EFFECT OF ORGANOSILICONE SURFACTANTS ON THE CONTROL OF GORSE BY METSULFURON

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ABSTRACT

Three trisiloxane ethoxylate surfactants (0.1-0.5% v/v) were evaluated for their effects on the performance of metsulfuron on mature gorse. Uptake and translocation of the herbicide was quantified radiochemically and the comparative efficacy of spray formulations determined at a sub-lethal rate of herbicide. The surfactants performed similarly in enhancing uptake and translocation at likely aerial application rates, and increased the herbicidal effect of metsulfuron on gorse with increasing organosilicone concentration. These results are discussed in light of current recommendations for the use of metsulfuron for gorse control in New Zealand forestry.

Keywords: gorse, metsulfuron, organosilicone surfactant, herbicide efficacy

INTRODUCTION

Herbicides are essential tools in forest establishment but are often only effective on scrubweeds, such as gorse, with the addition of a suitable surfactant. The development of organosilicones as agrochemical adjuvants has enabled the pre-plant use of herbicides, such as glyphosate and metsulfuron, to control gorse in New Zealand at cost-effective rates of application. In forestry situations, gorse control is undertaken predominantly by aerial application of herbicide sprays (at <300 litres/ha) and organosilicone surfactant quality is critical for achieving evenness and consistency of kill.

Currently there are at least five organosilicone surfactants sold in the New Zealand market in addition to Pulse (Monsanto), which has been the New Zealand agrochemical industry standard for many years. This study compared the performances of two alternative organosilicones with Silwet L-77, in enhancing the efficacy of metsulfuron on gorse in a simulated aerial application.

METHODS

Plants

Gorse plants (*Ulex europaeus*) were raised in pots (150 mm) from seedlings gathered in the field. They were planted in a proprietary potting mix with added fertiliser and watered daily. Plants were raised in a glasshouse until well established (*ca.* one month) then moved and raised outdoors under light shade cloth. All plants went through a growth flush prior to treatment and were approximately 40 cm tall with mature and "field hardened" foliage at the time of treatment in mid-winter.

Chemicals

Metsulfuron (Escort; 60%; Du Pont) was prepared at 102 g/250 litres for uptake and translocation studies, and radiolabelled metsulfuron (Du Pont) was added prior to use at <0.1% of the total herbicide mass. The organosilicone surfactants, Break-Thru S 240 (S240) and a 1:1 blend of Break-Thru S 240+S 278 (blend) (Goldschmidt Chemical Corp, USA) and Silwet L-77 (L-77) were added separately to herbicide sprays for uptake/translocation studies. Rate of surfactant addition was 0, 0.1, 0.2, 0.4 and 0.5% v/v.

Uptake and translocation experiments

Droplets of spray solution containing radiolabelled herbicide were applied to fully

mature gorse spines (replicated on four separate plants) as described by Gaskin and Zabkiewicz (1988). At 24 h after treatment (HAT), treated spines and associated stem portions were excised from plants and washed with 2 x 4 ml water+ethanol (1+1) to recover unabsorbed herbicide. Washings were taken up in 13 ml ACS II scintillant (Amersham) and the radiolabel quantified by liquid scintillation counting (Packard 4430). Washed foliage was combusted in a Harvey OX500 Biological Oxidiser to determine the amount of radiolabel remaining in the treated tissue.

Foliar uptake was defined as radiolabel not recovered by washes and was calculated as a percentage of the applied dose. The amount of herbicide translocated out of the treated area was determined by difference. Translocation was expressed as a percentage of both applied and absorbed herbicide (Field *et al.* 1995). Experiments were analysed as a factorial design and treatments were compared using analysis of variance and least significant difference (LSD) tests. Variance stabilising transformations were made where necessary prior to analysis.

Spray efficacy experiments

Metsulfuron was prepared at the sub-lethal rate of 90 g/250 litres, to enhance differences between treatments, and surfactants were individually added to herbicide sprays at 0.1% and 0.4% v/v. Individually potted gorse plants were randomly allocated to treatments (10 reps) and each plant's height was measured prior to spray application. Spraying was undertaken on 3 July 1996 between 2-4 pm, temperature 10-13°C. Applications were made through hydraulic nozzles (TeeJet 80015 fan; 20 psi), which simulated the droplet spectrum which might be expected from aerial application through a conventional D8-45 nozzle (A. Vanner pers. comm.). Nozzles were mounted 115 cm above ground level (ie. pot surface) and spray was delivered via a calibrated tracksprayer. Plants were maintained under cover in a glasshouse for 48 HAT after treatment and then placed outdoors for symptoms to develop, with daily watering as required. Replicates were arranged in a completely randomised block design, which was re-randomised every eight weeks.

Plants were examined at regular intervals up to 29 weeks after treatment (21 January 1997), by which time the effects of herbicide treatment had developed fully. At this stage, individual plant health status was assessed and a damage rating assigned, where 1 = completely dead (no live tissue); 2 = severely damaged by herbicide, with no regrowth but some green stem; 3 = severely damaged by herbicide, with abnormal regrowth exhibiting herbicidal effects; 4 = damaged by herbicide, but normal regrowth exhibiting no herbicidal effects; 5 = healthy, no herbicidal effects. The mean damage rating was determined as the average of all replicates in a treatment. Following this, above-ground plant material was destructively sampled and live stem height recorded. Post-spray plant height was calculated as a percentage of the original pre-spray height and used as the primary indicator of treatment efficacy. Due to the lack of physical uniformity in gorse plants, weight assessments at harvest provided no useful information due to the inability to account for pre-spray plant variation.

