides listed in Table 4. The cocksfoot was 15 cm tall with inter-row volunteer seedlings 5 cm tall with one to two tillers. Plots were 10 m^2 with four replications per treatment.

Established Cocksfoot cv 'Grasslands Wana'

Experiment 5

A 15-month-old crop, sown in 60 cm rows, was sprayed on 26 May 1982 with the herbicides listed in Table 5. Plots were 6.0 m^2 with four replications per treatment.

Experiment 6

A 15-month-old crop, sown in 30 cm rows, was sprayed on 13 July 1983 with the herbicides listed in Table 6. The crop was 12 cm tall, with inter-row volunteer seedlings 5 cm tall and tillering. Plots were 9.0 m^2 with four replications per treatment.

Table 1. Effect of herbicides applied to seedling cocksfoot cv. Wana in 1981 (Experiment 1)

Herbicide	Rate (kg ai ha^{-1})	Seedlings 26 June (no. m^{-2})	Crop Damage 26 June (%)	Fertile Tillers 26 December (no. m^{-2})	Seed Yield kg ha^{-1}	Weed Cover 26 June (%)
Control		31	0	50	170	53
ethofumesate	0.5	42	2	195	570	22
	1.0	52	0	360	960	2
	1.5	46	0	445	1310	1
methabenzthiazuron	1.0	40	0	185	490	35
	2.0	40	3	175	460	10
	3.0	33	5	210	490	9
chlorsulfuron	0.015	35	16	65	130	4
	0.030	28	20	35	65	5
	0.040	30	25	15	10	2
diclofop	0.4	0.8	9	2	0	41
asulam	0.75	8	30	60	130	25
	1.50	7	93	5	20	12
	2.25	8	97	1	0	15
terbutryn	0.3	32	10	105	360	17
	0.6	28	10	65	260	35
	0.9	22	16	115	400	27
LSD ($P < 0.05$)		13	23	97	189	26

Experiment 7

A new area within the field used for Experiment 6 was sprayed on 15 June 1984 with the herbicides listed in Table 7. Plots were 9.0 m^2 with four replications per treatment.

RESULTS AND DISCUSSION

Seedling Cocksfoot Tolerance to Herbicides

The herbicides chlorsulfuron, diclofop-methyl and asulam significantly reduced seed yield by reducing fertile tiller numbers at anthesis (Table 1). Diclofop-methyl and asulam markedly reduced seedling density. These three herbicides were therefore dropped from further testing. Good tolerance was shown to the herbicides ethofumesate (up to 2.0 kg ha^{-1}), methabenzthiazuron (up to 3.0 kg ha^{-1}), and a mixture of ethofumesate plus methabenzthiazuron (1.0 + 2.0 kg ha^{-1}, Tables 1 and 2). Satisfactory tolerance to terbutryn was also seen, but it was not included in 1983 because other treatments were better. Treatment for broad leaves with clopyralid plus bromoxynil plus MCPA did not affect cocksfoot seed yield (Table 2).

Table 2. Effect of herbicides applied to seedling cocksfoot cv. Wana in 1983 (Experiment 2).

Herbicide	Rate (kg ai ha^{-1})	Weed cover 6 September (%)	Seed Yield (kg ha^{-1})
Control		100	240
ethofumesate	2.0	47	305
methabenzthiazuron	1.0	92	280
	2.0	75	335
	3.0	62	300
ethofumesate + methabenzthiazuron	1.0 + 2.0	50	515
Lontrel[1]	1.3	90	215
Lontrel + ethofumesate	1.3 + 1.0	80	315
	1.3 + 1.5	72	375
	1.3 + 2.0	55	385
Lontrel + ethofumesate + methabenzthiazuron	1.3 + 1.0 + 2.0	30	450
LSD ($P < 0.05$)		22	111

[1]Broadleaf herbicide (Lontrel) is a mixture of clopyralid + bromoxynil + MCPA 0.09 + 0.30 + 0.90 kg ai ha^{-1}

Established Cocksfoot Tolerance to Herbicides

Both cultivars showed good tolerance to winter applications of all the herbicides in five trials over three years (Tables 3, 4, 5, 6 and 7). In this environment, cocksfoot does not become winter dormant, but makes slow growth during winter with a herbage accumulation rate of 10-15 kg DM per hectare per day. The higher rates of some herbicides used (especially terbicil plus diuron at 1.0 + 4.0 kg ha^{-1}, and metribuzin at 2.8 kg ha^{-1}) caused obvious visual crop injury and reduced the crop vegetative height in early spring (Tables 3, 4 and 5). Despite this injury, no consistent reduction in fertile tiller density or seed yield occurred. Cocksfoot showed excellent tolerance to diuron at 4.0 kg ha^{-1} and terbicil plus diuron at 0.5 + 2.0 kg ha^{-1}. The latter mixture is recommended because of its broad spectrum of weed control activity coupled with acceptable tolerance at twice the recommended rate.

Table 3. Effects of herbicides applied to established cocksfoot cv. Kara in 1982 (Experiment 3).

