CROSS-RESISTANCE IN CHLORSULFURON-RESISTANT CHICKWEED (*STELLARIA MEDIA*)

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ABSTRACT

In New Zealand chlorsulfuron-resistant chickweed was discovered in 1995. Experiments were conducted in the field and glasshouse to determine whether these resistant plants were also cross- and multiple-resistant to other herbicides normally effective on chickweed. A population of chlorsulfuron-resistant chickweed growing in an oat crop near Winton in the South Island was treated with 13 different herbicides. This population was not controlled by mecoprop, methabenzthiazuron and pendimethalin, and only partially controlled by bromoxynil + ioxynil, diflufenican + isoproturon and diflufenican + bromoxynil in the field trial. Two follow-up glasshouse experiments using plants grown from seeds harvested from the surviving plants confirmed cross-resistance to thifensulfuron and susceptibility to all the other herbicides, including tribenuron.

Keywords: herbicide resistance, *Stellaria media*, chlorsulfuron, thifensulfuron, cross-resistance.

INTRODUCTION

Chickweed (*Stellaria media*) is a winter annual weed that is one of the most widespread crop weeds in the world (Holm et al. 1977). In New Zealand it is an important weed of grain crops in the South Island. In 1995 the DuPont Company confirmed that certain populations of chickweed in the South Island were resistant to chlorsulfuron (Bourdôt 1996). Chlorsulfuron-resistant chickweed has been previously confirmed in Canada, Denmark and Sweden (Hall & Devine 1990; Kudsk et al.1992; Adreasen & Jensen 1994).

Chlorsulfuron works by binding to the ALS (aceto-lactate synthase) enzyme and covering the active site of the enzyme. ALS is a key enzyme in the metabolic pathway for formation of the branched chain amino acids. A single amino acid substitution to ALS can prevent chlorsulfuron from binding to the enzyme (Shaner 1991). Many of the amino acid substitutions to the ALS enzyme which impart resistance to chlorsulfuron, often result in cross-resistance to other herbicides with the same mode of action (Wright & Penner 1998). Cross-resistance is when a plant, which is resistant to one herbicide, is found to be resistant to other herbicides with a similar mode of action. Multiple-resistance is when that resistant plant is found to be resistant to herbicides with different modes of action. Resistance to chlorsulfuron is fairly widespread, with at least 22 weed species in 7 countries confirmed (Heap 2000). Chickweed has also been found to be resistant to atrazine and mecoprop (Heap 2000). The objective of this research was to determine whether a population of chlorsulfuron-resistant chickweed from the South Island was resistant to other ALS herbicides and herbicides with different modes of action.

MATERIALS AND METHODS

Field experiment

To pre-screen for herbicide resistance, a site was chosen near Winton in the South Island with a known population of chlorsulfuron-resistant chickweed. The site had

been planted in oats (*Avena sativa*) and had been treated by the grower earlier in the season with chlorsulfuron (Glean) at 15 g/ha. Experimental treatments (Table 1) were applied on 13 December 1999 when the surviving chickweed was anywhere from 1 cm (8-leaf stage) to 10 cm in size and the oats were at the joint stage (seven on the Feekes scale). The herbicide treatments were applied using a CO_2 powered plot sprayer with a 2 m boom calibrated to apply 200 litres water/ha using a Sprayer International 0.02 nozzle. Plots were 2 m x 10 m, arranged in a randomised complete block design with four replicates. Chickweed survival was evaluated on 22 December 1999 and 20 January 2000 (Table 2). Seeds from surviving plants were collected and bulked on a treatment basis and sent to Ruakura Research Centre for confirmation of herbicide resistance.

TABLE 1: Herbicides used on chickweed in the field experiment.

