HERBICIDE TOLERANCE OF GRASSLANDS PUNA CHICORY

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SUMMARY

Eight field trials from 1989 to 1993 examined the herbicide tolerance of 'Grasslands Puna' chicory (*Cichorium intybus* L.) to a range of broadleaf herbicides. The pre-emergence herbicides trifluralin and ethalfluralin had no injurious effect on seedling establishment. Bentazone, applied to well-established seedlings did not significantly injure them and was very effective in controlling storksbill (*Erodium cicutarium*). Well established chicory plants suffered no long term effects from atrazine, bromoxynil + ioxynil mixture, chlorpropham, diuron, metribuzin and paraquat. Low rates of 2,4-DB (0.8 kg/ha) initially checked chicory growth but plants later recovered. Higher rates of 2,4-DB and any rate of MCPB severely injured chicory plants for several months before plants were able to recover.

Keywords: seedling and mature chicory, broadleaf herbicides, tolerance, weed control

INTRODUCTION

'Grasslands Puna' chicory (*Cichorium intybus* L.) is a forage herb grown for seed in Canterbury. Weed seed contamination has been a problem affecting Puna chicory seed quality. Thistles (*Cirsium* and *Carduus* spp.) represent the most difficult to control weeds in Puna chicory seed crops.

Hare *et al.* (1990) reported that grass weeds can be controlled any time during chicory's growth with carbetamide, haloxyfop, propyzamide and fluazifop-butyl. Asulam controls docks (*Rumex* spp.) when applied in early spring but can check the growth of Puna chicory and cause some slight yellowing. These symptoms soon disappear (Hare *et al.* 1990).

The experiments reported here examined the tolerance of seedling and mature Puna chicory to a wide range of herbicides in a series of experiments from 1989 to 1993.

MATERIALS AND METHODS

Trials 1 to 6 were conducted in the Manawatu at AgResearch Grasslands 'Aorangi' farm on a poorly drained, silty alluvium soil (Kairanga silt loam), Trial 7 was conducted in Canterbury at the AgResearch Lincoln farm on a free-draining, silty alluvium soil (Temuka silt loam) and Trial 8 was conducted in Marlborough on a shallow, very stony yellow-grey soil (Redwick soil). The herbicides in Trials 1 to 6 were applied by a small pressure sprayer at 300 kPa in either 180 litres of water/ha (Trials 1 and 2) or 250 litres of water/ha (Trials 3, 4, 5 and 6). The herbicides in Trial 7 were applied by a knapsack sprayer in 250 litres of water/ha, and in Trial 8 in 500 litres of water/ha both at 150 kPa.

Trial 1 A range of herbicides (Table 1) were applied to a mature stand of Puna chicory on 8 May 1989. At the time of application the chicory was 30 cm in height and producing 3000 kg dry matter(DM)/ha. Treatments were replicated three times and each plot measured 8.6 m x 3 m. Nitrogen (100 kg/ha) was applied in September. Plots

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were visually assessed for chicory injury in early June and early September 1989 and the plots were machine harvested for seed in February 1990.

Trial 2 Eleven treatments (Table 2) were applied to volunteer chicory seedlings, producing 1550 kg DM/ha at the time of application on 6 June 1989. Treatments were replicated three times and each plot measured 2 m x 3 m. Nitrogen (100 kg/ha) was applied in September. Plots were visually assessed for chicory injury in early August and early September. In December 1989 reproductive stems were counted from 2 x 0.25 m² areas in each plot.

Trial 3 Herbicide treatments (Table 3) were applied to spring sown chicory (1989) on 21 March 1990 (MCPA and MCPB only) and on 18 October 1990. Treatments were replicated three times and each plot measured 8 m x 4 m. Each plot was visually assessed for chicory and thistle (*Cirsium arvense*) injury on 27 April 1990 (autumn treatments only) and for chicory survival and growth (visual assessment) on 21 November 1990 (all treatments).

Trial 4 Fourteen treatments (Table 4) were applied on 2 August 1991 to autumn-sown (1991) seedling chicory. There were three replications and each plot measured 4 m x 5 m. Plant height was measured on 16 October and herbage dry matter and plant numbers assessed on 0.25 m² quadrats cut from each plot on 22 October 1991.

