ECHIUM PLANTAGINEUM L. CONTROL IN PASTURES

J.W. Heap[A], D. Hogarth[A] and F.D. Burgoyne[B]
[A] Primary Industries SA, Box 618, Naracoorte, South Australia 5271, Australia
[B] Robe-Beachport Animal and Plant Control Board, Box 1, Robe, South Australia 5276, Australia

Summary *Echium plantagineum* L. (salvation Jane, Paterson's curse) is a major weed of pastures in southern Australia. Annually-repeated herbicide treatments often fail to control it. A range of herbicide treatments were evaluated in field experiments in South Australia to find a cheap, effective control. Terbutryn, terbutryn/MCPA, flumetsulam and diflufenican/MCPA have excellent potential for control of *E. plantagineum* in legume-based pastures. Early applications (2-leaf stage of *E. plantagineum*) of terbutryn and terbutryn/MCPA were effective and cheap, and minimized the period of interference with pasture species. Applied at the 2-leaf stage, terbutryn at 150 g a.i. ha^{-1} gave 87–98% control and terbutryn/MCPA at 83/48–138/80 g a.i. ha^{-1} gave 90–98% control. Applied at the small rosette stage (<5 cm diameter), terbutryn at 250 g a.i. ha^{-1} gave 87–100% control and terbutryn/MCPA at 138/80 g a.i. ha^{-1} gave 98–99% control. Preliminary results suggest that these rates are selective in some *Trifolium* and *Medicago* spp., but further research is needed to confirm this. Flumetsulam at 20 g a.i. ha^{-1} gave 59–87% control and diflufenican/MCPA at 19/188 g a.i. ha^{-1} gave 77–99% control at the small rosette stage. Other herbicide treatments which had useful activity were diflufenican/bromoxynil, imazethapyr, diflufenican, pyridate, bromoxynil, bromoxynil/MCPA, diuron+MCPA amine, Clovamax®, simazine+paraquat, metsulfuron methyl and metsulfuron methyl+MCPA amine. An experimental management strategy involving monitoring of seedling emergence and application of terbutryn-based herbicides is outlined.

INTRODUCTION

Echium plantagineum L. (salvation Jane, Paterson's curse) is an introduced annual weed of southern Australian pastures which emerges quickly after summer or autumn rainfall and competes vigorously with desirable species, especially where grazing pressure is low (Piggin and Sheppard 1995). It grows on a wide range of soils and is a declared noxious weed in many regions (Parsons and Cuthbertson 1992). Graziers control it in pastures to increase legumes and grasses and because it contains poisonous pyrrolizidine alkaloids, although it provides valuable early forage in areas with low rainfall. There is also a legislative obligation to control it in some areas.

In the south-east of South Australia spread of *E. plantagineum* has generated considerable community anxiety. Control in pastures is difficult and many graziers report poor results from spray-grazing techniques because high stocking rates cannot be attained in large paddocks. Control is further hampered by the longevity of buried seeds and establishment of plants during summer and early autumn following rain. There are no effective and affordable herbicide treatments which are selective in legume-based pastures.

This research was undertaken to evaluate a range of herbicides to identify treatments with potential for use on large infestations and which are inexpensive and selective in pasture legumes. It also aimed to identify herbicides with potential for treating small outbreaks where cost is less important. Terbutryn and terbutryn/MCPA were selected for further development following the efficacy found by Milne (1993) at high rates on large *E. plantagineum* rosettes in NSW.

MATERIALS AND METHODS

Six replicated small-plot field experiments were established in 1993 to 1995 near Naracoorte and Greenways in South Australia. Three experiments near Naracoorte were on deep sands (pH 6.2–6.7; mean average rainfall 525 mm) and three near Greenways were on a clay-loam soil (pH 7.9; mean average rainfall 675 mm). The experiments were established in degraded volunteer pastures dominated by *E. plantagineum* and the plots were open to grazing by animals within the paddocks. The treatments are listed in Tables 1 and 2 and were applied to 2 × 10 m plots arranged in three randomized blocks. Herbicides were applied at 147 L ha^{-1} through Hardi 4110-10 nozzles mounted on a 2 m wheel-mounted boom driven at 200 kPa by a 12 v pump. *E. plantagineum* control and *Medicago* spp. tolerance (Greenways site 1994) was estimated visually as per cent biomass reduction. *E. plantagineum* control and *Trifolium subterraneum* L. (subterranean clover) tolerance at Naracoorte in 1994 was estimated using rod-point pasture composition measurements (Little and Frensham 1993). Treatments were applied at Naracoorte and Greenways in 1993 on 28 June and 21 July, respectively. In 1994 early treatments were applied at the 1.5–2 true leaf stage of *E. plantagineum* at Naracoorte and Greenways on 6 June and rosette stage (3–5 cm diameter) treatments were applied on 27 June.

