TRICLOPYR—THE FOREST MANAGERS' ALTERNATIVE TO 2,4,5-T?

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ABSTRACT

Two triclopyr formulations (3,5,6-tricloro-2-pyridyloxyacetic acid) were evaluated at various rates sprayed over three tree species (*Pinus radiata* D. Don, *Cupressus macrocarpa* Hartweg, *Pseudotsuga menziesii* (Mirbel) Franco), and the likely impact on gorse (*Ulex europaeus* L.) regrowth after initial land clearing was assessed.

Post-plant release spraying with triclopyr is feasible if rates do not exceed 0.6 kg/ha. Release spraying should be carried out before the flush of new growth in the spring (for *Ps. menziesii*, before bud swell) to avoid apical death, multi-leadering, and reduced growth. Triclopyr should be used in preference to triclopyr + picloram as it is less damaging to tree seedlings and gives more effective gorse suppression for the first year after tree planting.

Keywords: tree tolerance; herbicides; weed control; *Ulex europaeus*; *Pinus radiata*; *Cupressus macrocarpa*; *Pseudotsuga menziesii*.

INTRODUCTION

For pre-planting control of scrubweeds in New Zealand forest plantations, metsulfuron methyl and glyphosate have proved efficient and cost-effective alternatives to 2,4,5-T when used with the surfactant Silwet L-77 (Balneaves 1987). These herbicides also control bracken (*Pteridium aquilinum* var. *esculentum* (Forst. f.) Kuhn.) (Dutkowski & Boomsma 1990). However, a selective herbicide that will give post-planting control of gorse and other scrubweeds without significantly damaging newly planted tree seedlings or any developing grass sward is also needed.

Terbuthylazine successfully controls very young gorse and broom (*Cytisus scoparius* L.) seedlings (Balneaves *et al.* in press), but also prevents the development of the dense grass sward that ensures longer-term control of scrubweeds (Balneaves & McCord 1990). In 1988 Ivon Watkins-Dow (now Dow Elanco) Ltd released two new scrubweed herbicides on the New Zealand market. The active ingredient is triclopyr (3,5,6-tricloro-2-pyridyloxyacetic acid) in the form of an emulsifiable concentrate, with or without the amine salt of picloram. Triclopyr is a selective systemic herbicide that is absorbed by the foliage and roots and translocated throughout the plant, accumulating in meristematic tissue (Anon 1989). In New Zealand it is recommended for the control of woody plants and many woody weeds (e.g., gorse, broom, blackberry (*Rubus fruticosus* agg.).

The products released in New Zealand are classed as non-volatile (Anon 1989) so that off-site movement, caused by volatility, should not be a problem. However, as many tree and shrub species, edible crops, and clovers are susceptible to triclopyr, damage may be caused by direct spray drift.

Since there has been little experience in New Zealand with triclopyr as a release spray for newly planted tree seedlings, trials at the Forest Research Institute (FRI) nurseries tested triclopyr at various rates over *Pinus radiata* (Rotorua and Rangiora), *Pseudotsuga menziesii*, and *Cupressus macrocarpa* seedlings (Rangiora only) in a direct comparison with standard 2,4,5-T applications. Additional trials in the Selwyn Plantation Board forests, on the Canterbury Plains, tested the effectiveness of both formulations at low rates, to determine the level of control of seedling gorse.

TRIALS

Tolerance of Newly Planted Tree Seedlings to Triclopyr

At the Rangiora nursery, 78 plots (3 × 2 m) were laid out on a cultivated weed-free site on fertile Wakanui silt loam with a low organic content and pH of 4.8.

Six 1/0 seedlings each of *P. radiata* and *C. macrocarpa*, and six 2/0 *Ps. menziesii* were planted in each plot. Six replications of 13 treatments were applied in early November (4 months after planting): unsprayed control; triclopyr at 0.3, 0.6, 1.2, 1.8, and 2.4 kg/ha; triclopyr [+ picloram] at 0.15 [+50 g], 0.3 [+100 g], 0.6 [+200 g], 0.9 [+300 g], 1.2 [400 g] kg/ha; 2,4,5-T at 1.08 kg/ha; and 2,4,5-T [+ picloram] at 0.3 [+75 g] kg/ha. All plots were kept free of herbaceous weeds by regular hand-weeding.

Herbicides were applied in 300 *l* water/ha using a CO_2 boom spray unit fitted with six 730077 T-jet nozzles.

