Recent herbicide resistance research in New Zealand

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Summary The number of published herbicide resistance cases in New Zealand is still quite minimal compared with Australia. However two new cases have been reported within the last year. The troublesome annual turf weed *Soliva sessilis* Ruíz Lopez & Pavón has developed biotypes in northern New Zealand resistant to picloram, clopyralid and triclopyr. This is the first case in New Zealand where resistance has developed to picolinic herbicides or within a turf situation. A glasshouse experiment has shown that commonly used turf herbicides such as clopyralid, picloram/triclopyr mixtures or picloram/2,4-D mixtures do not control this weed. However, bromofenoxim, bentazone and mecoprop/ioxynil/bromoxynil mixtures are still effective.

Biotypes of *Solanum nigrum* L. resistant to triazine herbicides have also been located in New Zealand. The population studied from Manawatu was resistant to cyanazine, atrazine, terbuthylazine and prometryn. Triazine-resistant *S. nigrum* has been frequently reported from Europe, and this resistance is suspected of being widespread within New Zealand.
Keywords Herbicide resistance, *Soliva sessilis*, *Solanum nigrum*, picolinic herbicides, triazines.

INTRODUCTION

Although Australia has numerous problems with herbicide resistance, New Zealand is fortunate still to have only a few cases. Up till 2001, only two weed species (*Chenopodium album* L. and *Polygonum persicaria* L.) had been reported as developing resistance to triazines, three species to phenoxy herbicides, one species to sulfonylurea herbicides and one to dalapon (Rahman *et al.* 2001). Of these cases, most can be controlled using alternative herbicides, but selective control of phenoxy-resistant *Carduus nutans* L. and *Carduus pycnocephalus* L. in pastures is very difficult without causing significant clover damage (Harrington 1989).

In 1999, poor control of *Soliva sessilis* was reported from the Helensville Golf Course, north of Auckland. Patches of this weed were unaffected each year when treated with a picloram/2,4-D mixture. The plants that were surviving had slightly different shaped leaves to the nearby susceptible plants, and the poorly controlled biotype was spreading throughout the course.

In the same year, reports were received of *Solanum nigrum* plants causing problems in arable crops grown in Manawatu, a region north of Wellington. Normally cyanazine would control this weed successfully in pea and sweet-corn crops grown for a local processing company, but poor control was being obtained at a farm near Rongotea.

This paper reports the work done to confirm whether herbicide-resistant biotypes had developed at both of these sites.

MATERIALS AND METHODS

***Soliva sessilis* trial** On 23 March 2000, seeds of the Helensville *S. sessilis* population were sown into 700 mL pots containing a peat-based potting mix, which were subsequently kept in a heated glasshouse at Massey University with automated overhead irrigation. A week later, more pots were planted with *S. sessilis* seedlings taken from a lawn at Massey University which were at the same growth stage as the Helensville plants. Most pots had 10–20 plants. The plants were occasionally trimmed and left over winter to become well established.

Eight herbicide treatments (Table 1) were applied to plants using a precision pot sprayer on 19 October 2000 in 286 L ha^{-1} of water, apart from the bentazone and bromofenoxim treatments which were applied in 572 L ha^{-1} of water. The temperature during spraying was 21°C, and the average temperature over the 7 days after spraying was 22°C (range 13–36°C). Damage was scored over subsequent weeks and an analysis of variance was used to compare treatment means.

***Solanum nigrum* trial** The susceptibility of the Rongotea black nightshade population to a wide range of herbicides was compared with that of a *S. nigrum* population from a cropping paddock several kilometres away at Kairanga where no herbicide resistance had been noticed in the past. Seedlings from within commercial pea crops (planted in mid-October) at both sites were transplanted on 20 November 2000 into planter bags (900 mL) in an unheated shade-house at Massey University. The soil from the original paddocks was used in the planter bags, which was a Kairanga sandy silt loam for both populations. The seedlings were allowed to recover from transplant shock before being sprayed on 6 December 2000 at the 4–6 leaf stage. The treatments (Table 2) were applied by precision pot sprayer at 316 L ha^{-1}. Damage to plants was scored at regular intervals, then all plants were harvested after 10 weeks and weighed.