Trial 5 Five pre-emergence herbicide treatments and one untreated control (Table 5), were applied to cultivated soil on 11 November 1992, rotary-hoed into the soil and chicory seed sown at 2 kg/ha on 19 November 1992. There were four replications and each plot measured 5 m x 4 m. Chicory plant counts were made on 8 December 1992 and on 11 January 1993, chicory herbage dry weight measured on 6 February 1993 and weed dry weight measured on 11 February 1993.

Trial 6 MCPB (5 rates) and bentazone + MCPB (2 rates) (Table 6) were applied to spring-sown chicory (2 kg/ha on 19 November 1992 after trifluralin was soil incorporated on 11 November 1992), at two stages of chicory seedling growth; two-three leaf stage (8 December 1992) and four to six leaf stage (21 December 1992). Flumetsulam (two rates) was also applied at the second chicory growth stage (Table 6). On 15 January 1993 chicory plants per m² were counted and the percent weed area cover visually estimated. On 5 February 1993, a 0.25 m² quadrat was cut in each plot for chicory dry weight determination and percent weed area cover was visually estimated.

Trial 7 Bentazone (2 rates) and bentazone + 2,4D-B (Table 7) were applied to a well established chicory seed crop (sown on 20 October 1987 in 15 cm rows at 8 kg/ha) on 25 September 1990. The treatments were replicated three times and plots measured 2.5 x 10 m. Citowett (0.025%) was mixed with the herbicides. Symptoms of herbicide injury to chicory were scored 47 days after treatment (DAT) and 134 DAT using a 1-5 rating scale, with 5 being severe damage. In February 1990 the plots were harvested for seed, number of reproductive stems counted and seed yield measured (14% moisture).

Trial 8 Bentazone, with and without surfactant (Table 8) was applied on 11 April 1991 to a late-February 1991 sown pasture comprised of perennial ryegrass, tall fescue, white clover and Puna chicory. At the time of application the chicory plants were between 5 and 15 cm in leaf diameter and storksbill (*Erodium cicutarium*) was at the 10 leaf growth stage. Treatments were replicated four times and plots measured 2.5 m x 10 m. Storksbill plants were counted at 34 and 133 DAT and percent pasture ground area cover was assessed at 133 DAT.

RESULTS AND DISCUSSION

Pre-emergence herbicides, trifluralin at 0.8 or 1.6 kg/ha and ethalfluralin at 1.44 kg/ha soil incorporated prior to sowing Puna chicory, were effective in reducing the amount of weeds 3 months after application and did not affect chicory plant establishment (Table 5). EPTC has also proven to be effective in reducing weeds and not harmful to chicory seedling establishment (Hare and Rolston, unpub. data).

TABLE 1: Effect of herbicides applied in May 1989 to mature Puna chicory (Trial 1).

Herbicide	Rate (kg ai/ha)	Chicory % injury (visual estimate)		Seed yield (kg/ha) (14% moisture Feb 1990)
		June 1989	Sept 1989	
No herbicide	0	0	0	552
Glyphosate	2.16	73	100	229
2,4-DB	2.4	3	47	554
2,4-D	2.16	53	100	255
Clopyralid	0.2	68	100	257
Chlorimuron	0.03	37	77	618
Bromoxynil + ioxynil	0.2+0.2	10	0	606
Glufosinate-ammonium	1.2	90	63	512
Bentazone	1.44	8	0	504
Dicamba	0.4	53	97	472
Picloram + 2,4-D	0.1+0.4	37	80	538
LSD 5%		12	16	127

TABLE 2: Effects of herbicides applied in June 1989 to Puna chicory seedlings (Trial 2).