Heights of seedlings were measured 7 days after planting, then 1 and 2 years later. At time of spraying each seedling was scored for stage of growth—e.g., dormant or flushing for *P. radiata* and *C. macrocarpa*; dormant, bud swell, bud burst, and flushing (shoot extension greater than 2 cm) for *Ps. menziesii*. Health was assessed at 6-weekly intervals for the first year after spraying. Data analyses (Coanova, Anova, and chi-square tests) were carried out using GENSTAT and SAS packages.

A smaller trial of *P. radiata* tolerance was set up at the Rotorua nursery. Triclopyr + picloram at the five rates used for the Rangiora trials was applied over actively growing *P. radiata* seedlings that had been planted 4 months previously. Examination for tree damage was not as intense and growth data are available for 1 year only.

Gorse Control

Sixty-five 5 × 4-m plots were established in the Selwyn Plantation Board forests. The same 13 treatments were applied in a randomised block design to give five replications/treatment, except that the hand-weeded control was replaced by an untreated control.

At spraying, gorse seedlings ranged from cotyledonary size to seedlings up to 15 cm tall. Some stool regrowth after the initial land clearing by windrowing was evident but was not prolific. The visual brown-out score by three independent observers was assessed at 6-weekly intervals, and is presented in the results as percentage of ground cover occupied by live healthy gorse.

An additional evaluation trial for gorse control was set up at Galatea, Bay of Plenty. Plots were not inspected regularly and data are available for 1 year only.

RESULTS

Tolerance of Newly Planted Tree Seedlings to Triclopyr

Pinus radiata

No tree seedlings died in any of the treatments over the 2 years of the Rangiora trial. However, height growth was significantly less for all treatments than for the unsprayed control ($p \leq 0.05$) (Fig. 1). This difference was most pronounced for trees treated with triclopyr + picloram.

Height growth decreased as rate of triclopyr increased, significantly so for both formulations. Triclopyr + picloram reduced height significantly more than triclopyr alone ($p \leq 0.05$). Height growth for trees sprayed with 2,4,5-T was not significantly different from that for trees sprayed with triclopyr alone except at the highest rate (2.4 kg) of triclopyr, which significantly reduced height growth (Fig. 1a). Height growth at all application rates of triclopyr + picloram was significantly less than that with 2,4,5-T + picloram (Fig. 1b).

Height growth of *P. radiata* seedlings in the 1-year Rotorua trial was significantly reduced by increasing rates of triclopyr + picloram, especially when rates exceeded 0.3 [+100 g] kg/ha. At 0.15 or 0.3 kg/ha, tree height was similar to that for seedlings treated with either 2,4,5-T or 2,4,5-T + picloram (Fig. 1c).

As rates of triclopyr formulations increased in the Rangiora trial, mean height growth was reduced more for flushed seedlings than for non-flushed seedlings (Fig. 2), the differences becoming significant at the highest rates (2.4 kg, 1.2 [+400 g] kg; $p \leq 0.05$). Triclopyr alone had less effect than triclopyr + picloram.

Multi-leadering was evident on treated seedlings at Rangiora within 2 months of spraying and over all the treatments was significantly more frequent in flushed seedlings (≤50%) than in non-flushed seedlings (≤30%) ($p \leq 0.05$). The incidence of multi-leadering was greater on seedlings receiving triclopyr + picloram than on those receiving triclopyr alone ($p \leq 0.05$; Fig. 3). There was little difference between multi-leadering on flushed seedlings (16%) and non-flushed seedlings (12%) sprayed with the single rate of 2,4,5-T. However, 2,4,5-T + picloram caused a greater incidence of multi-leadering on flushed seedlings (24%) than on non-flushed seedlings (8%).