RESULTS

Significant differences in susceptibility were detected between the Helensville and Massey University *S. sessilis* populations to both rates of the 2,4-D/picloram mixture tested (Table 1). There were also significant differences in their susceptibility to clopyralid, triclopyr and a triclopyr/picloram mixture.

However, similar levels of control for both populations were obtained when sprayed with bentazone, bromofenoxim or a mixture of mecoprop, ioxynil and bromoxynil.

Table 1. Scores (0 = healthy, 10 = dead) of *S. sessilis* plants from Helensville (R) and Massey University (S) two and six weeks after treatment (WAT) with herbicides.

	Score (2 WAT)		Score (6 WAT)	
Treatment	R	S	R	S
Clopyralid (0.3)	1.4	7.6	2.0	9.8
Triclopyr (1.2)	5.6	5.2	3.4	8.0
Triclopyr (0.6) + picloram (0.2)	4.0	8.4	3.0	10.0
2,4-D (0.39) + picloram (0.1)	2.6	8.0	3.0	10.0
2,4-D (0.78) + picloram (0.2)	5.0	8.4	6.0	10.0
Bentazone (1.4)	7.4	9.2	8.8	9.8
Bromofenoxim (1.0)	8.8	9.8	9.6	10.0
Mecoprop (1.2) + ioxynil (0.26) + bromoxynil (0.26)	8.8	9.4	9.6	10.0
Untreated	1.6	2.0	2.2	2.8
$LSD_{0.05}$	1.01		1.02	

Table 2. The effect of herbicide treatments on *S. nigrum* plants from Rongotea (R) and Kairanga (S) as determined by scores (0 = healthy, 10 = dead) and fresh weights of shoots 10 weeks after treatment.

Active ingredient	Score (2 WAT)		Score (6 WAT)		Fresh weight per pot (g)	
	R	S	R	S	R	S
Cyanazine (1.5)	0.8	9.6	0.0	10.0	10.91	0.00
Atrazine (1.5)	0.6	9.0	0.0	10.0	12.71	0.00
Terbuthylazine (1.0)	3.2	8.6	2.8	8.8	8.71	1.36
Prometryn (0.75)	4.6	9.0	2.0	9.6	7.38	0.75
Terbutryn (0.35)	0.6	4.8	0.0	2.6	10.68	7.79
Methabenzthiazuron (1.4)	9.0	8.6	8.6	6.4	1.39	3.91
Pendimethalin (2.0)	4.6	2.8	7.6	7.0	3.49	23.54
Mentazone (0.96)	9.0	7.6	6.0	5.0	3.77	4.01
MCPB (1.4)	7.4	5.4	8.4	4.0	1.71	4.68
Dicamba (0.3)	9.8	9.4	8.6	7.8	0.95	0.89
Untreated	0.4	0.0	0.0	0.0	11.25	12.60
$LSD_{0.05}$	2.7		3.2		4.81	

The Kairanga *S. nigrum* population was significantly more affected by the cyanazine, atrazine, terbuthylazine and prometryn applied than were the plants from Rongotea (Table 2). Differences were significant for terbutryn at two weeks after treatment (WAT) but not when assessed after six weeks due to poor control of the Kairanga plants.

For herbicides that were not triazines, generally there was little difference between the two populations in their susceptibility. However, there was some evidence of the triazine-resistant Rongotea plants being more susceptible than the Kairanga plants to some herbicides such as MCPB, bentazone and methabenzthiazuron. This difference was statistically significant for MCPB with the 6-week scoring.