Herbicide	Rate (kg ai/ha)	Chicory % injury (visual estimate)		Reproductive stems/m ² (no.) (Dec. 1989)
		Aug. 1989	Sept. 1989	
No herbicide	0	0	0	45
2,4-DB	2.4	55	92	57
2,4-D	1.04	95	100	0
Bentazone	1.44	5	0	57
Bentazone + 2,4-DB	1.44+2.4	55	58	56
MCPB	2.31	60	67	51
Dicamba	0.4	93	98	20
Chlorimuron	0.03	70	95	60
Paraquat	0.6	80	75	50
Atrazine	1.5	2	0	53
Metribuzin	0.49	0	7	55
LSD (P<0.05)		9.5	16.4	21

Bentazone at rates of up to 1.5 kg/ha had no effect on chicory plant height (Table 4), chicory plant numbers (Table 4), chicory dry matter (Table 4), chicory seed yield (Tables 1 and 7) and did not injure the chicory plants (Tables 1, 2 and 8). Storks-bill was completely killed by bentazone but there was no advantage in using a surfactant on storks-bill (Table 8). From experience by the authors, Puna chicory plants must be at least 10-15 cm in diameter before bentazone can be applied. Chicory plants smaller than this have been completely destroyed by bentazone. However, for bentazone to be effective against weeds, the weeds must be seedlings that have not developed extensive root systems.

Adding 2,4-DB to bentazone can severely injure chicory plants (Tables 2 and 7), but Puna chicory can recover from the injury symptoms and produce reproductive stems (Tables 2 and 7) and seed yields (Table 7) no different to untreated control plots. 2,4-DB severely distorts chicory plants (Tables 1, 2, 3 and 4) but they can recover and produce good seed yields (Tables 1 and 2).

TABLE 3: Effect of herbicides applied in the autumn and spring to chicory and weeds (Trial 3).

Herbicide	Rate (kg ai/ha)	Autumn % injury ¹		Spring survival score ²	
		Thistles	Chicory	Chicory	Weeds
Autumn herbicides					
No herbicide	0	0	0	100	7
MCPA (autumn applied)	1.5	99	99	3	100 ³
MCPB (autumn applied)	1.54	96	58	90	17
Spring herbicides					
MCPB	1.54	-	-	30	13
2,4-DB	1.6	-	-	23	10
Diuron	1.92	-	-	82	8
Bromoxynil + ioxynil	0.3+0.3	-	-	90	8
LSD (P<0.05)		3.3	10	13.6	6.3

¹ visual estimate

² 0 no survival; 100 total cover

³ thistles died, but weeds regrew on bare ground in the spring

TABLE 4: Effect of herbicides applied on 2 August 1991 to seedling chicory (autumn sown, Trial 4).

Herbicide	Rate (kg ai/ha)	October 1991		
		Plant height (cm)	Plant No. (m ²)	Dry matter (kg/ha)
No herbicide	0	41	331	449
Chlorpropham	2.4	41	304	448
2,4-DB	1.6	20	369	176
MCPB	1.6	23	289	190
MCPB + bentazone	0.8+0.96	43	263	564
MCPB + bromoxynil + ioxynil	0.8+0.4+0.4	40	328	540
MCPB + bromoxynil + ioxynil	1.6+0.4+0.4	39	252	464
Bromoxynil + ioxynil	0.4+0.4	40	297	499
Bentazone	1.5	40	337	530
Paraquat	0.3	39	184	449
Paraquat + atrazine	0.3+1.0	39	252	431
Paraquat + terbacil	0.3+1.0	34	286	415
Paraquat + metribuzin	0.3+0.5	39	182	423
Propyzamide	1.2	40	357	530
LSD (P<0.05)		7	125	148

TABLE 5: Effect of pre-emergence herbicides applied in November 1992 on chicory seedling growth and weed growth (Trial 5).

Herbicide	Rate (kg ai/ha)	Chicory plant No./m ²		Chicory dry weight (g/m ²) Feb. 1993	Weed dry weight (g/m ²) Feb. 1993
		Dec. 1992	Jan. 1993		
No herbicide	0	47	70	183	113
Trifluralin	0.8	42	58	223	35
Trifluralin	1.6	42	51	161	40
Ethalfuralin	0.36	42	53	206	65
Ethalfuralin	0.72	42	71	172	58
Ethalfuralin	1.44	50	67	173	20
LSD (P<0.05)		ns	ns	ns	70

TABLE 6: Effect of MCPB, bentazone and flumetsulam on seedling chicory and weed growth (Trial 6).

