Research reports

A comparison of surfactants to aid control of gorse and scotch broom with herbicides

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Summary

Of the surfactants tested, only Silwet L-77 significantly enhanced the efficacy of glyphosate on gorse when used at 2.16 and 3.24 kg a.i. ha^{-1} providing 100% mortality by 72 weeks. Frigate and Cidekick II appeared to antagonize glyphosate (3.24 kg a.i. ha^{-1}) control of gorse at the rates tested (2.0% and 0.75%, respectively). Metsulfuron-methyl at 120 g a.i. ha^{-1} achieved 100% mortality of gorse without surfactant; while at 90 g a.i. ha^{-1} the addition of Silwet L-77, Activator 90 or LI-700 gave faster brown-out and complete control. Bond appeared to antagonize metsulfuron-methyl. Triclopyr at 3.6 kg a.i. ha^{-1} gave 100% gorse mortality without surfactant; the addition of Silwet L-77, Frigate, or Cidekick II increased the speed of kill. These surfactants added to 2,4,5-T/picloram (4.32/0.3 kg ha^{-1}) boosted gorse mortality to 100%.

Complete mortality of Scotch broom was only achieved using glyphosate at 3.24 kg a.i. ha^{-1} with the addition of either Silwet L-77 and LI-700. Metsulfuron-methyl at 90 g a.i. ha^{-1} gave complete control but only with the addition of Silwet L-77. Activator 90 increased mortality of broom when added to both herbicides. Bond was ineffective with glyphosate and LI-700 was ineffective with metsulfuron-methyl (at the lower rate).

Table 1. Description of surfactants evaluated.

Trade name	Product description[1]	Rate used in spray trials[2] (vv)
Silwet L-77	organosilicone	0.5%
LI-700	750 g/litre soyal phospholipids, described as a dual action amphoteric surfactant. Disturbs leaf's waxy surface to ensure more rapid and increased absorption of applied herbicide.	0.5%
Bond	450 g/litre synthetic latex + 100 g/litre non-ionic surfactant. Claimed to ensure thorough crop coverage and reduces wash-off by rain 1 hour after application.	0.14%
Activator 90	850 g/litre alkyl polyoxyethylene ether and free fatty acids + 50 g/litre Isopropanol non-ionic surfactant. Described as providing quick wetting with uniform spreading characteristics over "hairy" and "waxy" plant surfaces.	0.125%
Frigate	A fatty amine ethoxylate 660 g/litre cationic surfactant. Developed for use with glyphosate in UK, Western Europe, and USA for difficult to control herbaceous weeds on agricultural or fallow land.	2.0%
Cidekick II	Derivative of isomeric terpenes (by-product from wood) which is blended with emulsifiers. Claimed to disrupt the waxy leaf surface to enhance stomatal penetration of spray mix. Also assists uptake via woody stems. It is recommended for use with several pesticides including triclopyr, hexazinone, and glyphosate.	0.75%

[1] Taken from product labels.

[2] Rates used were the highest recommended on product labels for hardy weed species with the exception of Silwet L-77. Earlier work (Balneaves and Fredric 1988) recommended that this product should be used at a rate ranging from 0.3-0.5% v/v.

Introduction

Gorse (*Ulex europaeus*) is a major weed in both plantation forestry and pastoral farming in New Zealand (Sandrey 1985, Balneaves and McCord 1990) and Scotch broom (*Cytisus scoparius*) is becoming so (Harman and Syrett 1990). Until 1989, 2,4,5-T (or products containing 2,4,5-T) was the herbicide most commonly used for gorse and broom control in New Zealand (Balneaves 1981). However, since its withdrawal from the market, other herbicides such as glyphosate (Roundup, 360 g a.i. L^{-1} glyphosate), metsulfuron-methyl (Escort, 600 g a.i. kg^{-1} metsulfuron-methyl ester), and triclopyr (Grazon 600 g a.i. L^{-1} triclopyr butoxy ethyl ester) formulations are now being used as replacement herbicides.

