

## EFFICACY OF HERBICIDES ON SERRATED TUSSOCK IN POT TRIALS

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**Abstract** In seven pot trials 12 herbicides were evaluated for their efficacy against serrated tussock (*Nassella trichotoma*). On larger plants (basal diameters of 2–5 cm and maximum leaf lengths of 28–70 cm), complete kill was given by clethodim at 60 g, haloxyfop at 104 g, imazapyr at 188 g and glyphosate at 450 g ha<sup>-1</sup>. Butroxydim at 125 g, and quizalofop-P ethyl at 96 g ha<sup>-1</sup> gave very high levels of control, while fluazifop-P plus butroxydim at 212 g + 100 g and propaquizafop at 150 g ha<sup>-1</sup> gave somewhat lesser control. Fluazifop-P at 336 g and sethoxydim at 841 g ha<sup>-1</sup> gave insufficient control.

Seedling plants with basal diameters of 0.7–1.2 cm, 28–>50 leaves and longest leaves of 13–30 cm, were killed by clethodim at 36 g and imazapyr at 25 g ha<sup>-1</sup>, while severe damage or death was produced by haloxyfop at 52 g, propaquizafop at 100 g, butroxydim at 62.5 g, quizalofop-P ethyl at 36 g ha<sup>-1</sup> and 2,2-DPA at 3 kg<sup>-1</sup>. Slightly less damage was caused by fluazifop-P at 212 g and imazapic at 48 g ha<sup>-1</sup>. Glyphosate at 225 g ha<sup>-1</sup> caused moderate damage.

### INTRODUCTION

Serrated tussock (*Nassella trichotoma* (Nees) Hack. ex Arechav.) is a tussock-forming perennial grass, which is a serious weed of grazing areas on the tablelands of NSW and in southern Victoria. It has been estimated that 32 m ha in south eastern Australia is at risk of invasion (McLaren *et al.* 1998).

For about the last 20 years, flupropanate has been the most effective herbicide for the control of serrated tussock. It replaced 2,2-DPA, which was less effective and more costly. With the withdrawal of flupropanate from the marketplace in 1998 alternative herbicide treatments are required.

Glyphosate gave good control in a Victorian, trial (Miller 1995) but was less effective in NSW (Campbell 1979). Campbell and Vere (1995) found that quizalofop at 0.2 kg ha<sup>-1</sup>, fluazifop at 0.4 kg ha<sup>-1</sup>, clethodim at 0.5 kg ha<sup>-1</sup>, sethoxydim at 0.6 kg ha<sup>-1</sup>, imazapyr at 0.4 kg ha<sup>-1</sup> and rimsulfuron at 0.06 kg ha<sup>-1</sup> were not as effective as flupropanate. In a pot trial glyphosate, imazapyr,

imazamox, imazapic and propaquizafop showed significant activity (Melland and McLaren 1998).

This paper reports the results of seven pot trials that evaluated 12 herbicides on serrated tussock.

### MATERIALS AND METHODS

Serrated tussock was grown from seed collected from St. Albans on Melbourne's north-western perimeter. Plants were grown singly, first in a glasshouse and then in a shadehouse (under green shade cloth), in 12 cm or 15 cm pots. The steam-sterilised potting mix consisting of 3 parts composted tan bark to 2 parts washed sand. A slow-release, complete fertilizer was added. At application the potting soil was moist. The plants were sized into five replicates according to basal diameter. Spray application was made with a mechanical track sprayer in a spray cabinet. The moving boom had 2 flat fan SS 110015 spray tips spaced 50 cm apart and set at least 30 cm above the tops of the plants. Spray pressure was 260 kPa. After spraying, the plants were placed in randomised blocks in a glasshouse maintained at 20–25°C or in a shadehouse. There was no watering for 24 hours after application. Additional details of each trial are given in Table 1.