Herbicide	Rate (kg ai ha^{-1})	Crop Damage 19 August (%)	Crop Height 1 October (cm)	Fertile Tillers 26 November (no. m^{-2})	Seed Yield (kg ha^{-1})
Control		2	32	450	700
diuron	2.0	4	31	355	715
	4.0	9	34	350	755
terbicil + diuron	0.5 + 2.0	20	26	375	735
	1.0 + 4.0	55	16	330	650
simazine	2.0	5	29	415	700
	4.0	14	34	405	650
metribuzin	1.4	19	29	405	755
	2.8	29	20	375	665
LSD ($P < 0.05$)		10	5	61	NS

Table 4. Effects of herbicides applied to established cocksfoot cv. Kara in 1983 (Experiment 4).

Herbicide	Rate (kg ai ha^{-1})	Crop Damage 24 Sept (%)	Inter-row Seedlings 24 Sept (no. m^{-2})	Crop Height 24 Sept (cm)	Fertile Tillers December (no. m^{-2})	Seed Yield (kg ha^{-1})
Control		0	23	24	250	405
diuron	2.0	4	1.2	26	245	505
diuron +	0.5 + 2.0	5	0	30	245	510
terbicil	1.0 + 1.40	31	0	20	235	405
simazine	3.0	0	1.8	30	260	445
atrazine	2.0	1	0.2	31	245	405
	4.0	8	0	23	215	440
metribuzin	2.8	5	0	29	205	430
LSD ($P < 0.05$)		5	6	7	NS	73

Table 5. Effects of herbicides applied to established cocksfoot cv. Wana in 1982 (Experiment 5).

Herbicide	Rate (kg ai ha^{-1})	Crop Damage 18 June (%)	Crop Height 1 October (cm)	Fertile Tillers (no. m^{-2})	Seed Yield (kg ha^{-1})
Control		0	37	910	800
terbicil	0.5	3	34	800	810
	1.0	4	31	880	740
diuron	2.0	0	31	960	780
	4.0	1	31	900	630
terbicil + diuron	0.5 + 2.0	4	33	1010	740
	1.0 + 4.0	11	26	940	780
simazine	2.0	1	31	920	770
	4.0	2	31	1080	850
metribuzin	1.4	14	32	970	940
	2.8	29	28	730	690
LSD ($P < 0.05$)		5	6	132	275

Good tolerance to diclofop in winter and spring was seen in an established crop (Table 7), in contrast to seedling cocksfoot, which was very sensitive to this herbicide (Tables 1 and 2). Good activity of diclofop in controlling ryegrass (*Lolium* species) has been reported (Khodayari, Frans and Collins, 1983), which suggests that diclofop could be used safely to control ryegrass contamination in established cocksfoot.

Table 6. Effects of herbicides applied to established cocksfoot cv. Wana in 1983 (Experiment 6).

Herbicide	Rate (kg ai ha^{-1})	Inter-row Volunteers 23 Sept (no. m^{-2})	Crop Height 23 Sept (cm)	Seed Yield (kg ha^{-1})
Control		42	21	950
diuron	4.0	35	24	1080
terbicil + diuron	0.5 + 2.0	13	22	1060
	1.0 + 4.0	5	20	1352
atrazine	2.0	9	23	1280
	4.0	3	19	1400
simazine	2.0	29	22	1210
	4.0	19	25	1310
LSD ($P < 0.05$)		15		250

Table 7. Effect of herbicides on established cocksfoot cv. Wana in 1984 (Experiment 7).

Herbicide	Rate (kg ai ha^{-1})	Heads (no. m^{-2})	Seed Yield (kg ha^{-1})
Control		615	495
diclofop	1.08	720	730
diclofop (spring)	1.08	600	670
atrazine	2.0	660	590
diclofop + atrazine	1.08 + 1.50	690	790
simazine	2.0	580	585
diuron	4.0	710	805
terbicil + diuron	0.5 + 2.0	805	665
paraquat + atrazine	0.3 + 0.2	730	425
LSD ($P < 0.05$)		141	229

Weed Control

The seedling trial demonstrates the strong competitive effect of weeds on seed yields (Tables 1 and 2). A herbicide mixture of clopyralid plus bromoxynil plus MCPA for broadleaf weed control had no additive effects on weed control and seed yield (Table 2), showing that the main competitive effects were from grass weeds, especially *Poa annua*. Seed yields were increased 7.7- and 2.1-fold, respectively, in Experiment 1 and 2 where weed control was good. Regression analysis of seed yield and weed control data (Rolston and Hare, 1986) showed strong positive linear to curvilinear increases in seed yield when weed cover in seedling stands was lowered by herbicides.

Only two of the established crops had volunteer seedlings after harvest. Experiment 6 had the highest number of inter-row volunteers in any of the tests, and the three treatments that significantly reduced the volunteer seedling density (atrazine at 2.0 and 4.0 kg ha^{-1} and terbicil plus diuron at 1.0 and 4.0 kg ha^{-1}) also significantly increased seed yield by 35-47% (Table 6). While there was no clear response to volunteer seedling control in Experiment 4, the initial density was only half that in Experiment 6.

CONCLUSION

In seedling cocksfoot, control of *Poa annua* by ethofumesate and other treatments gave large yield increases. In established cocksfoot, control of volunteer seedling cocksfoot increased yields in some cases. The tolerance to herbicides and the effectiveness of treatments was shown to be consistent in different years and for two cultivars in established cocksfoot.

ACKNOWLEDGEMENTS

The technical assistance of Jim Henderson is gratefully acknowledged. I also thank Alan Johnson for arranging purity and germination analysis by the Official Seed Testing Station, Ministry of Agriculture and Fisheries, Palmerston North and Michael Hare for help with experiment 7 and the preparation of this paper.

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