Analysis of variance, for a completely randomised design, was performed on the mean damage rating of plants, the mean height of plants, and the mean harvest height as a proportion of the original plant height prior to treatment. Variance stabilising transformations were made where necessary prior to analysis. Treatments were compared using LSD tests.

RESULTS AND DISCUSSION

Uptake and translocation

All surfactants improved herbicide uptake (Table 1), which generally increased with increasing surfactant concentration (two to seven-fold). Uptake of metsulfuron was similar in the presence of all surfactants; there were no differences between them at any concentration ($P=0.05$), with the exception of the blend and L-77 at 0.4%.

TABLE 1: Uptake of metsulfuron (102 g ai /250 litres) into gorse 24 HAT (as % of applied ^{14}C -herbicide) with addition of surfactants.

Treatment	Concentration of surfactant (%)				
	0	0.1	0.2	0.4	0.5
metsulfuron	12	-	-	-	-
+ L-77	-	35	65	80	76
+ S240	-	37	57	70	74
+ blend	-	27	53	62	70

LSD ($P_{0.05}$) = 13

Translocation of metsulfuron 24 HAT, as a % of applied herbicide, ranged from 10-16% (Table 2). Surfactant addition had no effect on the mass of herbicide moving away from the point of application ($P=0.05$). When translocation was calculated as a proportion of the herbicide taken up by the plant (% of absorbed), all surfactants had a negative effect on the translocation process (Field *et al.* 1995), but there were no differences between them ($P=0.05$; Table 2). Surfactant-induced disruption of the phloem loading and/or translocation of systemic herbicides is well established for a wide range of surfactants, including organosilicones (Gaskin and Murray 1988; Gaskin and Zabkiewicz 1988). The inverse relationship between surfactant concentration and translocation of absorbed herbicide (Table 2) supports this interpretation.

TABLE 2: Translocation of metsulfuron (102 g ai/250 litres) in gorse 24 HAT, as % of applied (and % of absorbed)¹⁴C-herbicide, with addition of surfactants.

Treatment	Concentration of surfactant (%)		
	0	0.1	0.4
metsulfuron	10 (79)	-	-
+ L-77	-	10 (28)	12 (16)
+ S240	-	13 (34)	11 (16)
+ blend	-	10 (38)	16 (20)

LSD ($P_{0.05}$) = 8 (14)

Spray efficacy

The use of a sub-lethal dose of herbicide enables the effects of different surfactants on herbicide efficacy to be evaluated (Balneaves *et al.* 1993). The efficacy of metsulfuron on gorse was improved substantially by the addition of all three surfactants, and concentration had a marked effect (Table 3). These results reflect uptake trends (Table 1) but not translocation (Table 2), which emphasises the need for good spray coverage and foliar wetting of gorse. The special properties of organosilicone surfactants (Stevens *et al.* 1993; Goddard and Padmanabhan 1992), which improve spray retention and distribution on foliage, obviously contribute substantially to increasing the efficacy of metsulfuron on this species.

At the lower concentration (0.1%), the addition of L-77 resulted in slightly more damage to plants, but stem heights were similarly reduced with all surfactants ($P=0.05$; Table 3). There were no differences between surfactants in any assessment parameter at the higher concentration of 0.4% (Table 3), and it is expected that the performance of metsulfuron would be similar with the addition of either L-77, S240, or the blend, at this concentration.

TABLE 3: Control of gorse by metsulfuron (90 g ai/250 litres) with addition of organosilicone surfactants.

Treatment	Damage rating ¹	Mean	Mean	% original
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	(% of treated plants)					damage rating	green stem ht (cm)	green stem height
	1 ¹	2	3	4	5			
Untreated control	0	0	0	0	100	5.0 a	74 a	231 a
metsulfuron	0	10	10	30	50	4.2 a	51 b	150 b
+L-77 (0.1%)	20	70	10	0	0	1.9 c	32 c	79 c
+L-77 (0.4%)	70	30	0	0	0	1.3 d	4 d	13 d
+ S240 (0.1%)	0	30	50	20	0	2.9 b	38 bc	100 c
+ S240 (0.4%)	90	10	0	0	0	1.1 d	2 d	7 d
+blend (0.1%)	0	40	40	10	10	2.9 b	42 bc	104 c
+blend (0.4%)	80	20	0	0	0	1.2 d	4 d	13 d

Means within columns sharing common postscripts are not significantly different (LSD; $P_{0.05}$)

¹ Damage rating 1-5 (see Methods)

Currently there is no aerial recommendation for metsulfuron to control mature gorse. The demands of low volume aerial application are expected to necessitate the use of organosilicones at rates greater than 0.1%, both to optimise adhesion and retention of spray droplets on foliage (Forster and Zabkiewicz 1994) and to ensure rapid uptake of herbicide deposits. This requires confirmation in operational field trials.

CONCLUSION

The efficacy of metsulfuron on gorse was improved similarly by all three organosilicone surfactants at potential aerial application rates of 0.4% surfactant in 250 litres/ha spray volume. High rates of organosilicone are expected to provide more consistent control of mature gorse by metsulfuron in low-volume aerial spray applications.

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