### RESULTS

**Trial 1** Clethodim at 90 g ha<sup>-1</sup> killed all plants (Table 2). Haloxyfop killed all plants at 208 g ha<sup>-1</sup> but none at 104 g ha<sup>-1</sup>. Quizalofop-P ethyl at 96.4 g ha<sup>-1</sup> killed or severely damaged plants, but was less effective at lower rates. Clodinafop (plus cloquintocet) at 150 g ha<sup>-1</sup> was ineffective.

**Trial 2** At application, flower heads were beginning to emerge. The most effective treatments were imazapyr at 188 g and 250 g ha<sup>-1</sup> and butroxydim at 125 g and 250 g ha<sup>-1</sup> (Table 3). Fluazifop-P plus butroxydim (as Fusion<sup>®</sup>) was no more effective than butroxydim on its own. Propaquizafop showed moderate activity at 150 g ha<sup>-1</sup>, but fluazifop-P at 636 g ha<sup>-1</sup>, and sethoxydim at 841 g ha<sup>-1</sup> gave insufficient control.

**Table 1.** Details of trials.

Trial No.	Pot Size (cm)	Spray vol (L ha <sup>-1</sup> )	Basal diam. (cm)	Longest leaf (cm)	Growth stage	Age at applic (weeks)
1	15	100	2.5-4.0	30-45	veget.	36
2	15	100	2.5-4.5	36-56	early flow	42
3	15	100	2.5-4.5	40-70	veget.	17
4	15	100	2.7-3.5	23-67	veget.	19
5	15	100	1.8-3.0	28-70	veget.	19
6	12	80	0.4-1.5	18-30	seedling	14
7	12	80	1.3-2.8	16-31	seedling	12

**Table 2.** Effect of herbicides on serrated tussock 14 weeks after application in Trial 1.

Herbicide	Rate (g ha <sup>-1</sup> )	Damage Score (0-10) <sup>A</sup>	Killed (%) <sup>B</sup>
Clethodim <sup>C</sup>	60	10	100
Clethodim <sup>C</sup>	90	10	100
Quizalofop-P <sup>D</sup>	24.1	5.6	0
Quizalofop-P <sup>D</sup>	48.2	7.6	40
Quizalofop-P <sup>D</sup>	96.4	9.3	40
Haloxifop <sup>E</sup>	104	3.8	0
Haloxifop <sup>E</sup>	208	10	100
Clodinafop <sup>C</sup>	75	1.0	0
Clodinafop <sup>C</sup>	150	1.6	0
Untreated	-	0	0
LSD (P=0.05)		1.7	

<sup>A</sup> 0 = No effect, 10 = dead. Mean of 5 plants.

<sup>B</sup> Percentage of plants killed.

<sup>C</sup> D-C-Trate included at 2% v/v.

<sup>D</sup> D-C-Trate included at 1% and BS 1000 at 0.1% v/v.

<sup>E</sup> D-C-Trate included at 1% v/v.

**Trial 3** The efficacy of glyphosate (as Roundup CT<sup>®</sup>) at 338 g ha<sup>-1</sup> was marginally improved by the adjuvants Dow Corning 212 at 0.125% and 0.25% v/v and by Wetter TX at 0.2% v/v (Table 4). Pulse and Sylgard 309 decreased the effectiveness of glyphosate. With glyphosate at 450 g ha<sup>-1</sup> all adjuvants except Codacide at 1.5% v/v and Dow Corning 212 at 0.125% decreased the effectiveness of glyphosate.

**Trial 4** This trial further evaluated adjuvants with glyphosate (as Roundup CT) applied at 338 g ha<sup>-1</sup>. Meteor, D-C-Trate, Ethokem and Predict increased the efficacy of glyphosate. Freeway, Activator and Liase decreased glyphosate efficacy (Table 5).