Herbicide	Active ingredient	Concentration	Rate (g ai / ha)
Glean	chlorsulfuron	750 g/kg	15
Harmony	thifensulfuron	750 g/kg	15
Granstar	tribenuron	750 g/kg	15
Combine	bromoxynil + ioxynil*	200 + 200 g/litre	300 + 300
Cougar	diflufenican* + isoproturon	100 + 500 g/litre	100 + 500
Jaguar	diflufenican* + bromoxynil	25 + 250 g/litre	37 + 375
Mecoprop	mecoprop	600 g/litre	3000
Tribunil	methabenzthiazuron	700 g/kg	1050
Sencor	metribuzin	750 g/kg	375
Karmex	diuron	800 g/kg	3200
Gardoprim	terbuthylazine	500 g/litre	1500
Stomp	pendimethalin	330 g/litre	2000
Starane	fluroxypyr	80 g/litre	160

*Ingredient active on chickweed.

Glasshouse experiment

Seeds of plants that had survived herbicides sprayed in the field experiment and of a susceptible population collected from a farm near Raglan in the North Island where chlorsulfuron had never been used, were germinated in vermiculite. When plants were at the cotyledon to 2-leaf stage, they were transplanted to 500 ml punnets (one per punnet for the suspected resistant population and five per punnet for the susceptible). At the 2 to 4-leaf stage the seedlings and a control sample were sprayed with the same herbicide and dose that their parents had survived in the field (Table 3). There were very few plants for this first trial so a dose-response experiment was not attempted. The herbicide treatments were applied with a moving belt pot sprayer using a single Tee Jet 80015E nozzle at 200 kPa to apply 200 litres/ha, except for methabenzthiazuron, which was applied in 400 litres/ha water. Two weeks after application these plants were evaluated visually for herbicide effects. Surviving plants were grown to maturity and seeds from these plants were collected.

A second, more complete, trial was conducted under the same conditions using plants that were grown from the seeds of plants that had survived the first glasshouse screening. Plants were grown as described above. As a large quantity of seed was available, a dose-response experiment was conducted. In this experiment there were five doses of herbicide and a water control for each susceptible (0, 0.45, 1.5, 4.5, 15 and 45 g/ha) and resistant line (0, 4.5, 15, 45, 150 and 450 g/ha). At each dose ten plants were sprayed and three weeks after application the plants were harvested at ground level, dried for 24 h at 80°C and weighed. An analysis of variance was used to determine if there were differences in plant response at each herbicide dose.

RESULTS

Field experiment

The field experiment confirmed that the chickweed population present was resistant to chlorsulfuron (Table 2). Thifensulfuron, tribenuron, methabenzthiazuron, pendimethalin, ioxynil and the two formulations of diflufenican also did not control the chickweed, causing only moderate injury. However there was concern that these plants were too large to be adequately controlled by these herbicides. Mecoprop killed smaller chickweed plants and suppressed the larger ones.

TABLE 2: Average suppression of chickweed and the oat crop in the field experiment.

Herbicide	Classification[1] and chemical family	Chickweed % injury	Oat Injury[2]
chlorsulfuron	B – sulfonylurea	0	0
thifensulfuron	B – sulfonylurea	22	0
tribenuron	B – sulfonylurea	20	0
bromoxynil + ioxynil*	C_3 – nitrile	28	4
diflufenican* + isoproturon	F_1 – nicotinanilide	27	5
diflufenican* + bromoxynil	F_1 – nicotinanilide	17	5
mecoprop	O – phenoxy	42	2
methabenzthiazuron	C_2 – urea	11	0
metribuzin	C_1 – triazinone	100	8
diuron	C_2 – urea	99	5
terbuthylazine	C_1 – triazine	100	8
pendimethalin	K_1 – dinitroaniline	2	2
fluroxypyr	O – carboxylic acid	100	0
LSD (P<0.05)		4	NA

[1]Based on the classification of herbicides according to site of action (Retzinger & Mallory-Smith 1997).
[2]Oat injury was scored on a 0-10 scale with 0 = no damage and 10 = severe damage.
*Ingredient active on chickweed.