Herbicide	Rate (kg ai/ha)	Chicory		Weed % area cover (visual estimate)	
		Plant/m ² (15 Jan)	Dry matter g/m ² (6 Feb)	(15 Jan)	(5 Feb)
No herbicide		37	243	40	42
2-3 leaf stage					
MCPB	0.8	33	328	15	23
MCPB	1.2	25	186	13	17
MCPB	1.6	33	225	8	13
MCPB	2.4	23	125	7	15
MCPB	3.2	17	80	7	7
MCPB + Bentazone	0.8+1.44	0	0	0	10
MCPB + Bentazone	1.6+2.88	0	0	0	5
4-6 leaf stage					
MCPB	0.8	40	290	22	25
MCPB	1.2	39	287	22	33
MCPB	1.6	31	169	12	15
MCPB	2.4	25	173	20	28
MCPB	3.2	21	51	12	18
MCPB + Bentazone	0.8+1.44	4	21	3	7
MCPB + Bentazone	1.6+2.88	0	0	0	5
Flumetsulam	0.04	31	169	22	17
Flumetsulam	0.08	33	257	12	22
LSD (P<0.05)		11	116	17	20

TABLE 7: Effect of bentazone and 2,4-DB on Puna chicory (Trial 7).

Herbicide	Rate (kg/ha)	Chicory injury 1-5 scale		Reprod. stem no./m ²	Seed yield (kg/ha)
		47DAT	134DAT		
No herbicide		1.0	1.0	48	500
Bentazone	0.72	2.3	1.0	58	753
Bentazone	1.44	3.0	1.0	49	588
Bentazone + 2,4-DB	0.72 + 0.80	5.0	3.0	47	626
LSD (P<0.05)		0.6	0.7	ns	ns

TABLE 8: Effect of bentazone and surfactants on storksbill plants and pasture percent ground cover (Trial 8).

Herbicide + surfactant	Rate (kg ai/ha)	Storksbill plants/m ²		Pasture % ground cover 133DAT
		34DAT	133DAT	
No herbicide		258	14.5	36
Bentazone	0.96	9	0.4	73
Bentazone + Citowett	0.96+0.025%	12	0	76
Bentazone + Citowett	1.44+0.025%	13	0	78
Bentazone + Citowett	0.96+0.51/ha	10	0	75
Bentazone + D-C-Tron	0.96+0.5%	18	0	73
Bentazone + D-C-Trate	0.96+0.5%	9	0	70
LSD (P<0.05)		23.7	1.7	9

Adding MCPB with bentazone can severely reduce chicory plant numbers (Table 6). Despite severe chicory injury, Puna chicory can recover from MCPB (Tables 2, 3, 4 and 6) but rates above 1.2 kg/ha would not be recommended. Furthermore, the time of year when thistles are a problem in seed crops (October to November) is the time when MCPB can severely check chicory growth (Table 3).

Bromoxynil + ioxynil (Tables 1, 3 and 4) can be applied to well grown chicory plants without severely injuring them. Atrazine will not retard well grown chicory plants (Table 2) but in combination with paraquat injury can occur, though the chicory plants do recover (Table 4). Metribuzin, diuron, chlorpropham had only slight effects on chicory and can be used with safety on well established chicory plants to control weeds (Tables 2, 3 and 4 respectively).

Despite, in some instances, recovery by chicory on heavy loam soils, the following herbicides at the rates tested would not be recommended for weed control in chicory seed crops: glyphosate, 2,4-D, clopyralid, chlorimuron, glufosinate-ammonium, dicamba, picloram+2,4-D and MCPA.

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APPENDIX 1: Trade names of chemicals used.

Alkylaryl polyglycol ether - Citowett; atrazine - Gesaprim 500 FW; bentazone - Basagran; bromoxynil + ioxynil - Combine; chlorimuron - Classic; chlorpropham - Chloro-IPC; clopyralid - Versatill; dicamba - Banvel 200; diuron - Karmex; ethalfluralin - soralan; glufosinate-ammonium - Buster; glyphosate - Roundup; intermediate spraying oil - D-C-Tron; MCPA - DowElanco MCPA; MCPB - DowElanco MCPB; metribuzin - Sencor DF; paraquat - Gramoxone; petroleum/polyglycol/sorbitan - D-C-Trate; picloram + 2,4-D - Tordon 50-D; propyzamide - Kerb Flo; terbacil - Sinbar; trifluralin - Treflan; 2,4-D - DowElanco; 2,4-DB - 2,4DB.