Trials have indicated that glyphosate and metsulfuron-methyl are effective on both gorse and broom when a suitable surfactant is added (Balneaves 1986, Davenhill and Preest 1986). Silwet L-77 has proved more effective than other surfactants tested when added to glyphosate and metsulfuron-methyl for control of gorse in New Zealand (Balneaves and Fredric 1988, Zabkiewicz and Gaskin 1989). It renders herbicides more rainfast, thereby improving spray performance in wet weather (Field and Bishop 1988, Thonke *et al.* 1989).

Many other surfactants are being introduced onto the market in New Zealand and no comparative studies have been made on these weeds. This paper presents results of two trials that compared Silwet L-77 with other surfactants (Table 1). Firstly, Bond, LI-700, and Activator 90 were added to glyphosate and metsulfuron-methyl to control young gorse and Scotch broom, and secondly, Frigate and Cidekick II were added to glyphosate, metsulfuron-methyl, triclopyr, and 2,4,5-T/picloram (Tordon Brushkiller 520, 200 g a.i. L^{-1}, 2,4,5-T iso-octylester, and 50 g a.i. L^{-1} picloram as a potassium salt) to control young gorse.

Material and methods

Plant material

Gorse and broom seedlings were raised in 6.5-litre pots (five plants per pot) initially in a glasshouse, then in a shadehouse, and finally in the open, until they were 18 months old, by which time they had flowered and seeded. At the time of spraying, plants were >70 cm in height and all were healthy. Gorse plants had about 10 cm of new shoot growth, and broom plants were in full leaf and had up to 15 cm of new shoot growth. The plants were watered 24 hours before spraying. Five pots (replications) of five plants received each treatment.

Table 2. Brown-out and recovery scores for gorse and Scotch broom (percent mean desiccation) by herbicide/surfactant treatments in Trial 1.

Weeks after spraying	No surfactant	Silwet L-77 (0.5%)	LI-700 (0 5%)	Bond (0.14%)	Activator 90 (0.125%)	No surfactant	Silwet L-77 (0.5%)	LI-700 (0.5%)	Bond (0.14%)	Activator 90 (0.125%)
(a) GORSE										
glyphosate			*2.16 kg ha^{-1}*					*3.24 kg ha^{-1}*		
6	0	80	0	0	0	0	80	0	0	10
18	0	100	0	10	0	10	97	10	0	5
30	0	100	10	20	0	10	100	10	0	0
42	0	100	5	10	0	30	100	10	0	0
72	0	100	5	10	0	30	100	10	0	0
metsulfuron-methyl			*90 g ha^{-1}*					*120 g ha^{-1}*		
6	20	40	40	20	50	20	50	25	20	30
18	90	97	87	80	97	100	100	97	95	100
30	90	100	100	100	100	100	100	100	100	100
42	95	100	100	92	100	100	100	100	95	100
72	92	100	100	85	100	100	100	100	90	100
(b) BROOM										
glyphosate			*2.16 kg ha^{-1}*					*3.24 kg ha^{-1}*		
6	55	80	50	35	55	35	80	80	20	80
18	50	90	50	30	50	25	97	100	40	95
30	40	92	50	25	50	25	95	100	40	100
42	0	75	20	10	50	25	100	100	40	85
72	0	25	20	10	50	0	100	100	30	40
metsulfuron-methyl			*90 g ha^{-1}*					*120 g ha^{-1}*		
6	80	60	60	62	70	56	60	70	55	70
18	95	90	80	85	90	90	92	82	72	77
30	98	95	85	87	92	95	90	87	90	95
42	75	100	60	50	95	75	95	72	75	95
72	20	100	0	50	75	20	100	50	50	75

Herbicide, surfactant treatment, and application

Trial 1: Treatments to both gorse and broom plants were glyphosate and metsulfuron-methyl at two rates (2.16 and 3.24 kg a.i. ha^{-1} and 90 and 120 g a.i. ha^{-1}, respectively), on their own and with the addition of one of four surfactants: Silwet L-77, LI-700, Bond, and Activator 90, and plants with surfactant only. Unsprayed plants served as the control.

Trial 2: Four herbicides were applied at a single rate to gorse (glyphosate 3.24 kg ha^{-1}; metsulfuron-methyl 120 g ha^{-1}; triclopyr butoxy ethyl ester 3.6 kg ha^{-1}; and 2,4,5-T/picloram in a proprietary mix (4.32/0.3 kg ha^{-1})), either alone or with the addition of Silwet L-77, Frigate, or Cidekick II.

