BIOLOGICAL AND ECONOMIC EFFECTS OF SURFACTANT ADDITION TO MCPA FOR GIANT BUTTERCUP (*RANUNCULUS ACRIS*) CONTROL

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SUMMARY

Two glasshouse experiments were conducted to determine the biological and economic effects of adding surfactant to MCPA for control of giant buttercup (*Ranunculus acris* subsp *acris*). In the first experiment the LD₅₀ of seedling progeny of an MCPA-tolerant biotype (S) was reduced by 68% by addition of Pulse at 0.2% (v/v) to MCPA, but Citowett and Triton X-45 had no effect. In the second experiment Pulse reduced the LD₅₀ of S by 26% and reduced the LD₅₀ of a susceptible biotype (J) by 24%. The cost of achieving kill of the MCPA-tolerant S biotype was reduced by the addition of Pulse in both experiments.

INTRODUCTION

Giant buttercup (*Ranunculus acris* L. subsp *acris*) occurs throughout New Zealand (Garnock-Jones 1981) and is a serious weed of dairy pastures in several regions (Popay *et al* 1984). Although it produces the vesicant γ -lactone protoanemonin, poisoning in grazing stock has not been recorded (Connor 1977). Hay containing *R. acris* is not toxic because the protoanemonin is volatile. The acidity of the protoanemonin explains why stock avoid *R. acris* and its closely associated vegetation, and consequently why infested pastures are low-producing (Harper and Sagar 1953) and vulnerable to the spread of *R. acris* when heavily grazed (Harper 1957).

MCPA and MCPB are the only herbicides that give adequate selective control of *R. acris* in pastures (Tuckett 1961). It is therefore of concern that recent research in Golden Bay has identified an MCPA-tolerant biotype of giant buttercup that required five times as much MCPA as a susceptible biotype to achieve the same mortality (Bourdot and Hurrell 1988). The histories of the two biotypes suggested that the MCPA-tolerant biotype had evolved as a consequence of repeated exposure to moderate to high doses of MCPA over a 30 year period.

The aim of the present work was to determine if the addition of surfactants to MCPA would reduce the amount of herbicide required for acceptable kill of MCPA-tolerant giant buttercups.

MATERIAL AND METHODS

Two glasshouse experiments were conducted with giant buttercup to determine the effect of surfactants on the dose-response curves for MCPA.

Experiment 1

Seeds from an MCPA-tolerant population (S) of giant buttercup (Bourdot and Hurrell 1988) collected in the summer 1986/87, were left to imbibe a 0.02% solution of KNO₃ for 24 hours at 20°C in late March 1988, then dusted with a 50:50 mixture of the fungicides benomyl, 500g/kg, (Benlate) and captan, 800g/kg, (Captan). The treated seeds were spread out on moistened beds of Perlite (crushed pumice) and germinated in an incubator set at 20°C during the day and 10°C at night. The germination beds were moved to an unheated glasshouse 13 days later. Cotyledonary and first-leaf seedlings were transplanted into methyl-bromide-treated Wakanui silt loam in 1.6 litre plastic pots after a further 29 days. There were 40 pots with four seedlings per pot.

In late July when the seedlings had developed six to 10 leaves, they were treated with five concentrations of the K salt of MCPA (IWD MCPA) ranging from 0.2 to 4.69 kg/ha spaced according to a 2.2 multiplier. Two replicate pots were treated at each dose

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of MCPA in the absence of added surfactant, or with Pulse at 0.2% (v/v), Citowett at 0.05% (v/v) or Triton X-45 at 0.2% (v/v). The MCPA was applied with a nitrogen gas-powered moving-belt sprayer delivering 200 litres/ha at 210 kPa through a single 8002E flat-fan Teejet hydraulic nozzle mounted 50 cm above the tops of the pots. The pots were passed under the stationary nozzle in single-file at 1 m/sec.

The pots were arranged in the glasshouse in two replicate blocks of a split plot design, with mainplot treatments being surfactant (nil, Pulse, Citowett and Triton X-45), and subplots five doses of MCPA. The plants were watered regularly until assessment 84 days after treatment on 20 October 1988. A plant was deemed dead if either (a) it had disappeared completely, or (b) some turgid root callous tissue remained at the soil surface, but no green leaf tissue was present, or (c) the root system was so decayed that the calloused root could easily be dislodged from the soil with slight finger pressure.

Experiment 2

Experimental methods were identical to those described above. Seeds of the tolerant population (S) collected in 1987/1988 and of a susceptible population (J) (Bourdott and Hurrell 1988) collected in 1986/87, were germinated in mid September 1988. Plants with one leaf and of uniform size were transplanted 34 days later into 112 pots with four seedlings per pot. In early December when the seedlings had developed six to 10 leaves, they were treated with seven concentrations of the K salt of MCPA ranging from 0.2 to 3.36 kg/ha spaced according to a 1.6 multiplier. Four replicate pots were treated at each dose of MCPA in the absence of added surfactant, or with Pulse at 0.2% (v/v). Pots were laid out in four replicate blocks of a split plot design, with mainplot treatment factors being population (S, J) and surfactant (nil, Pulse), and subplots seven dose rates of MCPA. Mortality was assessed on 15 February 1989, 69 days after treatment.

Analysis

The mortality data from each experiment were statistically analysed by fitting dose-response curves (Figs 1 & 2) using the method of generalised linear models with a probit transformation of the binomial data. The dose which killed 50% of the plants (LD_{50}) was calculated for each curve.

Fig. 1: Dose response curves for the MCPA-tolerant biotype of giant buttercup (S) treated with MCPA alone and MCPA plus the surfactants Citowett, Triton X-45 or Pulse. Mortality was assessed 84 days after treatment. The horizontal bar gives the LSD (5%) for comparisons of LD_{50} s.

