SAFETY OF TRICLOPYR TRIETHYLAMINE TO NATIVE WETLAND SPECIES

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ABSTRACT

Current management options for wetland weed control are limited. The triethylamine (TEA) salt formulation of the herbicide triclopyr effectively controls several broadleaf aquatic and wetland weed species and is relatively selective to many wetland species. To evaluate the tolerance of vegetation associated with weed species, a range of indigenous wetland species, including the widespread *Dacrycarpus dacrydioides*, *Apodasmia similis*, *Carex virgata*, *Eleocharis acuta*, *Isachne globosa*, *Juncus pallidus*, *Triglochin striata*, *Phormium tenax* and *Mazus radicans*, and the nationally endangered *Carex cirrhosa*, *Amphibromus fluitans*, *Crassula helmsii* and *Selliera rotundifolia*, were sourced from wild-collected or cultivated material and then grown on. Triclopyr TEA was applied to wetting at rates between 0.25% and 5%. *Dacrycarpus dacrydioides*, *I. globosa* and *A. fluitans* appeared to have recovered fully from early damage from the 0.5% rate by the conclusion of the trial. *Apodasmia similis*, *C. virgata*, *C. cirrhosa*, *E. acuta* and *J. pallidus* were damaged but not completely killed at this rate, whereas the remaining five species were killed at all herbicide rates applied.

Keywords: aquatic herbicide, Garlon® 360, herbicide tolerance, endangered plants.

INTRODUCTION

Methods of wetland weed control are, at present, limited to mechanical control and use of non-specific herbicides such as glyphosate and diquat. These often disturb existing vegetation and cause off-target damage that may lead to further weed invasion. The triethylamine (TEA) salt formulation of the herbicide triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid, Garlon® 360, 404.5 g ai/litre) was registered in 2007 for aquatic plant control in New Zealand. It is reported to be relatively selective in its mode of action with little damage to grasses, sedges, rushes and aquatic monocotyledonous species (e.g. Anon. 2004). Champion et al. (2008) evaluated triclopyr TEA for the control of a range of wetland weeds, with good control of various broadleaf species including willows (*Salix* spp.), alder (*Alnus glutinosa*) and several herbaceous species. This paper reports the tolerance of a range of indigenous wetland plants that grow in association with those weed species.

MATERIALS AND METHODS

The indigenous species tested for tolerance to triclopyr TEA (3,5,6-trichloro-2-pyridinyloxyacetic acid, Garlon® 360, 404.5 g ai/litre) are listed in Table 1.

TABLE 1: Native plants used in the trial, their conservation status (after de Lange et al. 2004) and associated weeds.

Species	Common name	Endangered status	Predominant associated weed species
<i>Dacrycarpus dacrydioides</i>	kahikatea	Not endangered	willows
<i>Apodasmia similis</i>	oioi	Not endangered	grey willow, purple loosestrife
<i>Carex virgata</i>	pukio, swamp sedge	Not endangered	all spp.
<i>Carex cirrhosa</i>		Gradual decline	willows
<i>Eleocharis acuta</i>	spike sedge	Not endangered	all spp.
<i>Isachne globosa</i>	swamp millet	Not endangered	willows
<i>Amphibromus fluitans</i>		Nationally endangered	All spp.
<i>Juncus pallidus</i>		Not endangered	alder, willows
<i>Triglochin striata</i>		Not endangered	purple loosestrife
<i>Phormium tenax</i>	harakeke, NZ flax	Not endangered	alder, willows, purple loosestrife
<i>Mazus radicans</i>		Not endangered	purple loosestrife (other endangered <i>Mazus</i> spp.)
<i>Crassula helmsii</i>		Sparse	water celery, monkey musk
<i>Selliera rotundifolia</i>		Gradual decline	purple loosestrife