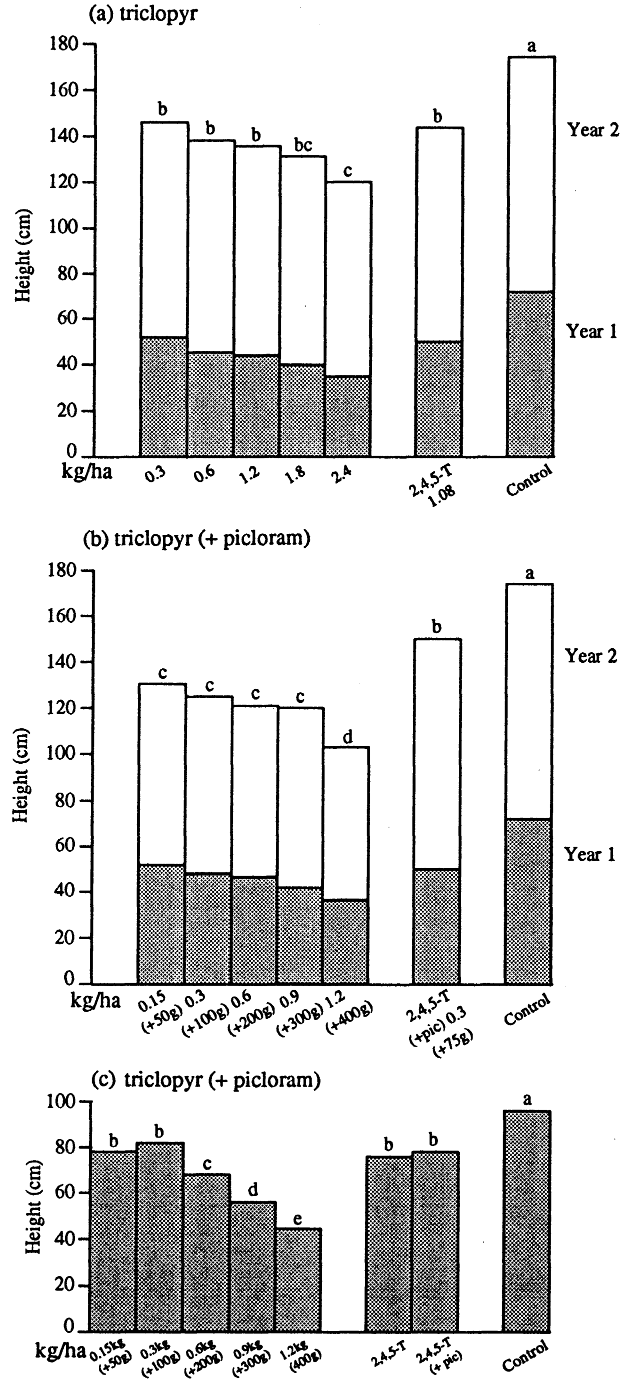


FIG. 1–Influence of treatment on height growth of *Pinus radiata*—(a) and (b) Rangiora 2-year trial, (c) Rotorua 1-year trial ($p \leq 0.05$).

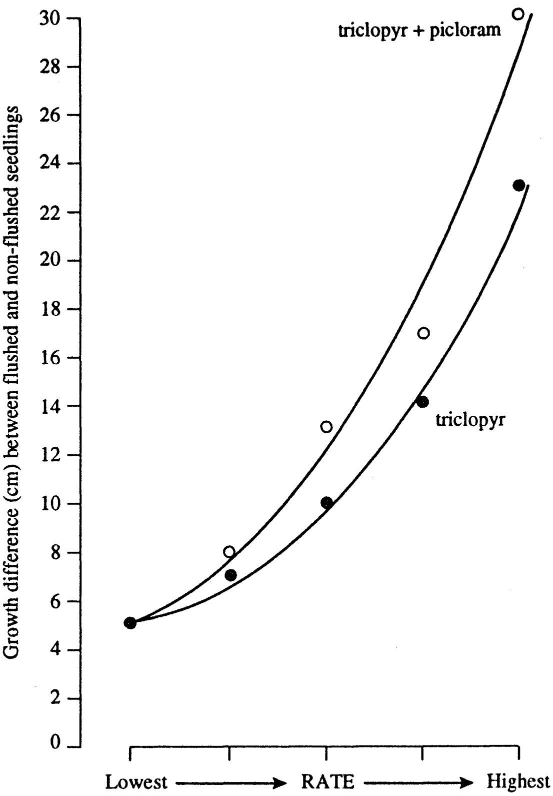
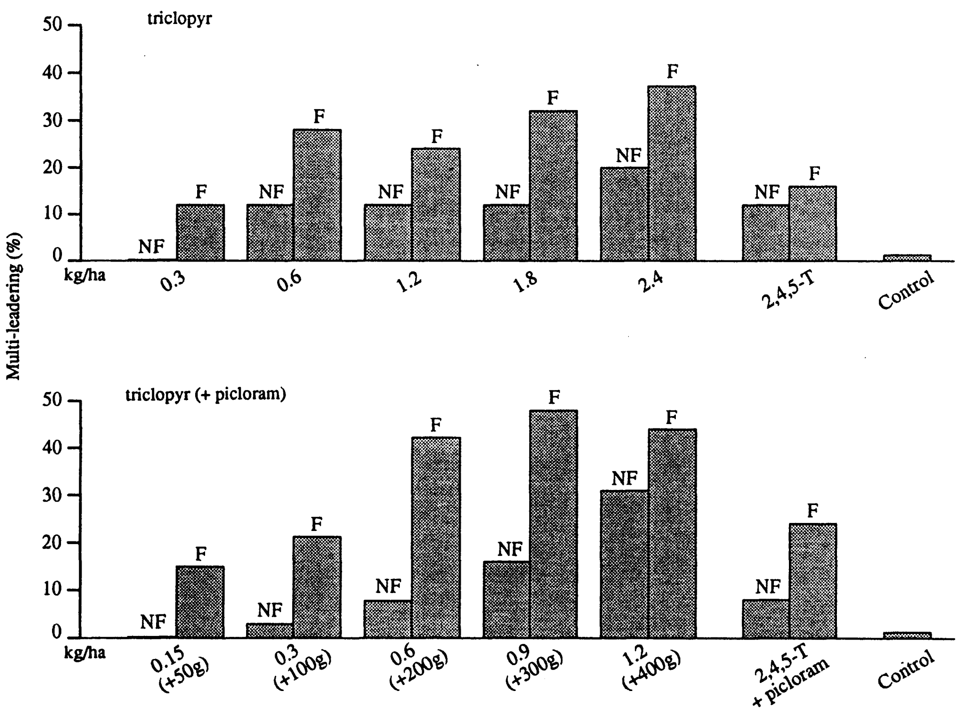