DISCUSSION

Soliva sessilis Failure of picloram, clopyralid and triclopyr to control *S. sessilis* at Helensville suggests this biotype has developed resistance to picolinic herbicides. Triclopyr is not very effective on this species, and this was seen in its incomplete kill of the Massey University plants (Table 1). However, picloram and clopyralid normally have excellent activity against *S. sessilis*. Note that the greater damage of the Helensville plants by the higher rate of the 2,4-D and picloram mixture suggests there was no cross-resistance to 2,4-D. Although this herbicide is also usually weak on *S. sessilis*, the 0.78 kg ha^{-1} applied at the higher rate was probably sufficient to cause the damage observed in these pots.

The development of resistance to picolinic herbicides has not been reported very frequently in the past, but other cases include *Sinapis arvensis* L. (wild mustard) in Canada (Webb and Hall 1995), and *Centaurea solstitialis* L. (yellow starthistle) in USA (Fuerst *et al.* 1996), both to picloram. It is the first case of a weed biotype developing resistance to picolinic herbicides in New Zealand, and also the first case of herbicide resistance in turf weeds for this country.

Soliva sessilis is a troublesome turf weed in New Zealand, where it is known as Onehunga weed, and also in parts of Australia, where it is called jo-jo, bindyi or lawn burweed (Harrington 2000a). The common strategy in New Zealand for controlling this weed commercially is to apply clopyralid, or mixtures of picloram and triclopyr or picloram and 2,4-D. The biotype found at Helensville appears to be resistant to all of these options, reducing the usefulness of these herbicides for turf weed control.

Although other herbicides such as bromofenoxim and bentazone are still effective against the resistant biotype, these contact herbicides need to be applied to *S. sessilis* at an earlier growth stage than translocated herbicides such as clopyralid to be sure of effective kills (Harrington 2000b). Once patches of the weed have shown up as being poorly controlled following a spring herbicide application by picolinic herbicides, it is generally too late to apply a contact herbicide to prevent seed production. However, green-keepers at the Helensville golf course have found a commercial mixture of MCPA, mecoprop, dichlorprop and dicamba will also kill it effectively.

Several other sites north of Auckland are known to have this resistant biotype, which has leaves with less branching compared to the susceptible biotypes (Harrington 2002). This difference in appearance will be helpful in devising management strategies.

Solanum nigrum The large differences in susceptibility of the Rongotea and Kairanga biotypes of *S. nigrum* (Table 2) indicate that the Rongotea biotype has developed resistance to triazine herbicides.

Differences in susceptibility to terbuthylazine and prometryn were also large, though smaller than with the cyanazine and atrazine. This was because of survival by a few Kairanga plants, and some damage to the Rongotea plants. However, in other work not reported here (Harrington *et al.* 2001), most Rongotea plants treated with 24 kg ha^{-1} of terbuthylazine were totally unaffected by this herbicide. The normal rate used to kill *S. nigrum* in pea crops is 0.75 kg ha^{-1}.

Differences in susceptibility to terbutryn appeared to be small, but the Kairanga plants were poorly controlled by the herbicide which should normally give good control of *S. nigrum*. The chemical used in the trial was old, so may have been less effective against susceptible biotypes because of this.

According to Heap (2002), resistance to triazines by *S. nigrum* is widespread in Europe, listed as being present in 10 different countries there. It is suspected of being fairly common in New Zealand too, as many farmers and growers already consider triazines to be ineffective against this species. The use of simazine was discontinued in the Massey University orchard in the 1980s following many sequential applications, as *S. nigrum* was establishing directly after applications had been made. However, the trials reported here are the first attempts to show that differences do exist between biotypes of *S. nigrum* in New Zealand.

Kutrys *et al*. (1998) reported negative cross-resistance in triazine-resistant *S. nigrum* populations to bentazone. Likewise, our work has suggested that triazine-resistant *S. nigrum* may be more easily controlled by alternative herbicides such as MCPB, bentazone and methabenzthiazuron.

As with the triazine-resistant *C. album* and *P. persicaria* found in New Zealand maize crops, a number of alternative herbicides are available for control of triazine-resistant *S. nigrum*. For example, MCPB or bentazone could be used in pea crops, and dicamba could be used in maize.

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