RESULTS

The 1993 and 1994 experiments demonstrated that a range of herbicides have commercially-acceptable activity (>95% control) on *E. plantagineum*. The efficacy of treatments at Naracoorte in 1993 was reduced by a moderate frost on the day of application. Bromoxynil, diflufenican, terbutryn, pyridate and simazine + paraquat appeared to be particularly susceptible to the effects of frost (Table 1). The 1995 experiments evaluated a broader range of terbutryn rates and timings, along with some of the more effective treatments from 1993 and 1994 (Table 2).

Early applications of terbutryn controlled small *E. plantagineum* plants (2-leaf stage) at low rates. Terbutryn at 150 g a.i. ha^{-1} gave 87–98% control in 1994 (Table 1). In 1995, 9 WAT, 75 g a.i. ha^{-1} gave 74–97% control, 150 g a.i. ha^{-1} gave 96–98% control and 250 g a.i. ha^{-1} gave 99% control. Later applications of terbutryn at the rosette stage were not as effective as earlier timings for the same rate (Table 2).

Terbutryn/MCPA also controlled small *E. plantagineum* plants at low rates, giving 93–96% control at 83/48 g a.i. ha^{-1} and 90–98% control at 138/80 g a.i. ha^{-1}. When applied as two equal split treatments at 275/160 g a.i. ha^{-1} (total) it gave 100% control. Applications at the rosette stage gave 72–91% control at 83/48 g a.i. ha^{-1}, 98–99% control at 138/80 g a.i. ha^{-1} and 99% control at 275/160 g a.i. ha^{-1} (Tables 1 and 2). Pasture legume tolerance was acceptable for terbutryn at 150 g a.i. ha^{-1} and for terbutryn/MCPA at 138/80 g a.i. ha^{-1} applied early, but there were moderate to severe growth reductions at higher rates (Table 1).

Flumetsulam gave 59–87% control at 20 g a.i. ha^{-1} (Tables 1 and 2) and was most effective against small plants (<5 cm diameter), with regrowth occurring in many larger rosettes. The addition of 250 g a.i. ha^{-1} MCPA amine increased control at Naracoorte but not Greenways. Pasture legume tolerance was acceptable for flumetsulam-based treatments (Table 1).

Diflufenican/MCPA at 19/188 g a.i. ha^{-1} gave 77–99% control and, with terbutryn treatments, was one of the most effective and reliable treatments over the 6 experiments. Pasture legume tolerance was acceptable for this treatment.

MCPA amine at 500 g ha^{-1} gave 23–98% control and was not reliable in the absence of high grazing pressure. 2,4-D amine at 400 g a.i. ha^{-1} gave 37–99% control and 2,4-DB at 1600 g a.i. ha^{-1} gave 13–69% control. Of this group 2,4-DB was least damaging to pasture legumes, with MCPA amine and 2,4-D amine causing severe damage at some sites (Tables 1 and 2).

There were a range of treatments which gave useful control of *E. plantagineum* in 1993 and 1994 but, because of cost, availability or unacceptable damage to pasture legumes, many were not included in the 1995 experiments. These included diflufenican/bromoxynil, imazethapyr, diflufenican, pyridate, bromoxynil, bromoxynil/MCPA, diuron+MCPA amine, Clovamax®, simazine+paraquat, metsulfuron methyl and metsulfuron methyl+MCPA amine (Tables 1 and 2).

DISCUSSION

These experiments have demonstrated that there is potential to control *E. plantagineum* soon after the autumn/winter break to the season with low rates of terbutryn or terbutryn/MCPA. The advantages of controlling *E. plantagineum* at the 2-leaf stage are lower herbicide rates, and hence costs, and shorter duration of *E. plantagineum* interference with pasture species. Plots were not significantly reinfested by later-emerging cohorts and bare ground was mostly covered by pasture species. Large plants, which established before spraying as the result of summer rains, were not controlled by low rates of herbicides. Most seedlings are observed to emerge in February to April, with many later-emerging seedlings succumbing to moisture stress. Up to 50% of seedlings can establish before the autumn break to the season and large plants contribute most to the soil seed bank (Piggin and Sheppard 1995). There is a clear need to control these plants if they establish in significant densities during summer and early autumn.

