MCPA-RESISTANCE IN GIANT BUTTERCUP (*RANUNCULUS ACRIS* L.) IN NORTH ISLAND DAIRY PASTURES

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SUMMARY

In a glasshouse at Lincoln, young plants of eight North Island populations of giant buttercup (*Ranunculus acris* L.) were treated under uniform conditions with MCPA dosages ranging from 0.198 kg/ha to 3.375 kg/ha. The LD₅₀ values for these populations varied from 0.31 kg/ha to 1.17 kg/ha, indicating genetic variability in resistance to MCPA. The LD₅₀ values corresponded to previously determined field-susceptibilities to MCPA, suggesting that these differences in control resulted from the differences in resistance. Populations with high LD₅₀ values were also those with a history of MCPA use, indicating that selection for resistance had occurred in these populations.

INTRODUCTION

Giant buttercup occurs throughout New Zealand (Garnock-Jones 1981). It is an important weed in dairy pastures in the North Island (Popay *et al* 1984) and in Takaka in the South Island (Bourdote *et al* 1989) owing to its unpalatability, attributable to an acrid-tasting protoanemonin present in the leaves (Connor 1977). MCPA is recommended for the control of giant buttercup (Tuckett 1961; Popay *et al* 1984, 1989) and this herbicide, sometimes augmented with MCPB (Matthews 1975), has been repeatedly applied to many infested dairy pastures since about 1950. Whilst moderately good control could be expected with MCPA in the early years of its use (Harper 1957; Tuckett 1961), reports of poor control have been increasingly common in more recent years (Bourdote *et al* 1989).

Differences in control with MCPA between populations in the North Island (Popay *et al* 1984) and in the South Island (Bourdote *et al* 1990), lead to speculation that some populations may be more resistant to MCPA than others. This was confirmed by Bourdote and Hurrell (1988) who found that the LD₅₀ of a population in Takaka, for which little effect of MCPA could be observed in the field, was 4.8 times greater than the LD₅₀ of a population which was almost eradicated with a single application of MCPA at 1.0 kg/ha. Further investigations with a range of populations from Takaka and one from Canterbury showed that variation in resistance between populations was correlated with the amount of MCPA applied in the past (Bourdote *et al* 1989; Bourdote and Hurrell 1990). These results supported the hypothesis that selection for resistance had occurred in giant buttercup in the South Island dairying area of Takaka, as a result of MCPA use.

The work described here compared, under uniform conditions, the MCPA-responses of several North Island populations of giant buttercup which had been shown previously to vary in their susceptibility to MCPA (Popay *et al* 1984). Two benchmark populations from the South Island with known responses were included for comparison.

MATERIALS AND METHODS

In January 1989, seeds were collected from eight populations of giant buttercup on dairy farms in the North Island for which the field efficacy of MCPA was known (Popay *et al* 1984). Seeds were also collected from two populations in Takaka in the South Island known to differ 4.8 times in their resistance to MCPA (Bourdote and

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TABLE 1: Owners and locations of the farms from which giant buttercup seed was collected, and population codes.

Owner	Location of farm	Population code
L. Morgan	Eltham, Taranaki	LM1
L. Morgan	Eltham, Taranaki	LM2
B. Brown	Eltham, Taranaki	B1
B. Brown	Eltham, Taranaki	B2
J. Mabey	Ballance, northern Wairarapa	JM1
J. Mabey	Ballance, northern Wairarapa	JM2
R. Mabey	Ballance, northern Wairarapa	RM
K. Suisted	Woodville, southern Hawkes Bay	KS
R. Silcock	Takaka, Golden Bay	S
B. Jones	Takaka, Golden Bay	J

Hurrell 1988). The farmers on whose properties the populations occur, the locations and the codes given to the populations are given in Table 1.

After soaking overnight in 0.02% KNO₃ solution on 30 March 1989, the seeds were dusted with a 1:1.6 mixture of the fungicides benomyl (Benlate) and captan (Captan) and placed on moistened vermiculite germination beds at 20 °C day/10 °C night. On 24 April 1989, one to two-leaf seedlings of each population were transplanted into methyl-bromide-treated Wakanui silt loam contained in 1.6 litre plastic pots. There were 32 pots of each population with four seedlings per pot. The potted plants were placed in a glasshouse maintained at 20 °C during the day and unheated at night. On 29 June, when the plants had produced five to eight leaves, they were treated with a range of concentrations of the K salt of MCPA (IWD MCPA). For each population, there were four pots of each of eight concentrations of MCPA ranging from 0.198 kg/ha to 3.375 kg/ha, spaced according to a 1.5 multiplier. The MCPA was applied with moving-belt sprayer delivering 200 litres/ha at 210 kPa through a single 8002E flat-fan Teejet hydraulic nozzle mounted 50 cm above the pots. The pots were arranged in the glasshouse in a split-plot design, with seedling population as mainplots and MCPA dose as subplots.