**Table 3.** Effect of herbicides on serrated tussock 19 weeks after treatment in Trial 2.

Herbicide	Rate (g ha <sup>-1</sup> )	Damage Score (0-10) <sup>A</sup>	Killed (%) <sup>B</sup>
Imazapyr <sup>C</sup>	125	9.1	40
Imazapyr <sup>C</sup>	188	9.8	80
Imazapyr <sup>C</sup>	250	10	100
Propaquizafop <sup>D</sup>	100	5.8	0
Propaquizafop <sup>D</sup>	150	8.0	40
Butroxydim <sup>E</sup>	62.5	7.2	20
Butroxydim <sup>E</sup>	125	9.9	80
Butroxydim <sup>E</sup>	250	9.9	80
Fluazifop-P	132		
+ butroxydim <sup>E</sup>	+ 62.5	6.6	0
Fluazifop-P	212		
+ butroxydim <sup>E</sup>	+ 100	8.1	20
Fluazifop-P <sup>E</sup>	424	5.5	0
Fluazifop-P <sup>E</sup>	636	6.3	0
Sethoxydim <sup>C</sup>	560	5.2	0
Sethoxydim <sup>C</sup>	841	4.2	0
Untreated	-	3.6	0
LSD (P=0.05)		2.0	

<sup>A</sup> 0 = No effect, 10 = dead. Mean of 5 plants.

<sup>B</sup> Percentage of plants killed.

<sup>C</sup> Hasten included at 1% v/v

<sup>E</sup> D-C-Trate included at 2% v/v.

<sup>D</sup> BS 1000 included at 0.2% v/v.

**Trial 5** This trial evaluated adjuvants with clethodim. Without adjuvant clethodim gave inadequate control at all rates tested. The vegetable oil adjuvants, Hasten and Kwicken, and the petroleum oil adjuvants, Uptake and D-C-Trate, enhanced the efficacy of clethodim (Table 6). The organosilicone Pulse and the non-ionic surfactant BS 1000 had no effect.

**Table 4.** Effect of adjuvants on the efficacy of glyphosate (as Roundup CT) on serrated tussock in Trial 3. Assessed 14 weeks after application.

Adjuvant	Conc. (% v/v)	Damage Score (0-10) <sup>A</sup>	
		Glyphosate (g ha <sup>-1</sup> ) 338	450
No adjuvant	-	8.6	10
Pulse	0.2	6.0	8.4
Pulse	0.35	6.4	8.6
Pulse	0.5	6.0	7.2
Sylgard 309	0.125	4.6	8.8
Sylgard 309	0.25	6.2	8.6
Sylgard 309	0.5	4.8	8.0
Dow Corning 212	0.125	9.0	9.8
Dow Corning 212	0.25	9.7	7.2
Dow Corning 212	0.5	8.5	8.7
Wetter TX	0.2	9.3	8.4
Wetter TX	0.4	8.8	8.8
Codacide	1.5	-	10
Untreated	-	1.1	0
LSD (P=0.05)		2.5	

<sup>A</sup> 0 = No effect, 10 = dead. Mean of 5 plants.**Table 5.** Effect of adjuvants on the efficacy of glyphosate (as Roundup CT) applied at 338 g ha<sup>-1</sup> in Trial 4. Assessed 15 weeks after application.

Adjuvant	Conc. (% v/v)	Damage Score (0-10) <sup>A</sup>	Killed (%) <sup>B</sup>
No adjuvant	-	5.8	0
Meteor	1.0	10	100
D-C-Trate	2.0	9.8	60
Ethokem	0.5	9.7	60
Ethokem	1.0	9.6	60
Predict	0.25	7.4	0
Predict	0.5	9.4	60
Sprayfast	0.25	6.0	20
Sprayfast	0.5	7.7	20
Liase	2.0	7.7	20
BS 1000	0.2	6.9	20
BS 1000	0.4	7.0	20
Agral 600	0.3	6.1	0
Agral 600	0.6	7.0	20
LI-700	0.25	3.2	0
LI-700	0.5	6.6	0
Activator	0.125	4.7	0
Activator	0.25	4.4	0
Freeway	0.2	2.2	0
Untreated	-	0.5	0
LSD (P=0.05)		2.7	

<sup>A</sup> 0 = No effect, 10 = dead. Mean of 5 plants.<sup>B</sup> Percentage of plants killed.**Table 6.** Effect of adjuvants on the efficacy of clethodim on serrated tussock in Trial 5. Assessed 22 weeks after application.

