TOLERANCE OF RADIATA PINE TO THREE FORMULATIONS OF HEXAZINONE

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SUMMARY

The tolerance of radiata pine (*Pinus radiata* D. Don) transplants to liquid, soluble powder and granular formulations of hexazinone were compared in two small-plot nursery trials. At the highest rate (14 kg ai/ha) the liquid was the least damaging formulation; but at lower rates (2, 4, 6, and 10 kg ai/ha) there was no significant difference between the formulations. By covering half the trees prior to treatment, foliar uptake was shown to be a significant cause of tree damage from the two sprayed formulations. What the granules lacked in foliar activity they made up for in soil activity. Overall there was no difference in tree response to the three formulations over the range 2-10 kg ai/ha. There was no evidence of tree height or diameter growth stimulation from hexazinone, apart from that due to weed control.

INTRODUCTION

The activity of hexazinone on a wide variety of herbaceous, woody and semi-woody annual and perennial weeds of importance in forest establishment has been observed by several authors (Bowers and Porter 1975, 1977; Coackley and Moore 1977; Cameron and Stokes 1978). Bowers and Porter noted that the addition of surfactant increased damage to radiata pine from hexazinone soluble powder formulation (1975) and also observed temporary growth suppression at 7.2 kg ai/ha (1977). Cameron and Stokes (1978) reported that two water-miscible formulations, a water-soluble powder and a wettable powder, were all sufficiently safe and effective for selective use on radiata pine, but an emulsifiable concentrate caused needle scorch. A pellet formulation, though causing least damage, provided inferior weed control.

While hexazinone damage has often been observed, it has also been suggested (unpublished) that it may stimulate radiata pine growth over and above the growth response due to weed control alone.

During the past 10 years a 900 g/kg soluble powder formulation of hexazinone (Velpar 90) has been available and widely used at rates of 2-6 kg ai/ha to selectively control many annual and perennial grasses, herbaceous broadleaves, and some woody weeds in young radiata pine plantings. Tree damage and mortality have been observed from the higher rates when applied to free-draining soils low in clay or organic matter, especially under warm, drought conditions. How much this damage is due to foliar uptake, as compared with root uptake (the predominant mode of entry of hexazinone), has been the subject of conjecture.

A 250 g ai/litre (water-miscible) liquid formulation (Velpar L) and a 200 g ai/kg granule formulation (Velpar 20G) have also become available. The liquid mixes much more easily than the soluble powder, but reports of excessive tree damage in operational trials (reputedly related to an alcohol solvent in the formulation) have tended to discourage its use in favour of the soluble powder. High cost and, until recently, lack of an accurate means of spreading from the air or by hand were reasons for lack of interest in the granular formulation.

Answers were sought to the following:

1. Is foliar uptake of hexazinone a significant cause of tree damage?
2. If foliar uptake is a significant factor, could this be minimised by using granules?
3. Are there differences of practical significance in tree survival and growth between the three formulations of hexazinone?

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4. Does hexazinone stimulate radiata pine growth?

METHODS

Two small-plot trials were established, both on light, cultivated, weed-free, sandy loam soils of pumice origin in Owata Nursery, Rotorua. The trees used were 9 to 10 month-old radiata pine seedlings transplanted at 0.5 x 0.5 m spacing. Randomised block designs were used with three replications in Trial 1 and five in Trial 2. There was a 2 m gap between the outside rows of trees of adjacent plots. The trees in both trials were healthy, and had resumed growth when treated.

High rates were used in Trial 1 (6, 10 and 14 kg ai/ha) to ensure that significant tree damage occurred. Since an unexpected result from Trial 1 may have been rate-related, Trial 2 (2, 4, 6 and 10 kg ai/ha) included both low and high rates.

Trial 1: Seven rows of 20 trees were planted in each 4 x 10.5 m plot on 24.7.80. Alternate trees were covered with manilla envelopes prior to treatment (3 months later) to prevent foliar contamination. The sprayed treatments were applied by hand-held, 4 m, CO₂-pressurised, precision boom sprayer fitted with Spraying Systems 730077 flat fan nozzles. Each application was made in two passes of 300^l litres/ha in opposite directions. The granules for each plot were thoroughly mixed with 8 litres of sieved pumice sand approximately the same size as the granules. The mixture was then divided into four equal lots, and each lot spread uniformly by hand over the same plot commencing alternately at different ends.

The weather during treatment on 24.10.80 was warm, clear and sunny. Little or no rain fell for several days preceding application. The first substantial post-application rainfall was 7.6 mm, 6 days later. Monthly total rainfalls for October, November and December were close to the 16-year averages recorded at Rotorua airport. The 0900 hr R.H. was 58%; maximum and minimum temperatures were 18.8°C and 2.2°C respectively.

All the plots (including untreated controls) were kept weed free throughout by hand weeding and spot spraying with glyphosate. Tree survival and height increment were recorded 10 months after treatment.

Trial 2: Planting was in early September 1982 into 2 x 2 m, nine-tree plots (three rows of three trees) and the treatments applied in mid-November 1982 in a similar manner to that used in Trial 1, except that there were no covered trees and a 2 m wide portable cabinet sprayer was used. Untreated control plots were of two types — weed free (periodically hand weeded) and weedy (sown with 'bush burn' seed at the time of planting).

