THE TOXICITY OF HERBICIDES TO THE GORSE SPIDER MITE *TETRANYCHUS LINTEARIUS*

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SUMMARY

The development of integrated control strategies for control of gorse, *Ulex europaeus*, requires an evaluation of the effects of herbicides on organisms introduced for biological control. The toxicity of four herbicides and four surfactants to adult female gorse spider mites, *Tetranychus lintearius*, was investigated in the laboratory. The herbicides were triclopyr, triclopyr plus picloram, glyphosate and metsulfuron. The surfactants were Silwet L-77, Triton X-45, Agral LN and Citowett. All herbicide and surfactant combinations except metsulfuron with either Triton X-45, Agral LN or Citowett were toxic to gorse spider mites.

INTRODUCTION

Integration of chemical, cultural and biological controls provides the strategic base for future insect pest, plant pathogen and weed control. Gorse is a significant weed in New Zealand to which chemical and cultural methods have been the primary focus for control. Biological controls for gorse have received increasing attention (Hill 1987) culminating in the introduction and release of the gorse spider mite in 1988 (Hill *et al* 1989). No single strategy is likely, however, to provide complete control of gorse. Herbicides and cultural methods will continue to be used, often in areas where gorse mites have been released.

The effects of chemicals on non-target beneficial arthropods are receiving increasing attention but comparatively few studies have reported on the effects of herbicides (Thieling and Croft 1988). Determination of the effects on gorse spider mite of the herbicides commonly used on gorse would permit the design of compatible control strategies. Herbicides could be used to enhance the effects of the gorse spider mite.

Although young gorse plants may be effectively controlled by some herbicides alone (Popay *et al* 1985) mature gorse requires the addition of a surfactant to get satisfactory wetting and penetration into the plant (Stevens *et al* 1988; Lane and Park 1984). The influence of surfactants, alone and with herbicides, also required investigation.

MATERIALS AND METHODS

A single strain of gorse spider mites was used in these experiments. The colony was obtained from DSIR Plant Protection, Lincoln and reared on potted gorse plants in a glasshouse with 16:8 L:D photoperiod at approximately 20°C.

Herbicides and surfactants used are listed in Table 1. Chemicals commonly used against gorse were selected for direct toxicity tests against gorse spider mite. The rates used (Table 1) were based on approximate field rates of the herbicides and surfactants. Two tests were conducted; the first tested the effects of the herbicides and surfactants alone, and a second assessed two herbicides in combination with the surfactants.

The slide dip method (FAO 1974) was used to assess the effect of the chemicals on 20 spider mites which had been transferred to a piece of double-sided 'ScotchTM' tape fixed to a microscope slide. Mites were placed dorsal side down onto the tape. Slides were dipped into a given aqueous solution of chemical or in a water-only control for 5 seconds. After dipping, the slides were left to drain on filter paper; any excess was carefully removed by tissue paper.

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TABLE 1: Chemicals and concentrations used for testing direct toxicity to gorse spider mites.

Trade Name	Chemical Name	ml product/litre	g ai/litre
Escort	metsulfuron	1.25 (g)	0.75
Grazon	triclopyr	3	1.8
Tordon BK*	triclopyr/picloram	3	1.2
Roundup	glyphosate	10	3.6
Silwet L-77	oxyethylene methyl siloxane	1	
Agral LN	nonylphenyl ethoxylate	1	
Citowett	alkylaryl polyglycol ether	0.2	
Triton X-45	alkylaryl polyether alcohol	2.5	

*Tordon Brushkiller NF

Treated slides were placed in covered plastic trays lined with moistened filter paper. Trays were held at $18 \pm 1^\circ\text{C}$, 70-80% RH and 24:0 L:D photoperiod. Mortality was assessed after 24 hours by gentle prodding with a fine (000) camel hair brush. Mites that did not move their legs were considered dead. Five replicates of 20 mites were used for each treatment.

Full dosage-mortality relationships were determined for three of the chemicals. Mortality was assessed using the slide dip method across a range of concentrations giving between 5 and 95% mortality. Six replicates of 20 mites were used at each concentration.

Direct toxicity data were analysed using ANOVA and Duncan's new multiple range test while dosage-mortality data were analysed using probit analysis with the POLO program (Russell *et al* 1977).

RESULTS

Field rate application of herbicides induced significant mortality of gorse spider mite when compared to a water-dipped control (Table 2). However, metsulfuron was relatively non-toxic, glyphosate moderately toxic and triclopyr and triclopyr/picloram highly toxic. All surfactants showed some toxicity to gorse spider mite. Silwet L-77 was extraordinary in giving 100% mortality (Table 2).

TABLE 2: Toxicity of herbicides and surfactants to adult female gorse spider mites 24 hours after slide-dip treatment at approximate field rates.

Herbicide	% Mortality	Surfactant	% Mortality
triclopyr	64a	Silwet L-77	100a
metsulfuron	7c	Agral LN	23b
glyphosate	29b	Citowett	24b
triclopyr/picloram	73a	Triton X-45	21b
control	2d	control	8c

Letters indicate significant differences, Duncans' new multiple range test ($P=0.05$).