FIG. 2 (left)–Differences in mean total height (1 year after spraying) of *Pinus radiata* flushed or non-flushed at time of spraying.

FIG. 3 (below)–Percentage of *Pinus radiata* with multi-leaders 1 year after planting, in relation to herbicide treatment and condition of trees at spraying.



Multi-leadering was not as serious a problem at Rotorua as at Rangiora, except at the highest rate of triclopyr + picloram, when 45% of the seedlings had multi-leaders 1 year after planting compared with only 2% of the seedlings in the control plots.

Cupressus macrocarpa

Cupressus macrocarpa survival was significantly reduced by the higher rates of both triclopyr formulations, and triclopyr + picloram had the most deleterious effect, at rates higher than 0.15 [+50 g] kg/ha (Table 1). Survival was not significantly affected by 2,4,5-T, but was reduced by 2,4,5-T + picloram in the second year. Height growth was significantly reduced by all herbicides concomitantly with increasing rates. Applications of 2,4,5-T and 2,4,5-T + picloram resulted in a significant decline in *C. macrocarpa* growth. Diameter growth was also significantly reduced (Table 1). Triclopyr alone was less severe on seedling mortality and growth than when formulated with picloram.

Differences between responses of flushing and non-flushing seedlings to herbicide treatment could not be detected in this trial. Although some double or multi-leadering did occur, this did not appear to be related to herbicide treatment or rate used.

Pseudotsuga menziesii

Survival of *Ps. menziesii* was significantly affected only by the highest rates of the triclopyr formulations (Table 2). Height growth was more severely reduced by triclopyr + picloram than by triclopyr alone, which did not have much effect. However, this was largely dependent on the growth phase of the *Ps. menziesii* at time of spraying (Fig. 4). Triclopyr alone affected only flushed seedlings significantly ($p \leq 0.05$), and this was not consistent.

TABLE 1–Effect of herbicide treatment on mean survival and growth of *Cupressus macrocarpa* for years 1 and 2 (Y1, Y2) after planting.

Treatment		Survival (%)		Mean stem height (cm)		Mean diameter* (mm)	
Herbicide	kg/ha	Y1	Y2	Y1	Y2	Y1	Y2
Triclopyr	0.3	100a†	100a	131b	217b	26ab	57ab
	0.6	96a	96a	124c	203bc	24b	54b
	1.2	92ab	90b	117cd	189c	24b	53b
	1.8	87b	85b	113d	171d	20c	45d
	2.4	79c	75cd	112d	159e	19d	43de
Triclopyr [+ picloram]	0.15 [+50 g]	96a	96a	119c	193c	22bc	49c
	0.3 [+100 g]	79c	78c	115d	175d	21c	47cd
	0.6 [+200 g]	71d	69d	110d	155e	20cd	45d
	0.9 [+300 g]	71d	68d	105e	140f	18d	41e
	1.2 [+400 g]	58e	54e	94f	119g	17d	39e
2,4,5-T	1.08	96a	96a	122c	187cd	21c	48c
2,4,5-T [+ picloram]	0.3 [+75 g]	92ab	89b	115d	163e	18d	42e
Control		98a	98a	150a	236a	29a	63a

* Diameter taken at ground level.