All treatments were applied in water by a CO_2 boom spray unit fitted with six 730077 T-jet nozzles, operating at a pressure of 275 kPa to give an equivalent total spray volume of 300 litres ha^{-1}. Spraying for both trials was done between 8:30–9:00 am in fine weather, (temperature 14–16°C, relative humidity 73–62%). The plants were sprayed inside a spray cabinet to reduce drift and optimize spray deposition. After treatment the plant pots were trenched into rotted bark/sawdust and watered by overhead irrigation 24 h later.

Assessment and statistical analysis

Visual assessments of desiccation (percent brown-out of green foliage) and recovery were made at 6-weekly intervals for 72 weeks after treatment. The data presented are the mean scores of three assessors. At the completion of the trials all plants were destructively sampled to determine mortality accurately. Mortality data were analysed by simple chi-square.

Results

Trial 1, Gorse

Glyphosate without surfactant had little to no effect on gorse (Table 2a). With the addition of Silwet L-77, 100% desiccation was achieved within 18 weeks of treatment (Table 2) and total plant mortality at 72 weeks (Table 3). Activator 90 gave no improvement in gorse mortality with glyphosate and while LI-700 and Bond improved mortality ($P \leq 0.05$) this was of no pratical worth.

Metsulfuron-methyl at 90 g a.i. ha^{-1} without surfactant gave at least 90% desiccation after 18 weeks. The addition of Silwet L-77, LI-700, or Activator 90 increased this to 100% after 30 weeks (Table 2), and total plant mortality was evident at 72 weeks for the higher rate (Table 3). When Bond was

Table 3. Plant mortality (percent) in Trial 1, 72 weeks after spray application

Surfactant	No herbicide	glyphosate 2.16 kg	glyphosate 3.24 kg	metsulfuron methyl 90 g	metsulfuron methyl 120 g
Gorse					
Nil	0 [ns1]	0 [a2]	60 [c]	93 [b]	100[b]
SilwetL-77	5	100 [d]	100 [d]	100 [c]	100[b]
LI-700	0	26 [c]	33 [b]	100 [c]	100[b]
Bond	0	10 [b]	0 [a]	70 [a]	90[a]
Activator 90	0	0 [a]	0 [a]	100 [c]	100[b]
Scotchbroom					
Nil	0 [ns]	0 [a]	10 [a]	20 [a]	20[a]
SilwetL77	0	25 [b]	100 [d]	100 [d]	100[d]
LI-700	0	30 [b]	100 [d]	20 [a]	83[b]
Bond	0	25 [b]	30 [b]	83 [b]	92[c]
Activator 90	0	75 [c]	83 [c]	92 [c]	92[c]

[1] ns = differences within that column are not significant (chi-square analysis)

[2] Within species, columns means sharing common postscripts are not significantly different ($P \leq 0.05$)

Table 4. Control of gorse: mean percent desiccation by herbicide/surfactant treatments in Trial 2.

Weeks after spraying	No surfactant	Silwet L-77 (0.5%)	Frigate (2.0%)	Cidekick II (0.75%)
glyphosate (3.24 kg ha^{-1})				
6	20	40	15	10
18	80	100	70	40
30	90	100	85	80
42	95	100	75	75
72	0	100	5	0
metsulfuron-methyl (120g ha^{-1})				
6	10	20	0	10
18	60	80	40	40
30	100	97	100	90
42	100	100	100	100
72	100	100	100	100
triclopyr (3.6 kg ha^{-1})				
6	0	20	0	0
18	20	80	70	70
30	90	100	100	100
42	100	100	100	100
72	100	100	100	100
2,4,5-T/picloram (4.32/0.3 kg ha^{-1})				
6	20	60	10	20
18	80	100	80	100
30	90	100	100	100
42	80	100	100	100
72	80	100	100	100

added metsulfuron-methyl was less effective and by 42 weeks some gorse regrowth was evident at both rates of herbicide. As 100% mortality was achieved at the higher rate of metsulfuron-methyl without a surfactant, Bond therefore apparently antagonizes metsulfuron-methyl.

Silwet L-77 was the only surfactant that affected gorse on its own. While not shown in Table 2 desiccation of plants of up to 30% but only 5% of the sprayed plants died (Table 3).