Casual and formal assessments during these experiments suggest that clover (*Trifolium* spp.) and medics (*Medicago* spp.) at the 1–2 trifoliate leaf stage have acceptable tolerance to low rates of terbutryn (75–150 g a.i. ha^{-1}) and terbutryn/MCPA (83/48-138/80 g a.i. ha^{-1}). The herbicide costs of these treatments are approximately \$A2.50–\$A5.50 ha^{-1}. The tolerance of pasture legumes to terbutryn and terbutryn/MCPA needs to be further evaluated and this has begun in other experiments. Preliminary results from this research suggest that subterranean clover is tolerant of terbutryn at 150 g a.i. ha^{-1} and terbutryn/MCPA at 138/80 g a.i. ha^{-1} at the 1-trifoliate leaf stage, but other clovers were damaged at this timing. At the time of writing Igran® (500 g L^{-1} terbutryn) is registered in pastures for control of *Arctotheca calendula* (L.) Levyns (capeweed) in some states at 225-425 g a.i. ha^{-1}, but Agtryne MA® (275/160 g L^{-1} terbutryn/MCPA) is not registered for pastures. There is a 7 day grazing withholding period set for both MCPA and terbutryn, so there should be no technical MRL barrier to registration of Agtryne MA® for pastures.

Terbutryn and terbutryn/MCPA have potential for inexpensive control of *E. plantagineum* in large infestations, but pasture legume tolerance has not been adequately established. Flumetsulam and diflufenican/

MCPA are more expensive options (approximately herbicide costs of $A13 and $A12 ha^{-1}, respectively) which are known to be selective in clover. These treatments gave good control of *E. plantagineum* and may be suitable for treating small outbreaks in clover pastures.

Annual application of herbicides by graziers often does not reduce the density of *E. plantagineum*, even after many years. Many are discouraged by this and are disinclined to continue control efforts. In order to reduce *E. plantagineum* there must be a sustained restriction of seed production so that the soil seed bank is reduced over a period of at least 3–5 years. The following suggestion for a population management strategy draws on the results from these experiments and previously published biology and control literature. The strategy will be field tested near Naracoorte from 1996–1999.

Table 1. *E. plantagineum* control and pasture legume growth at Naracoorte (NC) and Greenways (GW) in 1993 and 1994.

Treatment	Rate (g a.i. ha^{-1})	*E. plantagineum* control (% biomass reduction)				Pasture legume growth (% of untreated)	
		1993		1994		1994	1994
		NC[A] 5 WAT[C]	GW[A] 12 WAT	NC[B] 11 WAT	GW[A] 13 WAT	NC[B] 11 WAT	GW[A] 13 WAT
Cotyledon to 2-leaf stage of *E. plantagineum*							
terbutryn	150	–	–	87	98 (84)	153	100
terbutryn/MCPA	138/80	–	–	90	98 (84)	100	83
terbutryn/MCPA split[D]	275/160	–	–	100	100 (90)	45	77
Small rosette stage of *E. plantagineum*							
terbutryn	250	–	–	97	100 (90)	59	57
terbutryn	300	5	97 (81)	–	–	–	–
terbutryn	375	–	–	100	100 (90)	33	47
terbutryn+MCPA amine	250+250	–	–	100	100 (90)	57	33
terbutryn/MCPA	275/160	–	–	99	99 (88)	68	57
flumetsulam	20	60	73 (60)	83	80 (68)	109	93
flumetsulam+MCPA amine	20+250	–	–	100	80 (66)	99	87
diflufenican/MCPA	19/188	77	77 (62)	99	99 (88)	96	80
diflufenican/bromoxynil	19/188	10	88 (70)	85	50 (86)	63	47
imazethapyr	72	62	60 (51)	83	25 (29)	134	93
diflufenican	200	37	88 (71)	85	99 (88)	60	80
pyridate	900	12	92 (77)	82	99 (87)	97	90
bromoxynil	300	13	75 (61)	88	95 (80)	64	46
bromoxynil/MCPA	300/300	37	92 (74)	96	99 (88)	64	60
diuron+MCPA amine	150+375	37	23 (23)	93	99 (45)	86	73
Clovamax® (experimental)	–	85	98 (86)	100	90 (88)	76	73
simazine+paraquat	500+25	10	78 (62)	42	55 (49)	67	70
metsulfuron	3	–	–	100	90 (75)	0	0
metsulfuron	6	92	93 (75)	–	– –	–	
metsulfuron+MCPA amine	3+250	88	45 (41)	–	–	–	–
MCPA amine	500	23	40 (39)	98	50 (47)	101	37
2,4-D amine	400	40	37 (36)	99	40 (39)	83	8
2,4-DB amine	1600	13	47 (43)	69	25 (29)	73	77
untreated	0	0	0 (0)	0	0 (0)	100	100
LSD (P=0.05)		18	(20)	16	(18)	47	31

[A] Visual estimate. Figures in parentheses are transformed data ((180/p) × arcsin(ö(x/100))). LSD values in parentheses apply only to data in parentheses. 1993 GW data based on % reduction in flowers.

