Determining how soon ground covers can be planted in forests after applying metsulfuron

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Summary The relative susceptibility to metsulfuron residues in the soil of four ground cover species used for weed control in New Zealand pine forests was determined using a bioassay technique. Italian ryegrass (*Lolium multiflorum* Lam.) was the most tolerant; Yorkshire fog (*Holcus lanatus* L.) had an intermediate tolerance, while lotus (*Lotus pedunculatus* Cav.) and pink serradella (*Ornithopus sativus* Brot.) were the most sensitive. In another experiment, the number of months required after application of metsulfuron before Italian ryegrass and lotus could be safely planted in loamy sand, clay loam and scoria soils was investigated. For autumn sowings, 2–3 months were required to allow residues to dissipate, but for spring sowings, up to 8 months were required at times for lotus.

Keywords Ground cover, metsulfuron, forest, bioassay, *Lolium multiflorum, Lotus pedunculatus.*

INTRODUCTION

One form of weed control in New Zealand radiata pine (*Pinus radiata* D.Don) forests is to establish ground cover species, such as Yorkshire fog and lotus, between trees at establishment (Davenhill *et al.* 1994). These act to shade out seedlings of troublesome scrub weed species such as blackberry (*Rubus fruticosus* agg.) and provide fodder for cattle, which also helps reduce weed problems (West *et al.* 1991).

When land is prepared for planting of pines in New Zealand, existing weeds are often treated using a mixture of metsulfuron and glyphosate (Davenhill *et al*. 1994). Metsulfuron residues can affect the establishment of crops grown in soil soon after treatment (Rahman *et al.* 1991). Radiata pine seedlings are not recommended to be transplanted into treated soil within 2 months of spraying (Young 2009).

Little information exists on when ground cover species such as lotus can be safely planted into treated soil, so at present only extrapolation can be made from work on other species. For example, metsulfuron applied at 60 g a.i. ha^{-1} to a Horotiu sandy loam was no longer having major impacts on forage sorghum (*Sorghum bicolor* (L.) Moench) seedlings after 6 weeks and on white mustard (*Sinapsis alba* L.) after 8 weeks (James *et al.* 1995). However, white mustard and subterranean clover (*Trifolium subterraneum* L.) were still being affected 9 weeks after application of metsulfuron at 18 g a.i. ha^{-1} in work done by Rahman *et al*. (1991).

One objective of our work was to find out the relative susceptibility to metsulfuron residues of four different ground cover species used in forestry work. The length of time after metsulfuron has been applied at rates suitable for controlling scrub weeds before ground covers can be safely sown was also investigated for three soil types and at two times of the year when sowing is likely to occur, namely spring and autumn.

MATERIALS AND METHODS

Trial 1. Polythene planter bags were each filled with 1.8 L of Taupo yellow-brown pumice soil (3.7% organic carbon, pH 5.6). Metsulfuron (Escort™) was applied to the bags on 1 June 1994 at a range of rates (Figure 1) in order to produce dose response curves. The herbicide was applied in a water rate equivalent to 355 L ha^{-1} using a swinging pendulum sprayer similar to the one described by Wiese (1977). Bags were placed 35 cm below the pivotal centre of a swinging boom and herbicide was forced through two flat fan nozzles by compressed air at 200 kPa. The boom was released from the same height for each application, and a sheet of glass placed below the boom was weighed following application to calibrate the sprayer.

The treated pots were placed in a glasshouse (average temperature of 13.7°C) on moist felt mats that were irrigated daily from beneath. Each bag was planted with one of four species, namely Italian ryegrass cv. 'Concord', Yorkshire fog cv. 'Massey Basyn', lotus cv. 'Maku' or pink serradella cv. 'Koha'. Each combination of an application rate and species was replicated ten times, and compared with untreated pots. The damage to plants by the herbicide was scored 8 weeks after sowing (where 0 = no effect and 10 = dead plants), and all plants were cut from the pots after 23 weeks and their fresh weight immediately recorded and compared with the fresh weight from untreated pots. Standard errors were calculated for all means. For each application rate of metsulfuron, the relative susceptibility between bioassay species was compared using a multiple t-test (SAS 9.2, SAS Inst. Inc., Cary, NC).