Plants of kahikatea, oioi, pukio, *Juncus pallidus*, harakeke and *Mazus radicans* were sourced from Annton Nursery, Cambridge. Spike sedge and swamp millet were collected from the vicinity of Hamilton City and the remaining species were grown at the NIWA plant collection, Ruakura, Hamilton. Plant material was grown in potting mix (Daltons Premium Mix) in the AgResearch glasshouse suite at Ruakura, for at least 2 months prior to herbicide application. At that stage the kahikatea, harakeke, oioi, spike sedge and swamp sedge and purple loosestrife were between 0.5 and 1 m tall. The remaining herbaceous species were treated once they formed dense mats over their pots. Triclopyr TEA was applied to plants outside the glasshouse on 13 October 2006, 2 November 2006, 21 December or 13 February 2007, depending on the growth stage and/or successful establishment of each species. Herbicide was applied to run off as 0.25, 0.5, 1.25, 2.5 or 5.0% v/v solutions, each with a non-ionic surfactant Citowett® at 0.025%, using a knapsack sprayer. Five replicate pots were used for each treatment, with 5 untreated pots for a control. A second herbicide application at rates from 0.25 to 5% v/v was made to untreated *Triglochin striata* and *Crassula helmsii* plants on 21 December 2007. Plants were returned to the glasshouse after their foliage was dry.

Plants were monitored regularly after herbicide application. Monitoring involved visual assessment of the health of each plant compared to control plants, estimating percentage damage from 0 to 100%. Except where there was little variation in the results, e.g. all 100%, data were subjected to ANOVA to separate treatment means and the LSD was calculated.

RESULTS AND DISCUSSION

Tables 2-8 show the rates of triclopyr TEA applied to each species tested and the resultant percentage damage. The broadleaf species *M. radicans*, *C. helmsii* and *S. rotundifolia* and the monocotyledons harakeke and *T. striata* were all killed (100% damage) at all rates by the conclusion of the trial. Other monocotyledonous species in the Poaceae, Cyperaceae and Juncaceae and also the gymnosperm kahikatea were still alive, at least at the lowest rates. The two grasses *I. globosa* and *A. fluitans* completely recovered in all treatments apart from the 5% rate, while kahikatea appeared to fully recover from the 0.5% rate.

TABLE 2: Percent damage to *Carex virgata* and *Amphibromus fluitans* after treatment with triclopyr (rate (% v/v) in parentheses) on 13.10.06.

Treatment	<i>Carex virgata</i>			<i>Amphibromus fluitans</i>			
	20.10.06	1.12.06	13.2.07	20.10.06	13.2.07	6.3.07	10.4.07
Untreated	0	0	0	0	0	0	0
Triclopyr (0.5)	0	23	41	0	0	0	0
Triclopyr (1.25)	10	59	97	29	10	5	0
Triclopyr (2.5)	38	100	100	41	10	10	0
Triclopyr (5)	40	100	100	57	54	28	20
LSD(P<0.05)	12.7	23.8	5.9	11.0	6.2	5.5	-

TABLE 3: Percent damage to *Mazus radicans* after treatment with triclopyr (rate (% v/v) in parentheses) on 13.10.06.

Treatment	16.10.06	20.10.06	1.12.06	9.1.07
Untreated	0	0	0	0
Triclopyr (0.5)	20	15	92	99
Triclopyr (1.25)	26	21	100	100
Triclopyr (2.5)	36	30	100	100
Triclopyr (5)	48	52	100	100
LSD(P<0.05)	9.4	10.6	-	-

TABLE 4: Percent damage to *Triglochin striatum* after treatment with triclopyr (rate (% v/v) in parentheses) on 13.10.06 or 21.12.06.

Treatment	16.10.06	20.10.06	1.12.06	9.1.07 ¹	13.2.07 ¹
Untreated	0	0	0	0	0
Triclopyr (0.25)	-	-	-	82	100
Triclopyr (0.5)	0	5	100	90	100
Triclopyr (1.25)	15	7	100	93	100
Triclopyr (2.5)	20	16	100	94	100
Triclopyr (5)	40	50	100	-	-
LSD(P<0.05)	3.2	6.5	-	4.6	-

¹Second experiment.

TABLE 5: Percent damage to *Crassula helmsii* after treatment with triclopyr (rate (% v/v) in parentheses) on 13.10.06 or 21.12.06.

