Pasture tolerance and efficacy of three herbicides used against giant buttercup (*Ranunculus acris* subsp. *acris* L.)

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Abstract The herbicides flumetsulam, thifensulfuron-methyl and MCPA were compared for their efficacy against giant buttercup (*Ranunculus acris* subsp. *acris* L.) and their damage to perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). The tolerance of perennial ryegrass and white clover to five rates of each herbicide was measured using swards either sown in pots or transplanted from the field. The total clover yield harvested over 5 months from newly-sown pasture was 80, 59 and 4% of the untreated control for flumetsulam, thifensulfuron-methyl and MCPA applied at label rates and 95, 40 and 30% for transplanted swards respectively. The biomass yield of giant buttercup 3 months after treatment was 1, 22 and 2% of the untreated control for flumetsulam, thifensulfuron-methyl and MCPA applied at the label rate. Together these experiments suggest that flumetsulam is the most effective and least pasture-damaging of these three herbicides.

Keywords *Ranunculus acris*, flumetsulam, thifensulfuron-methyl, MCPA, efficacy.

INTRODUCTION

Giant buttercup (*Ranunculus acris* subsp. *acris*) is a serious weed of dairy pastures in many areas of New Zealand, causing losses in milk solids revenue nationally of around \$155 million per year (Bourdôt & Saville 2010). It has proved a difficult weed to eradicate due to its ability to regenerate both by seed and through a tenacious rhizome, avoidance by stock, and development of biotypes resistant to the phenoxy herbicides (Bourdôt & Hurrell 1988). Most farmers rely on herbicides for control because of a lack of cost effective or practical alternatives.

Four herbicides have product label claims for selective control of giant buttercup in pastures

in New Zealand: the phenoxy herbicides MCPA and MCPB, and the acetolactate synthase (ALS) inhibitors flumetsulam and thifensulfuron-methyl.

MCPA damages clovers, as does thifensulfuron-methyl (Young 2009), when applied at the label rate. In contrast, MCPB is not damaging to clovers but is not as effective on giant buttercup (Bourdôt et al. 2007) and is less cost-effective than MCPA (Popay et al. 1989). Farmers do not use MCPB widely because of its lack of effectiveness.

Due to resistance, some populations of giant buttercup require up to five times the label rate

of MCPA to achieve adequate control (Bourdôt & Hurrell 1988) thus markedly increasing control costs and potentially the damage to clover. Thifensulfuron-methyl damages both grasses and clovers and reduces pasture production for several months (Rahman & Martin 1989; Gomand et al. 1991). It is relatively cheap to use, but is slower acting than MCPA. Flumetsulam is claimed to be safe on pasture species, but farmer anecdote suggests that it does have some damaging effects. Only one study has compared the effects of these three herbicides on pastures (Harris & Husband 1997) but interpretation of these results is limited as damage was assessed only by visual estimations of effects. At label rates, flumetsulam suppressed clover by an order of magnitude less than both thifensulfuron-methyl and MCPA 1–2 months after spraying (6% versus 60 and 67% lower than untreated respectively).

The present study aimed to compare these three herbicides in terms of their effects on the yields of pasture grasses and clovers, and on giant buttercup. A range of doses was used to determine if there was scope for altering the rates of applied herbicide in order to reduce pasture damage whilst still giving adequate control of the weed.

METHODS

Experiment 1 – new pasture

In June 2010, 0.5-litre square pots were filled with bark, peat and sand potting mix plus 6-month slow-release fertilizer (Osmocote®) and sown with a seed mix of certified basic Nui perennial ryegrass (*Lolium perenne*) and Huia white clover (*Trifolium repens*), at a sowing rate equivalent to 20 and 3 kg/ha respectively, and then placed in a shadehouse.

The pasture swards in the pots were treated

with a logarithmic series (2.236 multiplier) of five doses of thifensulfuron-methyl (Harmony®), the dimethylamine salt of MCPA (Maestro™ 750) and flumetsulam (Preside™), each with two rates above and below the recommended label rates (Table 1) plus an untreated control (16 treatments).

Treatments were applied on the 20 August 2010, 2 months after sowing, under cool (10°C), still air conditions. All herbicides were applied by a moving conveyer-belt sprayer (belt speed 1.06 m/s) delivering 200 litres/ha at 210 kPa through a single 8002E flat-fan TeeJet® (Spraying Systems Ltd) hydraulic nozzle mounted 30 cm above the plants.