Trial 2. At monthly intervals, 1.8 L planter bags were filled with one of three soil types taken from New Zealand pine forests, namely a Mamaku loamy sand from west of Rotorua, a Marua light brown clay loam from north of Whangarei and a Haroharo gravel (which has a deep layer of Tarawera lapilli over a rhyolite ash (Taylor and Pohlen 1954)) from near Kawerau. Characteristics of each soil are shown in Table 1. Once filled, the bags were sprayed with metsulfuron at 45 or 90 g a.i. ha^{-1} using a precision gas-powered plot sprayer with a water rate of 500 L ha^{-1}, and some bags were also left unsprayed.

Once the bags were sprayed, they were exposed to the weather at an unirrigated nursery standing-out area at Kimbolton, Manawatu, at an altitude of 460 m. In April 1994, bags were then sown with either Italian ryegrass or lotus, so that there were treatments of metsulfuron at 0, 45 or 90 g a.i. ha^{-1} for each soil type that had been sprayed 0, 1, 2, 3, 4, 5 or 6 months prior to sowing with either Italian ryegrass or lotus, with each treatment replicated five times. In September 1994, the trial was repeated using another series of bags with identical treatments except there were also bags that were treated 7 and 8 months prior to sowing. Bags were irrigated once sowing occurred so water was not limiting to establishment of seedlings.

The effect of herbicide residues on the seedlings was determined by scoring seedlings for herbicide damage 10 weeks after sowing for April-sown pots and 9 weeks after sowing for September-sown pots. Scores for plants growing in herbicide-treated soil were compared with those for plants from untreated pots using multiple t-tests.

RESULTS

Trial 1. Results from the first trial indicated that Italian ryegrass was the most tolerant of the four species tested to residues of metsulfuron present in the soil (Figure 1). Lotus and pink serradella were similar in susceptibility and were more sensitive than the grasses tested, while Yorkshire fog had an intermediate tolerance.

Scores have been presented in this paper rather than dry matter results as the latter had much more variability, which was partly due to an apparent stimulation of plant growth at sub-toxic doses.

A comparison of the curves at a similar score such as 4.0 suggests that Italian ryegrass is about 10 times more tolerant of metsulfuron than lotus or yellow serradella, whereas Yorkshire fog is about three times more tolerant than the legumes.

Metsulfuron levels would need to fall to a level giving a score of 4 or less before sowing of a ground cover could be considered viable; for Italian ryegrass this equates to a rate of about 20 g a.i. ha^{-1}. Metsulfuron is recommended to be applied at 100 g a.i. ha^{-1} for clearance of scrub weeds in forestry blocks prior to planting pines (Young 2009), so residues would need to drop to 20% of this prior to sowing Italian ryegrass. To sow lotus, it would need to fall to 2% of the initial use rate applied. However, metsulfuron is usually applied with glyphosate so the rate of metsulfuron used is reduced, which is why 45 and 90 g a.i. ha^{-1} were used in Trial 2.

Table 1. Characteristics of the Marua light brown clay loam, Mamaku loamy sand and Haroharo gravel used in Trial 2.

Variable	Clay loam	Loamy sand	Gravel
pH	4.3	5.2	5.6
% gravel	0.0	1.3	20.7
% sand	12.3	53.5	67.3
% silt	62.5	38.0	10.3
% clay	25.2	7.2	1.7
Olsen P	9	4	10
CEC	19	23	16
% OM	8.8	14.1	7.6

