EVALUATION OF HERBICIDES FOR THE CONTROL OF *PINUS CONTORTA*

J.W. RAY and N.A. DAVENHILL

Forest Research Institute,
Private Bag, Rotorua

SUMMARY

Twelve different herbicides, with adjuvants, were applied individually or in combination, over self-sown *Pinus contorta* to determine the most effective and economical means of killing wilding trees on a live firing range where foot access is impossible. Tree mortality and the effect of the sprays on the ground cover were determined 11 months after treatment. None of the treatments tested killed all the trees. The three most effective treatments were diquat, bromacil and a mixture of metsulfuron and glyphosate. Diquat had the least effect on ground cover and produced the most rapid needle damage.

Keywords: control, *Pinus contorta,* lodgepole pine, herbicides

INTRODUCTION

In the USA *Pinus contorta* (syn. lodgepole pine) is regarded as a primary coloniser and has shown similar characteristics in New Zealand. Here it is an aggressive invader in sparsely vegetated areas and particularly in high country areas which are not intensively managed. It has spread extensively throughout the Army Training Reserve, at Waiouru where it impedes access, poses a fire risk and acts as a seed source for further spreading into adjoining tussock and native areas.

The trees can be controlled economically, and in an environmentally acceptable manner, by hand-pulling the small seedlings and cutting or burning the larger, seed bearing trees. Burning has the added advantage of reducing regeneration by destroying the seed (D. Clark, pers. comm.). These techniques cannot be used to control a dense stand of pines on a live firing range, where the presence of unexploded ammunition renders foot-access impossible. The only control option is to aerially spray with a herbicide which will satisfy the following criteria.

(i) kill the trees
(ii) rapidly desiccate the foliage so a burn can be undertaken before autumn, when meteorological conditions become unsuitable for burning
(iii) have minimum effect on the ground cover, mainly grasses, to avoid erosion due to the fragile nature of the soil.

In the early 1970's several chemical companies undertook trials with 2,4-D, 2,4,5-T, picloram, sodium chlorate, fosamine and bromacil. They were unsuccessful in finding a reliable control method. Davenhill and Preest (1973) evaluated several soil residual herbicides which also failed to kill large pines. The scientific literature contains little information on herbicides to kill pines. Boyd *et al* (1985) killed lodgepole pine with high rates of 2,4-D, dicamba, triclopyr or picloram, applied either singly or as mixtures; Brown and Mackenzie (1972) killed small lodgepole pine with 2,4-D, and Ryker (1970) reported that the addition of 2,4-D to either picloram or dicamba greatly increased their effectiveness.

The herbicides screened in this trial were selected on the basis of the above results, with the addition of some untested compounds. They were applied in December, at a time when temperatures are high and days are long; conditions which favour optimum translocation (Radosevich and Bayer 1979).

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To enable a cost comparison to be made, rates were adjusted so that each herbicide cost approximately $100/ha. Because herbicide uptake into lodgepole pine is known to be inadequate (R.E. Gaskin, pers. comm.), an organosilicone surfactant was added to the water soluble herbicides to improve uptake (Stevens *et al* 1988). For the same reason, crop oil was added to non water soluble formulations.

METHODS

The trial was located south of the Waiouru-Ohakune highway at Tangiwai. Plots (5 x 5 m) were laid out in an area of self-sown seedling lodgepole pine, of varying age, size and height. Ten trees in each plot from 0.5 to 1.7 m (average 0.9 m) tall were labelled for assessment.

The herbicides were applied to simulate aerial spraying, in a volume equivalent to 350 litres/hectare, using a 4.0 metre long, hand-held boom fitted with 8001LP nozzles (Spraying Systems Ltd NZ). The herbicides were mixed on site; treatments (#1-16) were applied on 5 December 1988 and (#17-22) on 10 December 1988. All treatments were replicated three times, within a randomised block design. Spray mixtures are listed in Table 1.

Needle damage on labelled trees was scored visually by two assessors at 5, 12, 18 and 26 weeks after treatment using a 0-5 scale (0 = healthy, 5 = dead).

Tree mortality was assessed by examination of the labelled trees 11 months after treatment. Tree death was confirmed in doubtful cases by examining the cambial layer at the root collar. At the same time, ground cover was assessed visually, as a percentage, in open areas within each sprayed plot.