The pots in the experiment were arranged in a randomised block design, with four blocks of the 16 treatments. After treatment the pots were returned to the shadehouse and observed for 5 months. All green plant material was harvested from each pot down to a height of 5 mm above soil level at 2, 3 and 5 months after treatment (allowing it to re-grow between harvests). The harvested material was separated into ryegrass and clover before being dried at 65°C for 48 h and then weighed.

Experiment 2 – established pasture

This was carried out in exactly the same way as Experiment 1, except that 75 mm diameter cores were taken from an established perennial ryegrass/white clover pasture at the AgResearch Lincoln farm and grown-on in the same-sized pots as the newly-sown experiment for 2 months before being sprayed. Experiments 1 and 2 ran concurrently in the shadehouse and were treated at the same time with the same 16 treatments (Table 1).

Table 1 Herbicide and dose rate treatments applied in Experiments 1, 2 and 3.

Proportion of recommended label rate	flumetsulam (g ai/ha)	thifensulfuron-methyl (g ai/ha)	MCPA (g ai/ha)
0.20	10.40	2.00	250
0.45	23.25	4.47	560
1.00	52.00	10.00	1250
2.24	116.26	22.36	2790
5.00	260.00	50.00	6250

Plant material was harvested on the same three occasions as Experiment 1, but in this case was separated into grasses, clovers and weeds before being dried and weighed. Only results for grasses and clovers are presented here because the weed component of swards was minimal.

Experiment 3 – giant buttercup

In January 2010, seeds were collected from 14 giant buttercup populations on dairy farms in Golden Bay and from one population on a roadside in North Canterbury (15 populations in total). These had a wide range of past exposures to herbicides ranging from never sprayed to sprayed annually, so is representative of giant buttercup on dairy farms in New Zealand. Seeds were sown in vermiculite, then after emergence on 20 April 2010, seedlings were transplanted into 0.5-litre square pots (two seedlings per pot), containing the same potting mix as before and grown on for 4 months. The pots were laid out in a split-plot design with population as main-plot and herbicide treatment as sub-plot. There were 11 populations with six replicates and four populations with four replicates. The same 16 treatments (five rates of three herbicides and an untreated control) were applied at the same time as in Experiments 1 and 2 (1,312 pots of giant buttercup in total).

All buttercup plants were assessed before spraying, and at 27, 59, 81 and 101 days after spraying, by visually estimating the percentage of green tissue in each pot, relative to that in the respective untreated control pot for each population.

Statistical analysis

Data from each experiment and for each time of harvest were analysed separately using GenStat's (Ver. 13) ANOVA procedure.

RESULTS

Experiment 1 – new pasture

Flumetsulam caused the least damage to the clover, which yielded significantly less than untreated at the two higher rates (39% and 32% reduction; Figure 1a) over the 5-month period.

At the label rate and below, yield was less but not significantly different from the untreated control. In contrast, thifensulfuron-methyl significantly reduced clover yield over the 5-month period at all rates ($P < 0.05$), by between 45% and 71%. MCPA was the most damaging and significantly reduced clover biomass at all rates ($P < 0.05$). For the lower two rates clover biomass was reduced by 46% and 80% respectively (0.2 and 0.45 times label rate), while at the label rate and above, the clover was virtually eliminated (Figure 1a).

Total grass yields over 5 months (Figure 1b) tended to be higher than the untreated control for both flumetsulam and MCPA at all rates, but significantly higher only for the highest rate of MCPA ($P < 0.05$). In contrast, thifensulfuron-methyl showed a highly significant linear decline in total grass yield with increasing rate ($P < 0.001$), although no rates were significantly lower than control.

Experiment 2 – established pasture

The dry weights of the grass and clover species of the cores were reduced in a similar way to the effects seen in Experiment 1, but the responses were more variable. There was a significant linear decline ($P < 0.05$) with increasing rate of flumetsulam in the total clover yield over the 5 months (Figure 2a), although no rates were significantly different from control. Both thifensulfuron-methyl and MCPA significantly reduced total clover yield over 5 months at all rates (Figure 2a). Grass yield was not significantly affected by any of the herbicides, and they all yielded the same or greater than the control (Figure 2b).

Experiment 3 – giant buttercup

The two ALS herbicides were slower to act than MCPA, by about 1 month (Figure 3). At 27 days after treatment biomass scores were 82%, 65% and 30% of control for flumetsulam thifensulfuron-methyl and MCPA respectively. The biomass scores continued to decrease at 59 and 81 days after treatment for all three herbicides. However, by 101 days after treatment biomass scores for thifensulfuron-methyl had increased markedly, as regrowth of survivors began to occur.