Broom

Glyphosate gave very poor control of broom at 2.16 kg ha^{-1}, with or without a surfactant, but at 3.24 kg ha^{-1} achieved total desiccation and mortality when Silwet L-77 or LI-700 was added (Table 2b and 3). Activator 90 also enhanced glyphosate activity against broom, but Bond had little effect.

Metsulfuron-methyl was more effective than glyphosate, but achieved total desiccation and mortality of broom only when Silwet L-77 was added, also significantly better control was achieved by adding Bond or Activator 90 (P≤0.05). The addition of LI-700 did not improve the efficacy of metsulfuron-methyl at 90 g ha^{-1}, but did offer considerable improvement at the higher rate (120 g ha^{-1}) (Table 2b and 3).

Trial 2

Metsulfuron-methyl and triclopyr without surfactants achieved 100% mortality of gorse by 72 weeks. However, addition of Silwet L-77 increased speed of desiccation by all four herbicides, with 100% desiccation occurring within 18–30 weeks of application (Table 4) and 100% mortality being confirmed at 72 weeks. Frigate and Cidekick II reduced desiccation and mortality by glyphosate and marginally slowed the action of metsulfuron-methyl. However, these two surfactants when added to triclopyr decreased the time taken to achieve 100% desiccation and the final mortality. When added to 2,4,5-T/picloram they enhanced control, which increased to 100% from the 80% achieved by the herbicide alone (P≤0.05).

Discussion

Effective control of gorse can be obtained using metsulfuron and triclopyr ester without addition of a surfactant. However, with glyphosate or 2,4,5-T/picloram better control could be achieved if a suitable surfactant is used. Surfactants can aid control of plants, especially if spraying, when plants are growing in droughty conditions (Wills 1978, Balneaves 1985) or if rain falls soon after spraying (Rao *et al.* 1976). As these trials have shown, the use of surfactants can also enable a reduction in the quantity of herbicides used. Jordan (1981) and Turner (1985) also alluded to this in their work with glyphosate. However, incorrect use of surfactants or the use of an inappropriate surfactant (McWhorter *et al.* 1980, Turner 1985, 1988) can reduce herbicide activity. In the trials described in this paper "Bond" significantly reduced metsulfuron-methyl activity against gorse, yet control of broom was improved. This confirms that some surfactants may be more effective with a herbicide against a specific weed species (Turner *et al.* 1988, Wells 1989).

This may be related to either the surfactants' ability to physically adhere to the plant cuticle or its mode of entry into the plant, viz., cuticular versus stomatal uptake. Either way there is the possibility that suitable surfactants could be developed that would assist selectivity such that crop species may be unharmed while target weed species are controlled. Examples have been noted already for arable crops (e.g., Chow and Taylor 1980, Turner 1085) and grass swards (Oswald *et al.* 1986). To date no work has been undertaken to test this hypothesis in a forest crop environment where brushweeds such as gorse and broom are major problems. It has been noted that radiata pine (*Pinus radiata*) is to some degree tolerant to metsulfuron-methyl (Langer 1992). Use of appropriate surfactants with metsulfuron-methyl could improve selectivity of the herbicide to effect control of the target weed while aiding tree tolerance to the active herbicide product.

For gorse control surfactant use is required to effect good control with glyphosate (Silwet L-77) and 2,4,5-T/picloram (Silwet L-77, Frigate, or Cidekick II). To achieve good control of Scotch broom with glyphosate, the addition of Silwet L-77 or LI-700 is essential and glyphosate must be used at 3.24 kg a.i. ha^{-1}. More recent work (Balneaves *et al.* in press) showed there is a highly significant interaction between herbicide and surfactant rate. That is as the rate of glyphosate increased the amount of Silwet L-77 could be reduced without lessening the efficacy of the herbicide. Even still without any added surfactant glyphosate could not provide more than 73% kill of gorse at the highest rate of 6.5 kg a.i. ha^{-1}. With the addition of an appropriate amount of Silwet L-77, complete mortality of gorse could be achieved with as little as 2.2 kg a.i. ha^{-1} glyphosate. Silwet L-77 aided effective control of Scotch broom with 90 g a.i. ha^{-1} metsulfuron-methyl.

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