† Column means sharing common postscripts are not significantly different ($p \leq 0.05$).

TABLE 2–Effect of herbicide treatment on mean survival and growth of *Pseudotsuga menziesii* for Years 1 and 2 (Y1, Y2) after planting.

Treatment		Survival (%)		Mean stem height (cm)		Mean diam.* (mm)	
Herbicide	kg/ha	Y1	Y2	Y1	Y2	Y1	Y2
Triclopyr	0.3	100a†	100a	51a	92a	11b	19b
	0.6	100a	100a	42b	84b	12b	19b
	1.2	100a	100a	42b	82b	12b	
18bc							
	1.8	100a	100a	39bc	78c	12b	19b
	2.4	98ab	96b	40bc	78c	11b	19b
Triclopyr [+ picloram]	0.15 [+50 g]	100a	100a	38c	77c	10bc	17c
	0.3 [+100 g]	100a	100a	38c	72d	9c	17c
	0.6 [+200 g]	100a	100a	36cd	67e	10bc	17c
	0.9 [+300 g]	97b	96b	35d	62ef	9cd	17c
	1.2 [+400 g]	96b	92c	32d	59f	9c	17c
2,4,5-T	1.08	100a	100a	44b	80bc	11b	19b
2,4,5-T [+ picloram]	0.3 [+75 g]	99a	96b	41b	75cd	11b	19b
Hand-weeded control		100a	100a	54a	98a	14a	23a

* Diameter taken at ground level.

† Column means sharing common postscripts are not significantly different ($p \leq 0.05$).

Seedlings showing bud swell, bud burst, or new shoot elongation were so severely desiccated by triclopyr + picloram that the mean height of the green stem 1 year after planting was less than the mean height at time of planting. Non-flushed seedlings were not checked at the lowest rate of triclopyr + picloram (0.15 [+50 g] kg), but as rate of application increased, the check in growth increased ($p \leq 0.05$).

The previously recommended rates of 2,4,5-T formulations also significantly reduced height growth in flushed seedlings.

Control of Gorse Regrowth

At time of spraying, 90% of the ground cover on the plots was gorse. The remaining ground cover was browntop (*Agrostis tenuis* Sibth.), sweet vernal (*Anthoxanthum odoratum* L.), and other grasses.

In the Canterbury trial, triclopyr at rates of 0.3 and 0.6 kg/ha gave similar control to 2,4,5-T, reducing gorse ground cover from 90% to 15–23% by 24 weeks. However, regrowth and new seedlings increased gorse cover to ≈70% by the end of the first year (52 weeks), and to >90% by the end of the second year in all three treatments (Fig. 5a). Triclopyr at rates ≥1.2 kg/ha achieved better initial control and restrained gorse ground cover to 20% or less for the first year and to 40% or less for the second year, significantly better than the lower rates ($p \leq 0.05$).

Triclopyr + picloram at the lower rates (0.15 [+50 g] kg/ha and 0.3 [+100 g] kg/ha) was less effective than triclopyr alone (at ≥0.3 kg/ha) for the initial 52 weeks after spraying (Fig. 5b). Better control was achieved by 2,4,5-T + picloram (0.3 [+75 g] kg/ha) than by the two lower rates of triclopyr + picloram. At the higher rates triclopyr + picloram reduced