Fishers protected least significant difference (FPLSD) ($P<0.5$) was used to test for differences among means.

TABLE 1: The effect of herbicide treatments on tree mortality and ground cover, 11 months after application to *Pinus contorta*.

Treatment No.	Herbicide ai	Herbicide product	kg ai/ha	%	Additive	*P. contorta* % Mortality	Ground cover %
1	glyphosate	Roundup	2.04	0.5	Silwet L77	13.3 abc[1]	61.7 c
2	glyphosate	Roundup	2.04	0.5	Silwet L7607	10.0 abc	36.7 b
3	glyphosate	Roundup	2.04	0.25	Silwet L77	26.6 bcd	40.0 b
				0.25	Silwet L7607		
4	2,4-D ester	Hi-ester 2,4-D*	10.08	2.0	BP Crop Oil	30.0 cde	93.3 g
5	glyphosate	Roundup	1.53			20.0 abcde	70.0 cde
	2,4-D ester	Hi-ester 2,4-D	2.52				
6	2,4-D amine	2,4-D amine*	3.00	0.5	Silwet L77	0.0 a	96.7 g
7	2,4-D amine	2,4-D amine	4.80	0.5	Silwet L77	13.3 abc	95.0 g
8	2,4-D amine	2,4-D amine	6.40	0.5	Silwet L77	6.6 ab	90.0 g
9	glyphosate	Roundup	1.53	0.5	Silwet L77	36.6 de	78.3 cdefg
	2,4-D amine	2,4-D amine	1.80				
10	hexazinone	Velpar L	0.75	0.5	Silwet L77	3.3 a	71.7 cdefg
	2,4-D amine	2,4-D amine	2.00				
11	metsulfuron	Escort	0.06	0.5	Silwet L77	36.6 de	93.3 g
	2,4-D amine	2,4-D amine	2.40				
12	picloram amine	Tordon 50D	0.35	0.5	Silwet L77	20.0 abcd	91.7 fg
	2,4-D amine	2,4-D amine	1.40				
13	metsulfuron	Escort	0.10	0.5	Silwet L77	50.0 e	95.0 g
14	glyphosate	Roundup	0.85	0.5	Silwet L77	40.0 de	81.7 cdefg
	metsulfuron	Escort	0.06				
15	glyphosate	Roundup	1.70	0.5	Silwet L77	84.6 f	65.0 cd
	metsulfuron	Escort	0.03				
16	ethidimuron	Ustilan	1.05	2.0	BP Crop Oil	0.0 a	81.7 cdefg
17	fosamine	Krenite	1.80	0.5	Silwet L77	0.0 a	95.0 g
18	bromacil	Hyvar X	2.00	2.0	BP Crop Oil	93.3 f	28.3 ab
19	hexazinone	Velpar L	1.25	0.5	Silwet L77	0.0 a	13.3 a
20	amitrole	Amitrole 4L	4.00	0.5	Silwet L77	0.0 a	90.0 efg
21	imazapyr	Arsenal	0.25	0.5	Silwet L77	0.0 a	83.3 defg
22	diquat	Reglone	1.40	0.5	Silwet L77	76.6 f	81.7 cdefg
23	untreated					0.0 a	95.0 g

*Dow Elanco Silwet L77 (Pulse), Silwet L7607 (coded compound)

[1]Treatment means sharing a common letter do not differ significantly at the 5% level.