Treatment	16.10.06	20.10.06	1.12.06	9.1.07 ¹	13.2.07 ¹
Untreated	0	0	0	0	0
Triclopyr (0.25)	-	-	-	88	100
Triclopyr (0.5)	20	44	100	96	100
Triclopyr (1.25)	38	73	100	98	100
Triclopyr (2.5)	90	100	100	100	100
Triclopyr (5)	89	99	100	-	-
LSD(P<0.05)	13.4	14.7	-	4.9	-

¹Second experiment.**TABLE 6: Percent damage to *Dacrycarpus dacrydoides* and *Phormium tenax* after treatment with triclopyr (rate (% v/v) in parentheses) on 2.11.06.**

Treatment	<i>Dacrycarpus dacrydoides</i>				<i>Phormium tenax</i>		
	6.11.06	9.1.07	6.3.07	10.4.07	6.11.06	1.12.06	9.1.07
Untreated	0	0	0	0	0	0	0
Triclopyr (0.5)	50	60	20	0	30	74	100
Triclopyr (1.25)	58	74	30	24	30	98	100
Triclopyr (2.5)	64	76	28	32	40	97	100
Triclopyr (5)	82	90	100	100	50	99	100
LSD(P<0.05)	13.8	5.9	6.8	5.4	9.4	14.7	-

TABLE 7: Percent damage to *Selliera rotundifolia* and *Juncus pallidus* after treatment with triclopyr (rate (% v/v) in parentheses) on 21.12.06.

Treatment	<i>Selliera rotundifolia</i>		<i>Juncus pallidus</i>		
	9.1.07	13.2.07	9.1.07	6.3.07	10.4.07
Untreated	0	0	0	0	0
Triclopyr (0.25)	99	100	32	66	52
Triclopyr (0.5)	100	100	30	64	52
Triclopyr (1.25)	100	100	50	75	78
Triclopyr (2.5)	100	100	70	93	98
LSD(P<0.05)	-	-	9.3	6.5	7.1

TABLE 8: Percent damage to *Eleocharis acuta* and *Isachne globosa* after treatment with triclopyr (rate (% v/v) in parentheses) on 21.12.06.

Treatment	<i>Eleocharis acuta</i>			<i>Isachne globosa</i>		
	9.1.07	6.3.07	10.4.07	9.1.07	13.2.07	6.3.07
Untreated	0	0	0	0	0	0
Triclopyr (0.25)	46	46	50	28	0	0
Triclopyr (0.5)	44	78	76	22	5	0
Triclopyr (1.25)	82	96	100	36	5	0
Triclopyr (2.5)	98	100	100	32	10	0
LSD(P<0.05)	7.8	7.4	5.7	4.3	-	-

TABLE 9: Percent damage to *Apodasmia similis* and *Carex cirrhosa* after treatment with triclopyr (rate (% v/v) in parentheses) on 13.2.07.

Treatment	<i>Apodasmia similis</i>		<i>Carex cirrhosa</i>	
	6.3.07	10.4.07	6.3.07	10.4.07
Untreated	0	0	0	0
Triclopyr (0.25)	6	8	20	30
Triclopyr (0.5)	24	42	20	30
Triclopyr (1.25)	50	68	25	30
Triclopyr (2.5)	72	100	30	52
LSD(P<0.05)	6.4	8.4	5.6	-

Members of the Cyperaceae, Juncaceae, Restionaceae and Poaceae are usually the dominant vegetation in herbaceous wetlands. These results show the relative tolerance of many of these indigenous monocotyledonous wetland species and also the swamp forest tree kahikatea (*D. dacrydioides*).