The weather was warm, dry and sunny on 16, 17 November when the liquid and soluble powder formulations were applied, and warm and cloudy with light drizzle patches (insufficient to wet foliage) on 19 November when the granules were applied. The monthly rainfall totals for November to March were only 25-50% of the 16-year averages recorded at Rotorua airport. There were only two substantial falls in November — 40.6 mm 5 days prior to the first treatment, and 11.3 mm 9 days after the last treatment. The R.H.'s at 0900 hours varied from 70-80%; maximum and minimum temperatures were 20.1°C and 6.7°C respectively.

Tree survival, stem diameter (approximately 25 mm above ground level), and height increment were recorded 9 months after treatment.

The plot means for the various measures of tree response (arcsin-transformed in the case of percentage measures) were subjected to analysis of variance (ANOVA), and the means compared using LSD tests.

RESULTS AND DISCUSSION**Trial 1:**

Results of Trial 1 (Table 1) showed:

1. A highly significant ($P < 0.001$) *formulation x exposure* interaction in both survival and height increment, indicating differences in foliar uptake between the three

¹ A relatively high volume was used because of the limited solubility of the soluble powder formulation and the high rates used.

TABLE 1: Effect of hexazinone *formulation and rate*, and foliage exposure on survival and height increment of radiata pine seedling transplants 10 months after treatment; Trial 1, Owata Nursery.

months after treatment, Trial 1, Gwahia Valley									
		Survival %			Height increment (cm)				
		Rate kg ai/ha			Rate kg ai/ha				
		0	6	10	14	0	6	10	14
Covered trees:									
untreated control	100					68			
liquid soluble powder granule		98a ¹	78a	77a		74a	62a	52ab	
		95a	87a	61a		72ab	64a	53a	
		76b	49b	29bc		57c	49b	41bc	
Exposed trees:									
untreated control	100					72			
liquid soluble powder granule		76b	53b	35b		61bc	40b	38c	
		68b	39b	18c		53c	47b	36c	
		73b	37b	25bc		55c	48b	36c	

¹ All LSD tests at 5% level. Values in the same column with the same letter are not significantly different.

LSD's are: Survival = 17%; Height increment = 12 cm.

formulations. Both survival and height increment of covered trees were greater than for exposed trees with the two sprayed formulations. This strongly suggests that foliar uptake is an important source of tree damage with sprayed formulations of hexazinone.

- A significant ($p < 0.05$) difference in survival between the sprayed formulations at the highest rate on the exposed trees; survival with the liquid was higher than with the soluble powder.
- No significant difference between the effect of the granules (on the covered and exposed trees), and the effect of the sprayed formulations on the exposed trees. What the granules lacked in foliar activity they appeared to make up for in soil activity.
- A significant ($P < 0.05$) *rate* x *exposure* survival interaction. Survival in all treatments decreased with increasing rates but this decrease was greater for the two sprayed formulations (especially the soluble powder) on the exposed as compared with the covered trees.
- That the *rate* x *formulation* and *rate* x *formulation* x *exposure* interactions were not significant.

The better survival resulting from the use of the liquid formulation compared to the soluble powder was unexpected. There were no abnormal weather conditions to account for this.

Trial 2:

Apart from a highly significant *rate* effect on survival, there were no other significant *rate*, *formulation* or *formulation* x *rate* effects (Table 2). The *rate* effect on survival was mainly attributable to the 10 kg rate. In all other respects tree response to hexazinone *formulation* and *rate* was not significantly different from that of the weed-free control. However, the weedy controls had consistently lower height increment, stem diameter (D) and 'volume factor' [D^2 x (total height)] than all the other treatments. There was therefore no evidence that hexazinone at either low, medium or high rates stimulated tree growth over and above that due to weed control, as has been suggested.

Although Trial 2 coincided with an unusually low rainfall period, there were again,

TABLE 2: Effect of hexazinone *formulation and rate* on survival, height increment, stem diameter (D) and 'volume factor' [D² x (total height)] of radiata pine seedling transplants 9 months after treatment; Trial 2, Owata Nursery.

	Survival (%)	Height increment (cm)	Diameter (cm)	Volume factor (cm ³)
Formulation (averages over all rates):				
Weedy control	100 (90)a	33.9a	1.21a	115a
Weed-free control	100 (90)a	51.0b	1.88b	318b
Liquid	96.7 (80.9)b	47.9b	1.89b	316b
Soluble powder	94.4 (76.8)b	49.5b	1.89b	321b
Granule	95.6 (78.0)b	50.3b	1.92b	334b
LSD's	(8.3)	6.9	0.19	84
Rate (averages over all formulations, kg ai/ha):				
Weedy control	100 (90)a	33.9a	1.21a	115a
Weed-free control	100 (90)a	51.0b	1.88b	318b
2	99.3 (87.8)a	49.8b	1.96b	341b
4	97.8 (83.3)a	49.6b	1.94b	336b
6	97.8 (83.3)a	48.7b	1.85b	307b
10	87.4 (70.0)b	49.0b	1.86b	308b
LSD's	(10.5)	7.6	0.19	80

Figures in parentheses are arcsin-transformed.

All LSD tests at 1% level. Values in the same column with the same letter are not significantly different.

no weather factors which would have been likely to significantly affect the relative performance of the three formulations.

CONCLUSIONS

1. Foliar uptake is an important source of tree damage from high rates of sprayed formulations of hexazinone.
2. What the granular formulation lacks in foliar activity it appears to make up for in soil activity, at least in so far as tree response is concerned.
3. There is no evidence that the liquid formulation of hexazinone is more damaging to radiata pine than the soluble powder; one trial indicated that if anything it is less damaging.
4. Hexazinone does not stimulate radiata pine growth over and above the growth response due to weed control.

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