On 17 November 1989, 141 days after treatment, dead plants were counted in each pot. A plant was deemed dead if it had disappeared completely or if the root system had decayed and remaining calloused root and stem tissue could be readily dislodged from the soil.

The mortality data were analyzed using a generalised linear model (Dobson 1983) which fitted a probit curve to the graph of percent mortality vs log MCPA dose for each population. The model included terms which estimated block and mainplot effects.

RESULTS

The ten populations of giant buttercup varied substantially in their responses to MCPA (Fig. 1). The order of susceptibility according to the LD₅₀ values derived from Fig. 1, was KS > J > B1 > B2 > RM > LM2 > LM1 > JM2 > JM1 > S. At the LD₅₀ level, population S from Takaka in the South Island was 6.32 times more resistant than population KS from southern Hawkes Bay, and 5.44 times more resistant than the J population from Takaka.

The LD₅₀ values for each population from Fig. 1 are given in Table 2 along with historical information on the herbicide exposure of the field populations. Populations KS and J have never been exposed to MCPA or any other herbicide and have low LD₅₀ values. By contrast the other populations have been treated with MCPA and sometimes MCPB at various frequencies and rates over many years and have comparatively high LD₅₀ values.

DISCUSSION

Evidence for the hypothesis that the use of MCPA to control giant buttercup in dairy pastures has resulted in the selection of resistant phenotypes and the evolution of

Fig. 1: Dose-response curves for mortality of ten populations of giant buttercup treated with MCPA. Mortality was assessed 141 days after treatment. The order of the curves at the LD₅₀ level is given by the population codes on the graph. The LSD is for comparisons among LD₅₀ values. Data are shown only for the two South Island populations, S (○) and J(□).

TABLE 2: Herbicide histories of the giant buttercup populations and the LD₅₀ values of the 1989 seedling progenies from Fig. 1.

Population	Herbicide	Frequency of herbicide application	Rate of herbicide application (kg ai/ha)	LD ₅₀ (kg ai/ha MCPA)
KS	None	—		0.31
J	None	—		0.36
B1	MCPA	Biennially for 31 yrs	1.3	0.50
B2	MCPA	Biennially for 31 yrs	1.3	0.65
RM	MCPA	Biennially from 1963 to 1984, annually from 1984 to 1989	>1.3	0.70
LM2	MCPA/MCPB	Biennially for 40 yrs	1.5-2.25	0.85
LM1	MCPA/MCPB	Biennially for 40 yrs	1.5-2.25	1.11
JM2	MCPA	Treated since 1960, c. every 2 or 3 yrs	1.1	1.14
JM1	MCPA	Treated since 1960, c. every 2 or 3 yrs	1.1	1.17
S	MCPA	Triennially from 1955 to 1966, biennially from 1966 to 1981 and annually from 1981	>1.0	1.96

resistant populations has been reported from the South Island (Bourdöt and Hurrell 1988; Bourdöt *et al* 1989). The LD₅₀ values of 0.36 and 1.96 kg/ha MCPA for populations J and S from the current work, confirm the extreme differences between J and S found previously. Of greater interest is that the populations of giant buttercup from North Island dairy pastures also vary genetically in resistance and exhibit the same range of responses to MCPA as the South Island populations from Takaka (Fig. 1). Selection for resistance has apparently resulted from MCPA use in these North Island pastures since the populations that had been repeatedly treated with MCPA had greater LD₅₀ values than population KS which had never been treated with herbicide (Table 2).

Popay *et al* (1984) reported that these North Island populations varied in the degree of control obtained with MCPA, but no explanation was given for this variation. Comparison of the LD₅₀ values obtained in the current experiment with the field efficacy data of Popay *et al* (1984) suggests that genetic differences between the populations in resistance to MCPA account for this variation. Popay *et al* (1984) found in an experiment in 1982 that giant buttercup was less effectively controlled with 1.0 kg MCPA/ha on the Morgan farm than on the Brown farm. The two populations tested in the current experiment from Morgan's were LM1 and LM2, and both had substantially higher LD₅₀ values than populations B1 and B2 from Brown's (Fig. 1, Table 2). Similarly in other experiments in 1980 and 1982, Popay *et al* (1984) obtained lower control with MCPA on Mabey's farm than on Suisted's farm and in the current experiment the three Mabey populations, JM1, JM2 and RM, had higher LD₅₀ values than the KS population from Suisted's (Fig. 1, Table 2). These results are consistent with the hypothesis that inter-population differences in resistance caused the inter-population variation in control found by Popay *et al* (1984).

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