RESULTS AND DISCUSSION

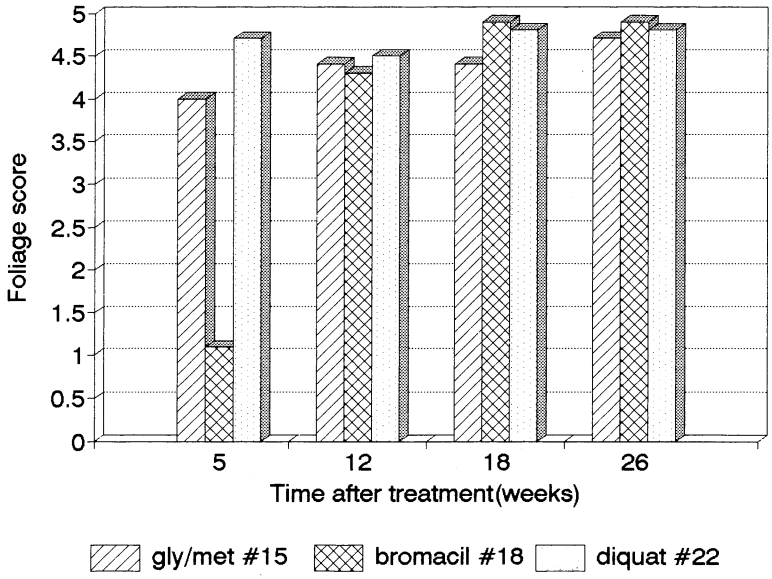
There were no significant differences in tree mortality (76.6%-93.3%) between the three most effective treatments — glyphosate/metsulfuron (#15), bromacil (#18) and diquat (#22) (Table 1). Mortality of 84.6% recorded from 1.7 kg glyphosate/0.03 kg metsulfuron (#15) significantly exceeded the 13% mortality from 2.04 kg glyphosate (#1), and 50% from 0.1 kg metsulfuron (#13) applied on their own. This indicates a synergistic effect between the two herbicides. Halving the glyphosate rate to 0.85 kg and doubling the metsulfuron to 0.06 kg (#14) was less effective, with only 40% mortality, inferring that the ratio of the two herbicides may be critical and that the optimum mixture is yet to be identified.

None of the treatments killed all the trees (Table 1). Thirteen treatments, glyphosate (#1 and 2), glyphosate/2,4-D (#5), 2,4-D amine (#6, 7 and 8), hexazinone /2,4-D amine (#10), picloram/2,4-D amine (#12), ethidimuron (#16), fosamine (#17), hexazinone (#19), amitrole (#20) and imazapyr (#21), failed to cause any significant mortality. The result obtained with glyphosate plus Silwet L-77 (#1) is at variance with that obtained by Crozier (1990) who found that when lodgepole pine seedlings were individually sprayed with 0.36% glyphosate plus 0.5% Silwet L-77 solution all the trees died. This difference may be due to Crozier's use of much smaller trees (0.5 m), and much higher spray volumes when spot spraying individual trees to the point of run-off.

Six treatments, glyphosate (#3), 2,4-D ester (#4), glyphosate/2,4-D amine (#9), metsulfuron/2,4-D amine (#11) metsulfuron (#13) and glyphosate/metsulfuron (#14) induced statistically significant mortality within a range of 26.6-50%.

The development of foliage symptoms, for treatments causing the highest mortality, are shown in Figure 1. Most foliage damage occurred within 5 weeks of spraying, with little damage thereafter. However, trees sprayed with bromacil (#18) showed little effect at 5 weeks, but severe damage by week 12. With the exception of metsulfuron (#13), the effects of treatments on tree foliage were similar within plots and between replicates. Fifty percent of trees sprayed with metsulfuron (#13) showed severe foliar damage and died, whereas the remainder were only slightly affected.

Fig. 1: Mean foliage damage scores for the three herbicide treatments causing the highest tree mortality. (0 = healthy, 5 = dead).



Initial ground cover in the open areas was estimated to be 95-100%. Various grasses, interspersed with flat weeds, were markedly reduced by seven of the herbicide treatments, Glyphosate (#1, 2, and 3), glyphosate/2,4-D ester (#5), glyphosate/ metsulfuron (#15), bromacil (#18) and hexazinone (#19) (Table 1). Eleven months after spraying, bromacil (#18) and hexazinone (#19) had killed all the grass, reducing the ground cover to less than 30%. In plots sprayed with bromacil, the resistant flatweeds were dominated by *Hieracium* spp. The activity of glyphosate plus Silwet L7607 (#2 and 3) on ground cover, was greater than glyphosate plus Silwet L77 (#1). Gaskin and Zabkiewicz (1989) reported that Silwet L77 reduced the uptake of glyphosate into Yorkshire fog. Diquat (#22) had little effect on grasses.

CONCLUSIONS

Diquat (#22) was the most suitable herbicide for lodgepole pine control on the live firing range. It was the only herbicide, to cause high tree mortality and rapid desiccation of the foliage without adversely affecting ground cover.

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