Figure 1 Dose responses (dry weight, g) of 2-month-old (a) white clover (*Trifolium repens*) and (b) perennial ryegrass (*Lolium perenne*) to flumetsulam, thifensulfuron-methyl and MCPA in Experiment 1. Dry weights are the sum of harvests at 2, 3 and 5 months after treatment. Vertical bar is LSD ($P=0.05$).

Figure 2 Dose responses (dry weight, g) of established pasture (a) clover and (b) grass species to flumetsulam, thifensulfuron-methyl and MCPA in Experiment 2. Dry weights are the sum of harvests at 2, 3 and 5 months after treatment. Vertical bar is LSD ($P=0.05$).

At 101 days after treatment, the mean biomass of giant buttercup plants was reduced to 1, 22 and 2% of the untreated at the respective label rates, for flumetsulam, thifensulfuron-methyl and MCPA (Figure 4). The lower two rates of flumetsulam still gave adequate control, while for thifensulfuron and MCPA control was not as good at the lower rates.

DISCUSSION

This study shows that thifensulfuron-methyl and MCPA, at their respective label rates, reduced the total productivity of both new and established pasture swards in the 5 months following treatment, mainly by a reduction in the clover content. These results are consistent with past research (Rahman & Martin 1989; Gomand et al.

1991; Harris & Husband 1997). In contrast, there was no evidence that flumetsulam affected clover or grass productivity at its label rate. The present results concur with those of the previous study by Harris & Husband (1997) but show that the damage from flumetsulam at rates above the label rate is greater than was reported earlier. The Harris & Husband (1997) study found 18% reduction in clover at 2× label rate, whereas in the current study the reduction over 5 months was 39% (Figure 1a). A search of the literature found no other studies on the effect of flumetsulam on white clover but studies on medics, red clover and subterranean clover showed some damage from this herbicide at label rates in some cases (Bowran et al. 1993; Gilmour 1996; Ceballos et al. 2005).

Established pasture was far more variable in its response than the new pasture, probably because it began with varying amounts of clover and grass species, whereas the new pasture pots were sown with a consistent rate of seed.

The white clover component of pastures is important for New Zealand dairy farmers (Harris et al. 1998) who rely on its high nutritive value for high milk productivity. Clover is also an important nitrogen fixing element, and therefore if its content in the pasture is reduced, additional sources of nitrogen (e.g. urea) may have to be added, which will increase production costs.

Thifensulfuron-methyl has a label warning indicating that damage to pasture species is likely and recovery of clover vigour can take up to 4 months. In the present study thifensulfuron-methyl damaged clover at all rates and the effects were still apparent after 5 months, supporting the label warning. There is also evidence, particularly in the new pasture, that this herbicide was toxic towards the grass since, despite the increasing damage to the clover with increasing rate that presumably would have resulted in reduced competition from the clover, the grass yield continued to decline (Figure 1b). This supports the results of an earlier study in which the ryegrass dry mass in a ryegrass/white clover sward as a percentage of the total sward was reduced with a four-fold increase in the rate of the herbicide (Rahman & Martin 1989).

Figure 3 Reduction in biomass of 4-month-old giant buttercup plants over time after herbicide treatment applied at label rate (flumetsulam, 52 g ai/ha; thifensulfuron-methyl, 10 g ai/ha; MCPA, 1.25 kg ai/ha). Data are the mean of 15 populations (82 pots per treatment).

Figure 4 Dose responses (biomass, g) of 4-month-old giant buttercup to flumetsulam, thifensulfuron-methyl and MCPA at 101 days after treatment. Data are the mean of 15 populations (82 pots per treatment). Vertical bar is LSD ($P=0.05$).

The herbicides differed in both their overall effects on 4-month-old giant buttercup plants and the speed at which those effects took place. MCPA reduced the biomass of the weed quickly and effectively, while the two ALS herbicides were much slower to act, taking about 2 months to reduce biomass levels to <10%. Furthermore, thifensulfuron-methyl was not totally effective and regrowth occurred after about 3 months. This is important for farmers to consider when spraying because the expected increase in productivity from controlling the weed would be realised more slowly with the ALS chemicals.