Clethodim (g ha <sup>-1</sup> )	Adjuvant	Conc. (% v/v)	Damage Score (0-10) <sup>A</sup>	Killed (%) <sup>B</sup>
24	No adjuvant	-	1.9	0
36	No adjuvant	-	3.0	0
48	No adjuvant	-	4.3	20
60	No adjuvant	-	2.8	0
24	D-C-Trate	2.0	5.2	0
36	D-C-Trate	2.0	4.6	0
48	D-C-Trate	2.0	8.0	40
60	D-C-Trate	2.0	7.2	0
36	Uptake	1.0	6.4	20
36	Hasten	1.0	6.6	20
36	Kwickin	1.0	6.0	0
36	BS 1000	0.2	3.4	0
36	Pulse	0.2	2.0	0
Untreated	-	-	1.1	0
LSD (P=0.05)			1.6	

<sup>A</sup> 0 = No effect, 10 = dead. Mean of 5 plants.<sup>B</sup> Percentage of plants killed.

**Trial 6** On large seedlings imazapyr at 25 g ha<sup>-1</sup> and clethodim at 36 g ha<sup>-1</sup> (the lowest rate tested in each case) gave complete control (Table 7). Quizalofop-P at 36.2 g, propaquizafop at 100 g, haloxyfop at 52 g, butoxydim at 62.5 g, fluzifop-P at 212 g and imazapic at 48 g ha<sup>-1</sup> also showed good activity.

**Trial 7** This trial assessed eight adjuvants with 2,2-DPA on seedling plants. Without adjuvant, 2,2-DPA gave almost complete control at 3 kg ha<sup>-1</sup> (Table 8). Comparable results were obtained with 2.2 kg ha<sup>-1</sup> when BS 1000 at 0.2% v/v (but not higher concentrations) or Pulse at 0.5% v/v was added. Significant enhancement was also given by Hasten, Meteor, Ethokem, Codacide and Predict.

**Table 7.** Effect of herbicides on seedling serrated tussock 19 weeks after application in Trial 6.

Herbicide	Rate (g ha <sup>-1</sup> )	Damage Score (0-10) <sup>A</sup>	Killed (%) <sup>B</sup>
Imazapyr <sup>C</sup>	25	10	100
Imazapyr <sup>C</sup>	43.8	10	100
Clethodim <sup>C</sup>	36	10	100
Clethodim <sup>C</sup>	48	9.9	80
Clethodim <sup>C</sup>	60	9.9	80
Propaquizafop <sup>D</sup>	25	3.6	0
Propaquizafop <sup>D</sup>	50	8.7	0
Propaquizafop <sup>D</sup>	100	9.5	40
Haloxypop <sup>E</sup>	26	1.6	0
Haloxypop <sup>E</sup>	52	9.6	20
Quizalofop-P <sup>F</sup>	14.5	6.4	0
Quizalofop-P <sup>F</sup>	24.1	8.4	0
Quizalofop-P <sup>F</sup>	36.2	9.3	0
Butroxydim <sup>G</sup>	31.3	8.7	20
Butroxydim <sup>G</sup>	62.5	9.5	40
Fluazifop-P <sup>G</sup>	106	3.8	0
Fluazifop-P <sup>G</sup>	212	8.4	0
Imazapic <sup>C</sup>	24	3.4	0
Imazapic <sup>C</sup>	48	8.2	80
Glyphosate	225	6.0	40
Untreated	-	0	0
LSD (P=0.05)		2.6	

<sup>A</sup> 0 = No effect, 10 = dead. Mean of 5 plants.

<sup>B</sup> Percentage of plants killed.

Adjuvants: <sup>C</sup> Hasten 1% v/v; <sup>D</sup> BS 1000 0.2% v/v; <sup>E</sup> D-C-Trate 1% v/v; <sup>F</sup> BS 1000 0.1% v/v + D-C-Trate 1% v/v; <sup>G</sup> D-C-Trate 2% v/v.