Hofstra et al. (2006) reported no damage to ditchbank grasses, the aquatic grass *Glyceria declinata* and pondweed *Potamogeton cheesemanii*, by triclopyr TEA application to control *Myriophyllum aquaticum* (parrot’s feather). At Kaituna Wildlife Management Reserve, *P. cheesemanii* and the charophyte alga *Nitella* aff. *cristata* colonised the open areas left by *M. aquaticum* control using this herbicide (P.D. Champion, unpubl. data). Anon. (2004) list the following plants as tolerant to triclopyr TEA at the rates recommended for use in water: rushes (genera *Juncus* and *Scirpus*), *Typha* spp., *Potamogeton* spp., *Ceratophyllum demersum*, *Elodea canadensis* and *Paspalum* spp. Gabor et al. (1995) noted that grass density (stem number) was not affected by 3.8, 7.6 and 10.9 kg ai/ha rates, but sedge (*Carex* spp.) density initially declined at the highest treatment rate. However, sedge density recovered to pre-trial densities 1 year after herbicide application. These results were similar to the findings of the present trial. Assuming a water rate of 400 litres/ha, the herbicide application rates used in this trial varied between 8.1 kg ai/ha (5% v/v) and 0.4 kg ai/ha (0.25% v/v). Grasses were unaffected, but sedges and rushes were killed at the highest rate, with damage noted even at rates lower than those used by Gabor et al. (1995).

The butoxyethyl ester formulation of triclopyr is also widely used for managing problem terrestrial weeds, such as wandering Jew (*Tradescantia fluminensis*) and climbing asparagus (*Asparagus scandens*), in sensitive environments (Timmins & Reid 2000; Standish 2002). When used under mature trees, including kahikatea, little

damage was observed from this form of triclopyr, although some saplings were killed and seedling regrowth was impaired.

The concentrations applied to species in these pot trials are likely to be much higher than those received in a field situation, either because these plants would be present in the understory beneath a canopy of treated *Alnus* or *Salix* spp. and not receive the full dose of herbicide, or if the target weeds are spot sprayed – the spraying of non-target plants can be avoided. Where susceptible species are present, the application of triclopyr TEA by more selective means (e.g. cut stump, drill and inject or wick wiper) or covering susceptible plants with impermeable material during herbicide application would prevent their damage.

Further evaluation of impacts on non-target species in the field is currently underway in the South Taupo Wetland, Cockayne Reserve in Christchurch and sites adjacent to the Waikato River. Preliminary evaluations showed limited off-target damage (P.D. Champion, unpubl. data).

Triclopyr TEA is therefore far more selective than existing herbicides and this selectivity would make it a beneficial tool for the management of dicotyledonous weeds in natural wetlands. Its use would also permit control of susceptible weeds near flowing waterways while maintaining a cover of grasses and other species beneficial to bank stability. Conversely, using triclopyr TEA to control willows in the presence of invasive grasses such as *Glyceria maxima* and *Phalaris arundinacea*, which are likely to be tolerant of triclopyr TEA, could facilitate the invasion of treated areas by these grasses.

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Conservation for funding this project and also Ian Popay for assistance with trial design.

REFERENCES

- Anon. 2004. Environmental impact statement (EIS) for permitted use of triclopyr. Washington State, Dept of Ecology Publication, Water Quality Program Publication No. 04-10-018. 115 pp.
- Champion PD, James TK, Carney, E. 2008. Evaluation of triclopyr triethylamine for the control of wetland weeds. *New Zealand Plant Protection* 61: 374-377.
- de Lange PJ, Norton, DA, Heenan PB, Courtney SP, Molloy BJP, Ogle CC, Rance BD, Johnson PN, Hitchmough R 2004. Threatened and uncommon plants of New Zealand. *New Zealand Journal of Botany* 42: 45-76.
- Gabor TS, Haagsma HR, Murkin H.R, Armson E 1995. Effects of triclopyr amine on purple loosestrife and non-target plants in south-eastern Ontario, Canada. *Journal of Aquatic Plant Management* 33: 48-50.
- Hofstra DE, Champion PD, Dugdale AM 2006. Herbicide trials for the control of parrot's feather. *Journal of Aquatic Plant Management* 44: 13-18.
- Standish RJ 2002. Experimenting with methods to control *Tradescantia fluminensis*, an invasive weed of native forest remnants in New Zealand. *New Zealand Journal of Ecology* 26: 161-170.
- Timmins SM, Reid W 2000. Climbing asparagus, *Asparagus scandens* Thunb.: a South African in your forest patch. *Australian Ecology* 25: 533-538.