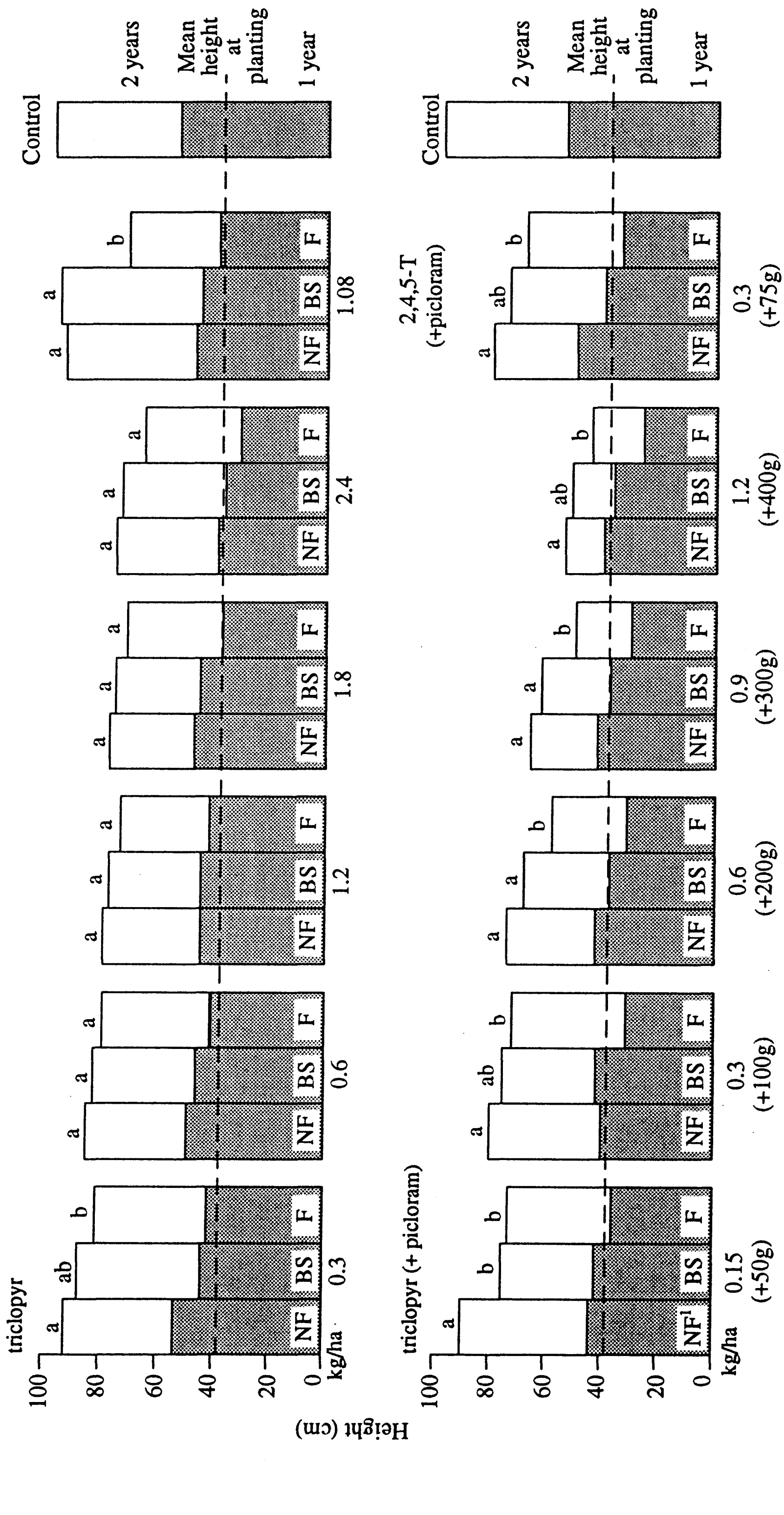


FIG. 4–Mean height of *Pseudotsuga menziesii* 1 year and 2 years after planting, in relation to growth stage and spray treatment.