When comparing the effects of these herbicides at their respective label rates on giant buttercup plants, flumetsulam and MCPA gave best control (99% and 98%, respectively), while thifensulfuron-methyl was less effective (78% control). The rate of thifensulfuron-methyl would, according to these results, need to be at least doubled to achieve a similar level of control to flumetsulam. The rate of flumetsulam could be reduced somewhat, whilst still giving a high level of control of giant buttercup but, because higher rates were damaging to clover, there is no scope for increasing the rate should resistance develop, as some farmers have reported doing. In contrast, rates could not be reduced for either MCPA or thifensulfuron-methyl without sacrificing efficacy as rates below the label gave poor control. However, these results on 4-month plants are only an indication of relative efficacy against the species as results may differ for mixed-age plants in the field, which may be more tolerant of herbicides.

The results of this study have shown that the use of two herbicides marketed as 'selective' (MCPA and thifensulfuron-methyl) can have a serious detrimental effect on pasture composition. Although the grass tended to partially compensate for the removal of the clover there was, overall, less total biomass produced. This, together with the removal of the giant buttercup, would inevitably result in an opening up of the sward, which could promote the ingress of giant buttercup and other weeds by allowing the establishment of seedlings. This may be another factor contributing to

the lack of pasture persistence, which has been widely reported in dairy pastures, caused by ingress of weedy species from the seedbank in weakened or damaged pasture (Tozer et al. 2010). Therefore, removing giant buttercup without any follow-up to prevent seedling establishment may be only a short-term solution to improving pasture production.

Given these results, flumetsulam appears the best herbicide choice because of its efficacy and tolerance by pasture. However, it is a more expensive product and has a disadvantage of a longer interval for its effect to occur. When farmers are contemplating spraying pastures for giant buttercup control they need to carefully consider the consequences of using herbicides that can damage the pasture and weigh this up against the benefits of removing the weed. Also, they need to consider the optimum timing of spraying to maximise these benefits. Both flumetsulam and MCPA have recommendations for spraying giant buttercup in spring or autumn. It may be preferable to spray in the autumn at the end of the milking season so that pasture quality is not compromised during the peak of milk production and to allow the herbicide time to remove the weed before the next season begins.

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REFERENCES

- Bourdôt GW, Hurrell GA 1988. Differential tolerance of MCPA among giant buttercup (*Ranunculus acris*) biotypes in Takaka, Golden Bay. Proceedings of the 41st New Zealand Weed and Pest Control Conference: 231-234.
- Bourdôt GW, Hurrell GA, Saville DJ 2007. Variation in the efficacy of a mycoherbicide and two synthetic herbicide alternatives. XII th International Symposium on Biological Control of Weeds: 507-511.

- Bourdôt GW, Saville DJ 2010. Giant buttercup - a threat to sustainable dairy farming in New Zealand. Proceedings of the Australasian Dairy Science Symposium. Lincoln University, New Zealand. Pp. 355-359.
- Bowran D, Wilson B, Swarbrick J 1993. Differential response of four pasture legume species to broad-leaf herbicides. Proceedings of the Queensland Weed Society Conference: 181-185.
- Ceballos R, Palma G, Brevis H, Ortega F, Quiroz A 2005. Effect of five post-emergent herbicides on red clover shoot and root growth in greenhouse studies. *Phytoprotection* 85: 153-160.
- Gilmour JG 1996. Broadstrike and Broadstrike+diuron use in subterranean clover and medic pastures in Western Australia. Proceedings of the 11th Australian Weeds Conference. Pp. 326-330.
- Gomand M, Luxen P, Salembier JF 1991. Trials for control of *Rumex* in permanent pasture with metsulfuron-methyl. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* 56: 701-709.
- Harris BM, Husband BM 1997. Flumetsulam for control of giant buttercup in pasture. Proceedings of the 50th New Zealand Plant Protection Conference: 472-476.
- Harris SL, Auldish MJ, Clark DA, Jansen EBL 1998. Effects of white clover content in the diet on herbage intake, milk production and milk composition of New Zealand dairy cows housed indoors. *Journal of Dairy Research* 65: 389-400.
- Popay AI, Barlow ND, Bourdôt GW 1989. Economics of controlling *Ranunculus acris* in New Zealand dairy pastures. Proceedings of the Brighton Crop Protection Conference, Weeds 3: 943-948.
- Rahman A, Martin A 1989. Pasture tolerance to spring applications of the herbicide thiameturon-methyl. Proceedings of the 42nd New Zealand Weed and Pest Control Conference: 35-38.
- Tozer K, Barker G, Cameron C, James T 2010. Relationship between seedbank and above-ground botanical composition during spring. *New Zealand Plant Protection* 63: 90-95.
- Young S ed. 2009. New Zealand Novachem Agrichemical Manual. Agrimedia Ltd, Christchurch, New Zealand. 779 p.