DIFFERENTIAL TOLERANCE OF MCPA AMONG GIANT BUTTERCUP (*RANUNCULUS ACRIS*) BIOTYPES IN TAKAKA, GOLDEN BAY

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SUMMARY

In a glasshouse experiment conducted at Lincoln, young plants of two Golden Bay populations of *Ranunculus acris* (giant buttercup) contrasting markedly in their field response to MCPA, were treated under uniform conditions with several rates of MCPA ranging from .198 kg/ha to 3.375 kg/ha. The LD₅₀ estimate for the population readily controlled with MCPA in the field was .31 kg MCPA/ha whilst the LD₅₀ estimate for the population poorly controlled with MCPA was 1.51 kg MCPA/ha. This 4.8-times difference in tolerance to MCPA explained the difference in field response to MCPA. The tolerant biotype may have evolved under a selection pressure of historical applications of MCPA.

INTRODUCTION

Ranunculus acris L. (giant buttercup) occurs throughout New Zealand (Garnock-Jones 1981) and is an important weed in dairy pastures in the North Island (Popay *et al* 1984) and in Golden Bay in the South Island (Bourdôt unpub.). Its weed status in dairy pasture is attributable to its unpalatability (Tuckett 1961), persistence, and its exclusion of more desirable pasture plants. No cases of stock poisoning are known (Connor 1977). Early experiments with giant buttercup in New Zealand showed the plant to be poorly controlled with 2,4-D and 2,4,5-T while both the sodium salt and, more particularly, the potassium salt of MCPA at 1.0 to 1.5 kg/ha and MCPB at 2 kg/ha gave "very satisfactory" results (Tuckett 1961).

The efficacy of MCPA is not only dependant upon the timing of application (Tuckett 1961, Popay *et al* 1984), but also varies between sites (Popay *et al* 1984, Bourdôt unpub.). The experiment described here compared the responses of two giant buttercup populations, which differ markedly in their field susceptibility to MCPA, to a wide range of MCPA rates applied under uniform glasshouse conditions.

MATERIAL AND METHODS

Experimental procedure

In late December 1986, seeds were collected from two populations (paddocks) of giant buttercup on two dairy farms in Takaka valley, Golden Bay. The two populations had previously been found to have sharply contrasting responses to MCPA in the field. The 'Jones' population had been virtually eradicated when sprayed with 1.0 kg/ha MCPA while the 'Silcock' population was almost unaffected (Bourdôt unpublished).

After soaking overnight in .02% KNO₃ solution on 9 July 1987, seeds were placed on moistened vermiculite germination beds at 20°C day/10°C night. On 19 August 1987, 1 to 1.5-leaf seedlings of each population, were transplanted into methyl-bromide-treated Wakanui silt loam contained in 1.6-litre plastic pots. There were 36 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 23 September 1987, when the plants had produced six to seven leaves, they were removed from the glasshouse and treated with a range of concentrations of the K salt of MCPA (IWD MCPA). For each population, there were four replicate pots (16 plants), of each of nine

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rates of MCPA beginning at 0.198 kg/ha and finishing at 3.375 kg/ha, spaced according to a 1.5 multiplier, and an untreated control. All pots were returned to the glasshouse, placed in a split-plot layout (mainplot = population, subplot = rate MCPA), and watered regularly until assessment.

Treatments were applied with a nitrogen gas-powered precision sprayer delivering 200 litre/ha through a single 8002E fan nozzle at 210 kPa. All the pots receiving a single rate were placed in a line and the nozzle was manually passed over them at a speed of 1.1 m/sec.

On three occasions (28, 34, and 40 days after treatment) the growth of the plants in each pot was visually assessed using an 11-point scale from 0 to 10. Each pot was scored relative to its replicate control; the controls were scored 10.

On 4 December 1987, 71 days after treatment, mortality was measured by counting the number of dead plants per pot. A plant was deemed to be dead when no green tissue was present, or when the root system was so decayed that the plant could be easily dislodged from the soil with slight finger pressure, even though some green tissue was present.

Analytical procedure

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

RESULTS

The results of the first visual rating of productivity made 28 days after treatment on 21 October 1987, are given in Fig 1. At this early stage (before any obvious mortality) the Jones population had been reduced in growth more than the Silcock population. Growth made, as a percentage of untreated, was linear against $\log_{10}$ dose and overall, was significantly lower ($P = .01$) in the Jones population. Later ratings of growth are not presented since they confound growth and mortality. Twisting and distortion symptoms, typical of phenoxy herbicide damage, were evident in both populations within days of treatment.