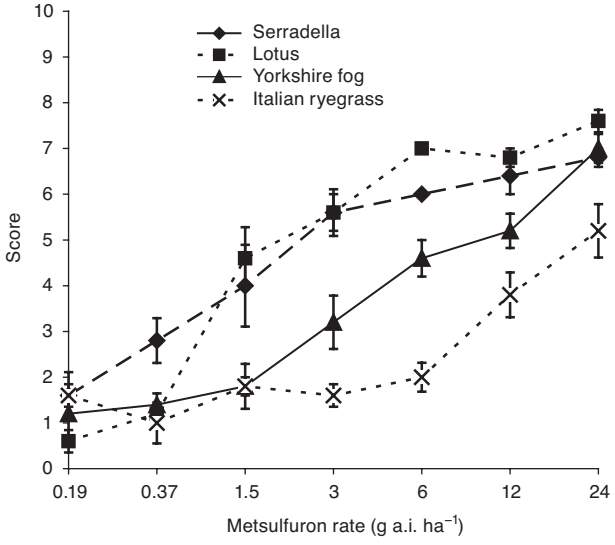

Figure 1. The score (where 0 = healthy and 10 = dead) of plant species 8 weeks after being sown into soil with differing levels of metsulfuron residues. Vertical bars are ± standard errors.

Trial 2. Tables 2 to 4 indicate the months after spraying metsulfuron that are needed before the herbicide residues no longer significantly affect the score of plant health. For the clay loam soil, the results in Table 2 suggest that metsulfuron at 90 g a.i. ha^{-1} should not be applied within 6 months of a spring sowing of Italian ryegrass. In contrast, for the gravel soil metsulfuron at 90 g a.i. ha^{-1} had dissipated after 2 months to allow safe sowing of Italian ryegrass, and the loamy sand had no harmful residues present 1 month after application. Results were very similar for metsulfuron at 45 g a.i. ha^{-1}.

For lotus, a waiting period of 8 months was necessary in the clay loam soil if sowing in spring for either rate of metsulfuron (Table 3). In the gravel soil, results were more variable with a 7 month plant-back period required. In the loamy sand, lotus could be safely planted 2 months after application of metsulfuron. Although significant differences from the untreated control plants in the loamy sand were detected in later months, the scores were so low that these plants were not affected.

For Italian ryegrass sown in autumn, there was less difference between soil types than for spring-sown plants. For all three soil types, 3 months were needed before metsulfuron residues were no longer having significant effects on the grass seedlings at either application rate (Table 4).

Similar results were obtained for lotus when metsulfuron at 45 or 90 g a.i. ha^{-1} was applied 3 months prior to an autumn sowing of this species in any of the soil types without significantly impacting on its establishment (Table 5).

Table 2. The score (0 = healthy, 10 = dead) of Italian ryegrass health 9 weeks after being planted in spring in media sprayed with metsulfuron at 45 or 90 g a.i. ha^{-1} 0 to 8 months prior.

	Clay loam		Loamy sand		Gravel	
Month	45 g	90 g	45 g	90 g	45 g	90 g
0	9.6[A]	10.0	5.2	6.8	5.4	8.6
1	7.6	8.8	3.8	3.0	4.8	6.2
2	5.2	5.6	1.8	2.2	3.6	3.4
3	3.4	6.2	3.6	4.4	1.8	3.0
4	5.4	5.4	2.8	2.0	2.4	3.2
5	5.0	8.0	2.0	2.8	1.0	3.6
6	6.6	7.0	2.6	4.6	2.0	3.4
7	5.8	5.6	0.4	2.4	2.6	2.6
8	4.2	4.6	1.4	2.0	0.4	1.8

[A] Underlined means are significantly (P <0.05) less healthy than untreated plants grown in the same soil type exposed in pots for the same time period.

Table 3. The score (0 = healthy, 10 = dead) of lotus health 9 weeks after being planted in spring in media sprayed with metsulfuron at 45 or 90 g a.i. ha^{-1} 0 to 8 months prior.