Triclopyr and triclopyr/picloram have surfactants incorporated into their formulations so no additional surfactants would normally be added. Therefore, the toxicity of only glyphosate and metsulfuron in combination with each surfactant was determined (Table 3). Glyphosate plus each surfactant caused near 100% mortality, significantly increasing the toxicity caused by glyphosate alone. In contrast, metsulfuron plus Agral LN, Citowett and Triton X-45 gave negligible increases in direct toxicity. Metsulfuron plus Silwet L-77 did, however, give toxicity equivalent to glyphosate plus surfactants.

The more toxic chemicals, Silwet L-77, triclopyr and triclopyr/picloram, were subject to dosage-mortality tests to determine if toxicity to gorse spider mite fell rapidly as concentrations were lowered. The dosage mortality relationships show lethal

TABLE 3: Toxicity of glyphosate and metsulfuron with surfactants to adult female gorse spider mites 24 hours after slide-dip treatment at approximate field rates.

Herbicide and Surfactant	% Mortality
metsulfuron/Agral LN	12a
metsulfuron/Citowett	12a
metsulfuron/Triton X-45	14a
metsulfuron/Silwet L-77	98b
glyphosate/Agral LN	99b
glyphosate/Citowett	98b
glyphosate/Triton X-45	97b
glyphosate/Silwet L-77	100b
control	8a

Letters indicate significant differences, Duncans' new multiple range test ($P=0.05$).

TABLE 4: Dosage-mortality relationships for triclopyr, triclopyr plus picloram, and Silwet L-77 to adult female gorse spider mites.

Chemical	LC ₅₀ *	95% C.L.	Slope	SE
triclopyr	0.775	0.655-0.994	3.37	0.23
triclopyr/picloram	0.678	0.582-0.790	2.10	0.16
Silwet L-77	0.066	0.057-0.079	2.03	0.19

*LC₅₀ expressed as g ai/litre

concentrations (LC₅₀'s) well below recommended field rates with the toxicity of triclopyr decreasing more rapidly with decreasing concentrations than it did for triclopyr/picloram and Silwet-77 (Table 4).

DISCUSSION

Sustainable control of gorse is most likely to be achieved by the integration of chemical and cultural methods with the spread of the gorse spider mite. The colonial habit of the mite (Stone 1986) makes an integrated approach particularly important during the period when gorse spider mites are being established in New Zealand. Instant reductions in gorse vigour are unlikely in this establishment phase so there will be a need for some herbicide use. The selection of herbicides and their surfactants must now take into account their effects on the gorse spider mite.

Triclopyr and triclopyr/picloram were toxic to gorse spider mites in slide-dip tests. LC₅₀'s were below the minimum rates recommended for gorse control (O'Connor 1989) suggesting that even low rates of these chemicals are likely to prevent mite establishment. As currently formulated, these products would be unsuitable for an integrated programme of gorse control unless rates significantly lower than that recommended could be used to enhance the effects of gorse spider mites.

The need for effective wetting and penetration of gorse foliage, particularly of older, hardened foliage (Stevens *et al* 1988) means that surfactants are recommended for use with glyphosate and metsulfuron. While the direct toxicity of these products to the gorse spider mite is relatively low, more realistic results are obtained when combined with surfactants. The surfactants Triton X-45, Citowett and Agral LN alone were relatively non-toxic but in combination with glyphosate close to 100% mortality occurred. Metsulfuron remained relatively non-toxic to gorse spider mites when used either with Triton X-45, Citowett or Agral LN. These combinations show the greatest potential for use in integrated gorse control.

Silwet L-77 is the surfactant recommended for use with glyphosate and metsulfuron, but unlike other surfactants, Silwet L-77 is highly toxic to adult female gorse mites. This coincides with the findings of Stevens *et al* (1988) that the properties of the organosilicone Silwet L-77 on the plant are markedly different from those of the

nonorganosilicone surfactants. The steep slope of the dosage-mortality relationship with Silwett L-77 indicates that it would be unsuitable for use in integrated gorse control even at concentrations below the recommended rate.

While metsulfuron with nonorganosilicone surfactants is the combination of choice, further work is necessary on the toxicity to other life stages and the effects on reproduction and development before definitive recommendations can be made. Triclopyr and triclopyr/picloram are clearly toxic in their current surfactant-included formulation but different formulations may give differing toxicities.

The effects of the preferred herbicides on the nutritional value of the gorse for gorse spider mites should also be assessed. Gorse is a relatively low quality plant for arthropods so causing slow development and low fecundity (Hill 1982). Low nitrogen levels may be the key factor since both growth and fecundity are determined to some extent by available nitrogen in the host plant (Mattson 1980). Since stress is a factor in the mobilisation of nitrogen in plants, treating gorse with sublethal doses of herbicide may mobilise nitrogen which, in turn, may enhance gorse spider mite development. Complex relationships between the effects of low rates of herbicides, degree of gorse kill and gorse spider mite populations remain to be unravelled.

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