## DISCUSSION

The herbicides with the most activity on serrated tussock were clethodim, imazapyr, butroxydim and glyphosate. Clethodim gave a complete kill of larger plants at 60 g ha<sup>-1</sup> in Trial 1 (Table 2), although in Trial 5 (Table 6) this rate was not as effective. This latter trial showed the need to include an adjuvant with clethodim and indicated that Hasten at 1% v/v, Uptake at 1% v/v and Kwickin at 1% v/v were equal to or better than D-C-Trate at 2% v/v. On seedling plants in Trial 6 (Table 7) clethodim (with Hasten at 1% v/v) gave a 100% kill at 36 g ha<sup>-1</sup>.

**Table 8.** Effect of adjuvants on the efficacy of 2,2-DPA on serrated tussock seedlings in Trial 7. Assessed 16 weeks after application.

2,2-DPA (kg ha <sup>-1</sup> )	Adjuvant	Conc. (% v/v)	Damage Score (0-10) <sup>A</sup>	Killed (%) <sup>B</sup>
2.2	No adjuvant	-	4.5	0
3.0	No adjuvant	-	9.7	40
3.7	No adjuvant	-	9.7	40
2.2	BS 1000	0.2	9.0	60
2.2	BS 1000	0.5	6.0	0
2.2	BS 1000	1.0	8.1	20
2.2	Meteor	1.0	8.4	20
2.2	Ethokem	0.5	8.1	0
2.2	LI-700	0.5	6.8	20
2.2	Codacide	1.5	8.1	40
2.2	Hasten	1.0	8.5	0
2.2	Pulse	0.5	9.5	60
2.2	Predict	0.5	8.0	0
Untreated	-	-	0	0
LSD (P=0.05)			2.7	

<sup>A</sup> 0 = No effect, 10 = dead. Mean of 5 plants.

<sup>B</sup> Percentage of plants killed.

On larger plants in Trial 2 imazapyr gave a complete kill at 250 g ha<sup>-1</sup> and was almost as effective at 188 g and 125 g ha<sup>-1</sup> (Table 3). On seedlings in Trial 6 it gave a 100% kill at 25 g ha<sup>-1</sup> (Table 7).

Butroxydim was very effective on larger plants at 125 g ha<sup>-1</sup> (Table 3) and on seedlings at 62.5 g ha<sup>-1</sup> (Table 7). A mixture with fluazifop-P did not increase the control of larger plants (Table 3).

Other herbicides to show good activity on seedlings were haloxypop, propaquizafop, quizalofop-P and 2,2-DPA (Tables 7 and 8). The efficacy of 2,2-DPA on seedlings was enhanced by adjuvants. This herbicide has never had a specific label recommendation for seedlings, although in early New Zealand trials, depending on timing, rates down to 1 kg ha<sup>-1</sup> gave control (Leonard 1962). However, in NSW 4.4 and 8.8 kg ha<sup>-1</sup> gave only moderate control (Campbell 1987). It potentially offers a selective treatment for seedlings in sown pasture. On mature plants the recommended rate of 28 kg ha<sup>-1</sup> is too costly, although in the past lower rates in conjunction with burning were effective.

Glyphosate at 450 g ha<sup>-1</sup> killed all plants in Trial 3 (Table 4) as did 338 g ha<sup>-1</sup> when the adjuvant 'Meteor' was included in the spray (Table 5). Several adjuvants decreased the efficacy of glyphosate on serrated

tussock (Tables 4 and 5). Most seedlings survived 225 g ha<sup>-1</sup> (Table 7) and other results not presented also indicated that seedlings are not particularly sensitive to lower rates of glyphosate.

Glyphosate is the herbicide that could most immediately be used for the control of mature tussock. However its lack of selectivity will restrict the situations in which it can be used. Wiper application, if effective, could overcome this difficulty on more level terrain. Herbicides such as clethodim, butoxydim, and imazapyr may not be effective on mature tussock at rates that are economic or sufficiently safe to sown pasture species. However the results from these pot trials indicate that they have the potential to control seedling serrated tussock at rates which could have a minimal impact on pasture species.

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