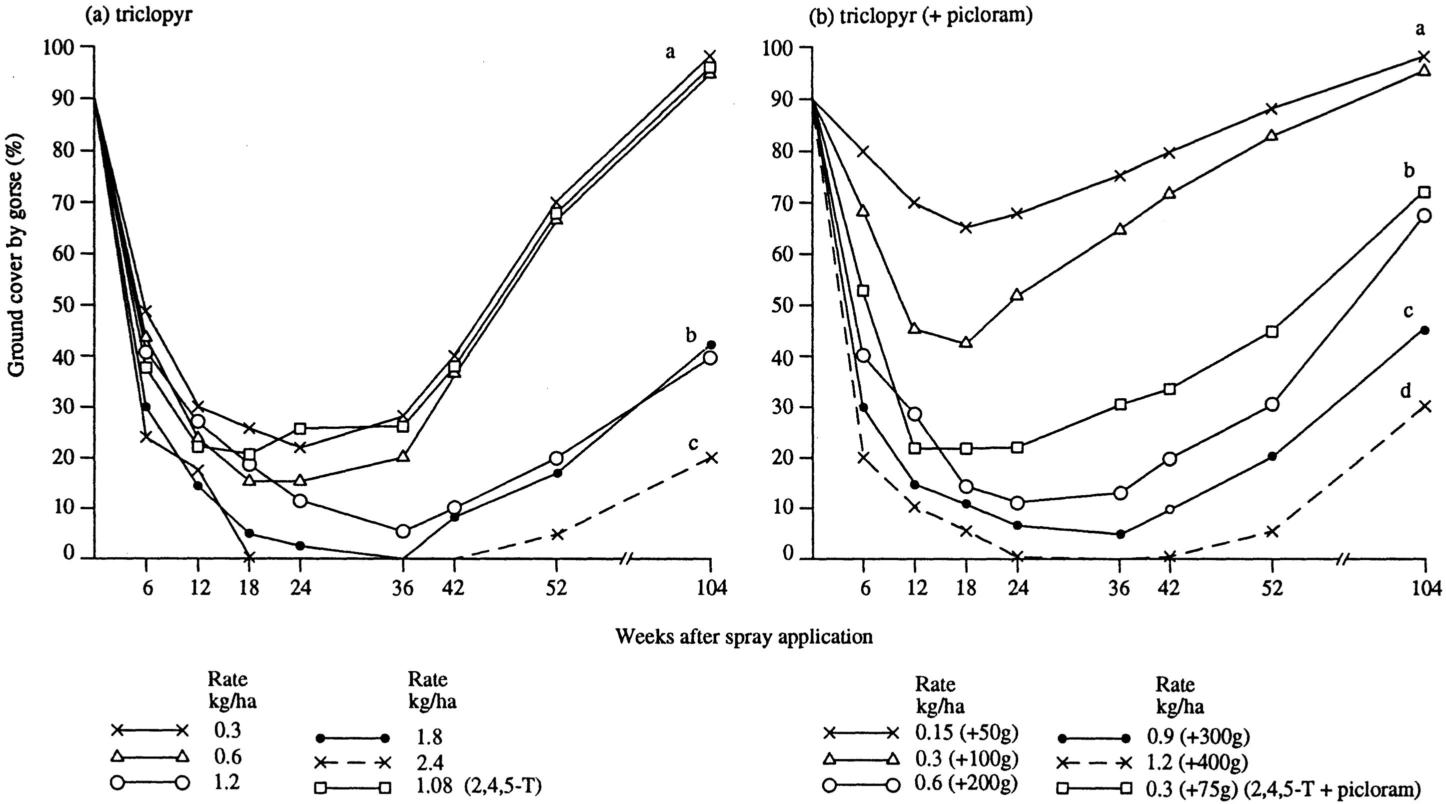


FIG. 5–Percentage ground cover by live gorse in relation to herbicide treatment and time interval from spraying. Treatments with the same letter are not significantly different ($p \leq 0.05$)

gorse ground over to an extent similar to triclopyr alone (N.B.: triclopyr when applied with picloram was used at half the rate of triclopyr alone), and eventual regrowth was similar.

In the Galatea trial, gorse control with triclopyr + picloram was effective at rates of 0.3 [+100 g] kg/ha and higher (Fig. 6) in providing control equal to or better than that achieved with 2,4,5-T or 2,4,5-T + picloram. The best long-term control was achieved with the highest rate of triclopyr + picloram.