[B] Measured using rod-point technique. [C] WAT = weeks after treatment.

[D] 138/80 g a.i. ha^{-1} applied twice to same plots (early and at small rosette stage of *E. plantagineum*).

Table 2. *E. plantagineum* control and pasture legume growth at Naracoorte (NC) and Greenways (GW) in 1995.

Treatment	Rate (g a.i. ha^{-1})	*E. plantagineum* control[A] (% biomass reduction) 5 WAT[B] NC	5 WAT[B] GW	9 WAT[B] NC	9 WAT[B] GW
		Cotyledon to 2-leaf stage of *E. plantagineum*			
terbutryn	75	90 (73)	83 (66)	97 (80)	74
terbutryn	150	98 (84)	99 (84)	96 (80)	98
terbutryn	250	100 (88)	100 (88)	99 (85)	99
terbutryn/MCPA	83/48	86 (70)	96 (79)	93 (75)	96
terbutryn/MCPA	138/80	98 (84)	98 (84)	99 (84)	98
		Small rosette stage of *E. plantagineum*			
terbutryn	150	–	–	63 (53)	85
terbutryn	250	–	–	87 (69)	97
terbutryn/MCPA	83/48	–	–	91 (74)	72
terbutryn/MCPA	138/80	–	–	98 (82)	96
flumetsulam	20	–	–	97 (80)	55
diflufenican/MCPA	19/188	–	–	99 (84)	98
diuron + MCPA amine	150 + 375	–	–	95 (77)	91
MCPA amine	500	–	–	68 (57)	67
untreated	–	–	–	0 (0)	0
LSD (P=0.05)				(9)	16

[A] Visual estimate. Figures in parentheses are transformed data ($(180/\pi) \times \arcsin(\sqrt{(x/100)})$). LSD values in parentheses apply only to data in parentheses.
[B] WAT = Weeks after treatment.

Experimental management strategy

1. Learn to recognise *E. plantagineum* at the cotyledon stage.
2. Monitor rainfall during summer. If more than 8–10 mm falls over several days then check for seedling plants 2 weeks later. If seedlings are present wait for them to grow to the 3 to 4 leaf stage and apply terbutryn at 150 g a.i. ha^{-1} or terbutryn/MCPA at 138/80 g a.i. ha^{-1}. In many cases populations may perish before this stage if there is no follow-up rain.
3. Ensure that there are adequate pasture legume seed reserves present. Resow if necessary.
4. After the break to the season monitor for seedling plants and apply terbutryn at 150 g a.i. ha^{-1} or terbutryn/MCPA at 138/80 g a.i. ha^{-1} at the 2-true leaf stage.
5. Ensure pasture has adequate fertilizer and mite/insect control. A vigorous pasture will reduce the establishment of later-germinating *E. plantagineum* seedlings.
6. If large numbers of *E. plantagineum* survive or escape the 2-true leaf stage treatment consider a later herbicide treatment to restrict seedset.
7. Repeat from step 1 annually.

ACKNOWLEDGMENTS

The authors acknowledge the support of Primary Industries SA, South East Animal and Plant Control Boards, Mr. Greg Mitchell (SARDI) and the co-operating graziers for assistance with this research.

REFERENCES

Little, D.L. and Frensham, A.B. (1993). A rod-point technique for estimating botanical composition of pastures. *Australian Journal of Experimental Agriculture* 33, 871-5.

Milne, B.R. (1993). Paterson's curse (*Echium plantagineum*) control in pasture. *In* 'Results Book', Weed Research and Demonstration Unit, Orange, Australia. NSW Agriculture, pp. 88-91.

Parsons, W.T. and Cuthbertson, E.G. (1992). 'Noxious weeds of Australia'. pp. 325-30. (Inkata Press, Melbourne, Australia).

Piggin, C.M. and Sheppard, A.W. (1995). *Echium plantagineum* L. *In* 'The Biology of Australian Weeds', eds. R.H. Groves, R.C.H. Shepherd and R.G. Richardson, Volume 1, pp. 87-110. (R.G. and F.J. Richardson, Melbourne, Australia).