RESULTS

The results of Experiment 1 are given as dose-response curves in Fig. 1. Mortality of the S biotype of giant buttercup was increased ($P = 0.05$) by the addition of Pulse to the MCPA but Citowett and Triton X-45 had no effect. The derived LD_{50} in the absence of Pulse was 1.79 kg MCPA/ha and this reduced to 0.58 kg MCPA/ha with the addition of Pulse. The LD_{50} s in the presence of Citowett and Triton X-45 were respectively 1.58 and 1.73 kg MCPA/ha.

Fig. 2: Dose response curves for the MCPA-tolerant (S) and MCPA-susceptible (J) biotypes of giant buttercup treated with MCPA alone and MCPA plus Pulse. Mortality was assessed 69 days after treatment. The horizontal bar gives the LSD (5%) for comparisons of LD_{50} s.

Fig. 3: The costs of the MCPA and MCPA plus Pulse treatments plotted against percent mortality for the S biotype of giant buttercup in Experiment 1.

The results of Experiment 2 are given as dose-response curves in Fig. 2. As anticipated, the mortality of the MCPA-tolerant S biotype was lower than in the susceptible J biotype. The addition of Pulse to the MCPA increased the mortality in both biotypes and this effect was significant ($P=0.10$) when averaged over both biotypes. The derived LD_{50} s for the S biotype in the absence and presence of Pulse were 3.11 and 2.29 kg MCPA/ha respectively while the corresponding values for the J biotype were 0.79 and 0.60 kg MCPA/ha.

The costs (\$/ha) of the with- and without-Pulse treatments for Experiments 1 & 2 are given in Figs. 3 & 4 respectively. These costs were derived from the appropriate dose-response curves in Figs. 1 & 2 taking the price of MCPA to be \$18/kg ai and Pulse at a constant \$13/ha (i.e. \$13/400 mls). In Experiment 1 the addition of Pulse lowered the cost of achieving a given mortality in the S biotype with the benefit of Pulse increasing with mortality (Fig. 3). This meant that the cost of achieving 90% kill in the presence of Pulse was only half that without Pulse. In Experiment 2 costs were similar between the with- and without-Pulse treatments for the S biotype (Fig. 4). By contrast costs were greater with Pulse in the J biotype (Fig. 4).

Fig. 4: The costs of the MCPA and MCPA plus Pulse treatments plotted against percent mortality for the S and J biotypes of giant buttercup in Experiment 2.

DISCUSSION

Surfactants facilitate wetting, spreading, dispersion, solubility and emulsifying, to bring about enhanced herbicidal action. They accomplish these roles by their joint polar/apolar properties, providing compatible aqueous and lipoidal phases. By reducing the contact angle of spray droplets and surface tension, and thus improving wetting, they also favour both stomatal and cuticular penetration of herbicides (McWhorter 1982). Stevens *et al* (1988) have shown that Pulse is more effective than the surfactants Agral 90 and Triton X-45 at enhancing the uptake of glyphosate and attributed this to its very low aqueous surface tension leading to greater wetting of foliage and stomatal entry. The current work indicates that Pulse is more effective at enhancing the uptake of MCPA in giant buttercup than either Citowett or Triton X-45 (Fig. 1). For the tolerant biotype in Experiment 1, the LD_{50} for MCPA was reduced by 68% by the addition of Pulse. For the tolerant and susceptible biotypes used in Experiment 2, the corresponding reductions were 26% and 24%.

In Experiment 1, the benefit of adding Pulse to MCPA increasingly outweighed the cost above levels of kill of about 25% for the tolerant biotype (Fig. 3). Accordingly, the cost of achieving 90% kill of the tolerant biotype was reduced from \$82/ha with MCPA

alone to \$42/ha with MCPA + Pulse, corresponding to a reduction in the rate of MCPA from 4.6 kg/ha to 1.6 kg/ha. In Experiment 2 this result was not repeated, with the addition of Pulse having little effect on costs which were generally much higher for a given kill of the tolerant biotype in the second experiment (Fig. 4) than in the first (Fig. 3). This reflected the lower mortality at equivalent rates of MCPA (Fig. 2 cf. Fig. 1) and the lower effectiveness of Pulse (26% versus 68% reduction in LD_{50}) in Experiment 2.

Differences in timing of the two experiments may explain the differing responses of the S biotype to MCPA. The first experiment was conducted in the winter months and gave a similar response in S to MCPA (LD_{50} = 1.79 kg MCPA/ha) as a previous experiment with S conducted in winter (LD_{50} = 1.51 kg MCPA/ha) (Bourdote and Hurrell 1988). The higher LD_{50} for S in the second experiment of 3.11 kg MCPA/ha (Fig. 2) may be a function of the better summer growing conditions. However a complicating factor is that the S seed used in the first experiment was collected in 1986/87 (as was the S seed used by Bourdote and Hurrell (1988) a year earlier), whilst the S seed used for the second experiment, giving the exceptionally high LD_{50} , was collected in 1987/88. There may have been seasonal and/or genetic differences in MCPA tolerance between the two collections of S seeds.

For the susceptible (J) biotype included in Experiment 2, the relatively low rates of MCPA (LD_{50} = 0.79) and the low percentage reduction associated with Pulse (24%), resulted in the addition of Pulse being uneconomic at all rates of MCPA (Fig. 4).

In summary, the results of these glasshouse experiments suggest that further evaluation of the effect of Pulse as an additive to MCPA for field control of MCPA-tolerant giant buttercup is warranted.

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