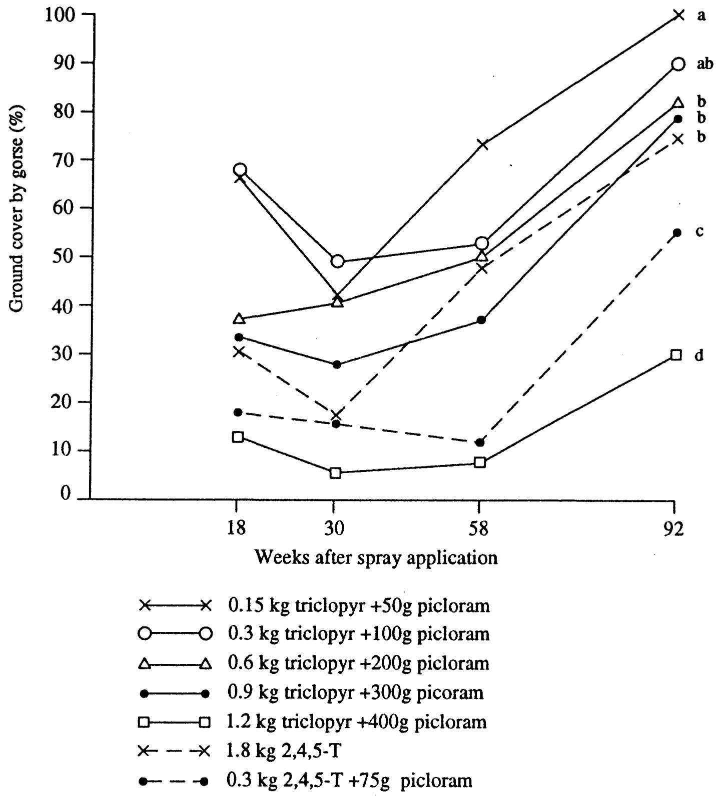


FIG. 6–Assessment of percentage gorse regrowth after herbicide treatment (Rotorua trial). Treatments with the same letter are not significantly different ($p \leq 0.05$).

CONCLUSIONS

Pinus radiata sprayed with triclopyr at rates of 1.8 kg/ha or higher grew less in diameter only than those sprayed with 2,4,5-T at 1.08 kg/ha, but neither herbicide affected survival of trees. However, trees sprayed in the dormant growth stage were less influenced by herbicide treatment than those sprayed after the spring flush had started. Saville (1989) concluded that *P. radiata* seedlings still in dormancy after planting could tolerate triclopyr at 1.8 kg/ha but that, if seedlings had flushed before triclopyr application, the rate of triclopyr should not exceed 0.6 kg/ha. Our work supports this conclusion. Triclopyr + picloram significantly reduced growth compared to that for seedlings sprayed with 2,4,5-T + picloram, but had no effect on tree survival.

In the Rangiora trial, *P. radiata* seedlings sprayed with triclopyr formulations were prone to multi-leadering. This was not a problem in the Rotorua trial. Multi-leadering was more pronounced if trees were sprayed after new spring growth had begun. In the second growing season, many seedlings reverted to a single dominant leader, with some minor stem malformation and a basket whorl of branches that could be easily corrected with form pruning (McLaren 1987).

Cupressus macrocarpa survival was reduced by ≤25% by 1.2 kg triclopyr/ha or more, while 2,4,5-T reduced survival by only 4%. Triclopyr + picloram had a more severe effect at rates ≥0.3 [+100 g] kg/ha. Height growth was significantly reduced by triclopyr and the severity of growth loss increased with increasing rates of herbicide. Similarly, 2,4,5-T and 2,4,5-T + picloram resulted in a marked reduction in growth. Differences between responses of flushing and non-flushing seedlings to herbicide treatment could not be detected in height growth.

Survival of *Ps. menziesii* was reduced significantly by triclopyr at the highest rate (2.4 kg/ha) tested and by triclopyr + picloram at the rate of 0.9 [+300 g] kg /ha or greater. Height growth was more severely curtailed by triclopyr + picloram than by triclopyr alone. This was dependent on growth phase at the time of spray application. Triclopyr alone had a significant effect on growth if applied to flushed seedlings even at the rate of 0.6 kg/ha, but no worse than 2,4,5-T. However, triclopyr + picloram severely desiccated seedlings showing bud swell, bud burst, or new shoot elongation. Seedlings showing no sign of breaking dormancy were not checked by the lowest rates of triclopyr + picloram (0.15 [+50 g] kg /ha or 0.3 [+100 g] kg /ha) but, as rate of application increased further, the check in growth increased.

Triclopyr at 0.3–0.6 kg/ha gave more effective gorse control for the first year after application than triclopyr + picloram (0.15 [+50 g] kg /ha and 0.3 [+100 g] kg /ha), but by 2 years after spraying no differences in gorse control between these treatments could be detected. Triclopyr above the application rate of 1.8 kg/ha and triclopyr + picloram at 1.2 [+400 g] kg /ha, respectively, completely killed the existing gorse sward. However, longer-term gorse control was achieved as much by the invasive ground cover of a brown-top sward, which may have helped reduce the emergence of new gorse seedlings, as by herbicide application.

Release spraying *P. radiata, Ps. menziesii,* and *C. macrocarpa* with triclopyr is feasible if rates **do not exceed 1.8 kg/ha,** but it should be carried out before the flush of new growth in the spring to prevent multi-leadering and reduced growth. Triclopyr should be used in preference to triclopyr + picloram as it is less damaging to trees and gives more effective gorse control for the first year after planting. On all three tree species ≤1.8 kg triclopyr/ha resulted in growth rates equivalent to those after application of present 2,4,5-T recommendations.

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