Fig. 1: The effect of MCPA on the productivity of two Takaka populations of giant buttercup as assessed by visual score 28 days after treatment.

The dose-response curves for mortality in each population, as assessed 71 days after treatment, are given in Fig. 2. The LD_{50} estimated for the Jones population was 0.31 kg MCPA/ha with upper and lower 95% confidence limits (CLs) of 0.39 and 0.25 kg MCPA/ha respectively. By contrast the LD_{50} estimated for the Silcock population was 1.51 kg MCPA/ha with CLs of 1.87 and 1.24 kg MCPA/ha.

The LD_{90} estimated for the Jones population was 0.74 kg MCPA/ha with CLs of 1.0 and 0.58 kg MCPA/ha and that for the Silcock population was 3.54 kg MCPA/ha with CLs of 5.19 and 2.72 kg MCPA/ha.

The LD_{50} s and LD_{90} s for the Silcock population were estimated to be 4.81 times greater than for the Jones population with CLs of 6.74 and 3.59 kg MCPA/ha.

Fig. 2: Dose-response curves for mortality for two Takaka populations of giant buttercup treated with MCPA. Mortality was assessed 71 days after treatment.

DISCUSSION

Intraspecific differences in tolerance to phenoxy herbicides has been demonstrated only once before in New Zealand. Harrington and Popay (1987) reported a 4.8 times difference in MCPA tolerance between biotypes of *Carduus nutans* L. (nodding thistle) in Hawkes Bay, and a 2.1 times difference between a Hawkes Bay and a Manawatu population of this species. Over recent years, a number of weed species in other countries have been shown to have biotypes with varying tolerance to phenoxy herbicides. Most of these cases involve biotypes that are morphologically distinguishable, suggesting that differences in physical characteristics such as cuticle thickness, pubescence, erectness of growth habit *etc* may provide the mechanisms for the differences in tolerance (LeBaron and Gressel 1982). By contrast, there are no consistent morphological differences between the two biotypes of giant buttercup compared here. Both the Jones and the Silcock plants fall within *R. acris* subsp *acris* (Garnock-Jones pers. com.), although considerable variation in depth of cut and narrowness of leaf segments and erectness and vestiture of leaves, occurs in both populations. The tolerance mechanism may therefore be biochemical in nature, possibly concerning metabolic breakdown of the MCPA. The ability of surfactants to enhance control of the MCPA-tolerant type, is being studied as part of further investigations into the mechanisms of MCPA-tolerance in giant buttercup.

Since the difference in tolerance to MCPA in giant buttercup occurred under uniform environmental conditions, it may be assumed that it is genetically based. MCPA-tolerance in giant buttercup is therefore heritable and 'selection pressure' provided by repeated MCPA treatment could be expected to 'produce' a tolerant

biotype by favouring tolerant genotypes. That this has happened in Takaka is supported by historical details of MCPA treatment of the Jones and Silcock buttercups. The Jones population has had no MCPA treatment for at least 20 years (Jones pers. com.) whilst the Silcock population was treated with 1.0 kg MCPA/ha every 3 years from 1955 to 1966 (Johnson pers. com.) and with a somewhat higher rate every second year from 1966 to 1981 (McKenzie pers. com.). From 1981 the Silcock population has been treated annually with MCPA.

Our results indicate that the tolerant Silcock buttercup currently requires 3.5–5.2 kg MCPA/ha for 90% kill whilst the susceptible Jones type requires only 0.6–1.0 kg MCPA/ha (Fig. 2). The usual rate of MCPA (1.0 kg/ha) can be expected to cause only about 20% kill in the Silcock biotype (Fig. 2). Field efficacy tests with MCPA in Takaka confirm this expectation (Bourdout unpub.).

It seems probable that difficulties in controlling giant buttercup on some North Island dairy farms may also be explained by the existence of tolerant biotypes. Popay *et al* (1984) has found that the level of control of giant buttercup varies between sites in southern Hawkes Bay and Wairarapa. Confirmation of the wider existence of tolerant biotypes of giant buttercup arising from past use of MCPA awaits comparative studies under uniform conditions, of a wider variety of populations for which the field efficacy and historical usage of MCPA is known.

Our findings of variable tolerance of MCPA within *R. acris* brings to four the number of New Zealand weed species confirmed as showing intraspecific variation in herbicide tolerance; *Carduus nutans* — variable tolerance of MCPA (Harrington and Popay 1987), *Chenopodium album* — triazine resistance (Rahman 1982), *Polygonum persicaria* — triazine resistance (Rahman and Patterson 1987).

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