Glasshouse experiment

In the glasshouse experiment pendimethalin, methabenzthiazuron, ioxynil and the two formulations of diflufenican killed all chickweed plants when used at the recommended field application rate (Table 3). Seed harvested from the field plots sprayed with mecoprop did not germinate which indicated that mecoprop may have effectively prevented viable seed production in chickweed. Chlorsulfuron, thifensulfuron and tribenuron did not control chickweed in the glasshouse, with 100 % survival of the seedlings. Because of the low number of plants in this trial, a second experiment using plants grown from seeds of the surviving chickweed plants was conducted.

Susceptible plants were killed at very low doses of all three herbicides (Fig. 1). Chlorsulfuron resistant plants were confirmed to be resistant to chlorsulfuron and thifensulfuron but susceptible to tribenuron (Fig. 1). At 450 g/ha (30 times the recommended use rate), chlorsulfuron killed 80% of the resistant plants. Thifensulfuron was not lethal at any dose tested.

DISCUSSION

The glasshouse experiment confirmed the suspicion that in the field experiment pendimethalin, methabenzthiazuron, ioxynil, mecoprop and the two formulations of

TABLE 3: Number of chickweed plants surviving in the glasshouse experiment.

Herbicide	Susceptible control		Resistant	
	Alive	Dead	Alive	Dead
chlorsulfuron	0	5	2	0
thifensulfuron	0	5	1	0
tribenuron	0	5	6	0
bromoxynil + ioxynil*	0	5	0	8
diflufenican* + isoproturon	0	5	0	6
diflufenican* + bromoxynil	0	5	0	6
mecoprop	0	5	-	-
methabenzthiazuron	0	5	0	11
pendimethalin	0	5	0	3
control	5	0	-	-

*Ingredient active on chickweed.

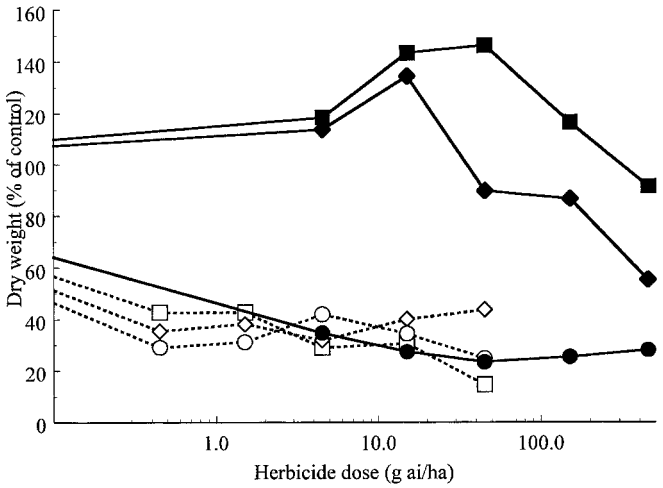

FIGURE 1: Response of chlorsulfuron-resistant (filled symbols) and susceptible (open symbols) chickweed to chlorsulfuron (◆), thifensulfuron (■) and tribenuron (●) harvested 3 weeks after treatment.

diflufenican were applied to chickweed plants that were too advanced in their growth for the herbicide to have effective control. Therefore the chickweed population in this field was not multiple-resistant to these herbicides. The chickweed plants were significantly ($P<0.05$) more resistant to chlorsulfuron and cross-resistant to thifensulfuron but not to tribenuron. Other reports for cross-resistance in the sulfonylurea herbicides confirm that cross-resistance is common and that the cross-resistance patterns are dependent on the particular amino acid substitution in the ALS enzyme (Wright & Penner 1998; Heap 2000). Growers in the South Island can expect that chlorsulfuron-resistant chickweed plants will not be controlled by thifensulfuron. However all other

registered herbicides, if applied according to the label, should continue to control chickweed.

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