	Clay loam		Loamy sand		Gravel	
Month	45 g	90 g	45 g	90 g	45 g	90 g
0	10.0[A]	10.0	8.8	8.6	9.6	10.0
1	10.0	9.8	6.0	6.4	9.0	9.8
2	7.2	7.8	2.2	2.4	3.4	6.8
3	6.8	8.6	3.6	3.8	2.2	3.6
4	7.6	10.0	2.6	3.2	4.8	6.4
5	8.6	9.6	2.8	4.0	6.2	8.0
6	8.6	8.6	2.0	2.4	4.0	8.6
7	6.2	7.6	1.2	1.4	2.4	5.4
8	2.8	4.0	2.4	2.6	0.8	1.6

[A] Underlined means are significantly (P <0.05) less healthy than untreated plants grown in the same soil type exposed in pots for the same time period.

Table 4. The score (0 = healthy, 10 = dead) of Italian ryegrass health 10 weeks after being planted in autumn in media sprayed with metsulfuron at 45 or 90 g a.i. ha^{-1} 0 to 6 months prior.

	Clay loam		Loamy sand		Gravel	
Month	45 g	90 g	45 g	90 g	45 g	90 g
0	8.6[A]	8.8	7.2	7.4	7.6	8.6
1	6.2	6.2	6.0	6.0	3.4	5.8
2	6.2	6.2	4.6	6.8	2.4	4.8
3	3.0	3.4	1.0	1.2	0.6	1.0
4	3.0	4.2	1.6	1.4	0.8	0.8
5	1.8	3.8	1.2	1.8	0.6	1.2
6	6.8	6.6	2.2	1.8	1.4	0.8

[A] Underlined means are significantly (P <0.05) less healthy than untreated plants grown in the same soil type exposed in pots for the same time period.

Table 5. The score (0 = healthy, 10 = dead) of lotus health 10 weeks after being planted in autumn in media sprayed with metsulfuron at 45 or 90 g a.i. ha^{-1} 0 to 6 months prior.

	Clay loam		Loamy sand		Gravel	
Month	45 g	90 g	45 g	90 g	45 g	90 g
0	8.2[A]	8.4	8.6	9.6	8.8	8.6
1	7.0	8.2	7.0	7.8	7.4	8.6
2	2.6	4.2	3.6	4.6	4.6	5.2
3	1.2	2.2	2.0	2.2	2.0	2.2
4	1.8	2.0	2.0	2.0	0.8	1.2
5	1.2	1.0	1.4	1.4	1.0	0.8
6	1.2	1.0	1.4	1.2	1.2	0.8

[A] Underlined means are significantly (P <0.05) less healthy than untreated plants grown in the same soil type exposed in pots for the same time period.

DISCUSSION

Variability existed in the results, and some of this resulted from the soil being affected differently by being left exposed to raindrop impaction often for many months, compacting the surface layers and leaching nutrients from the soil. As a result a score of 3.0, for example, was significantly different from the untreated control in some situations and not others, because often seedlings in untreated pots looked chlorotic or stunted due to lack of nutrients or compaction of the soil.

Despite this problem, the trial has given indications of how soon before sowing of ground covers in forests that metsulfuron can be applied without affecting establishment of the seedlings. Residues appear to dissipate sooner if applied at warmer times of the year (i.e. prior to an autumn sowing) than at cooler times of the year prior to a spring sowing. For both Italian ryegrass and lotus, sowing 2 months after metsulfuron applications caused some stunting of plants but after 3 months, it was generally safe. However, lotus was still being significantly affected by metsulfuron residues 7 months after application to the clay loam and gravel soils for spring sowing. Metsulfuron was less persistent in the loamy sand at this time of the year than for the other two soil types.

Metsulfuron is degraded mainly by chemical hydrolysis and microbial breakdown, so degradation occurs faster in soils that are moist, warm, light textured and low in pH (Beyer *et al.* 1988). This explains the more rapid degradation over the summer months when it was warmer. Although the clay loam was low in pH, it was also easily compacted within the pots, presumably creating fairly anaerobic conditions.

Therefore, if sowing ground covers in April, application of metsulfuron can be safely applied until January without affecting the seedlings. However, if sowing in September, residues from metsulfuron may persist for up to 7 months after an autumn/winter application.

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