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Chemicals for non-commercial thinning of *Pinus radiata* by basal stem injection

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Summary

The use of chemicals as basal stem injections for late non-commercial thinnings was investigated in *Pinus radiata* stands at Myrtleford. None of the treatments consistently gave complete mortality of treated stems but several caused more than 40% mortality, with severe defoliation of surviving stems. Picloram plus 2,4-D, 2,4-D alone, and dicamba were found to be suitable for use in both winter and spring. MCPA and glyphosate produced satisfactory results from spring injections, whereas amitrole and 2,4,5-T were ineffective. On the basis of cost, and excluding 2,4-D about which there is currently some public concern, MCPA is the most viable herbicidal treatment.

Trees injected with picloram plus 2,4-D, 2,4-D alone, dicamba, MCPA, and glyphosate attracted and provided habitat for *Sirex noctilio*, and it is recommended, therefore, that chemicals should not be used to thin plantations containing *Sirex*.

Introduction

In north-eastern Victoria many stands of *Pinus radiata* contain more than 2000 trees ha^{-1}. About one-third of these stands are located on sites capable of producing trees of more than 28 m in height in about 20 years, which, if left unthinned, are predisposed to wind damage (Lewis, 1963). In stands susceptible to wind damage, undue delay of thinning is likely to result in substantial damage to the retained trees following thinning, and possible further damage due to sun scorch and internal stresses. The large quantity of residue from such thinnings may also pose a serious fire hazard. Unthinned stands may also contain small or defective trees of limited market value which can be regarded as weeds and require control.

As a possible means of substantially reducing these economic and practical disadvantages, a study was conducted to examine the feasibility of non-commercial thinning by basal stem injection of herbicides. Measurements were made of their toxicity to *P. radiata*, the relationship between age of tree and effectiveness of the herbicides, and the rates of application necessary for an acceptable level of mortality. The susceptibility of treated trees to attack by *Sirex noctilio* was also studied.

Materials and methods

Two trials were conducted in 1978 at three sites in the Myrtleford district in north-eastern Victoria. The first trial tested the phytotoxicity of seven herbicides to *P. radiata* in winter (May 1978) and spring (October 1978). The second trial was in spring (October 1978) and set out to determine the minimum dose of three herbicides necessary to produce an acceptable level of mortality in treated trees. In both trials the herbicides were applied with a tree injector which dispensed 1 mL of water-soluble chemical per injection at 10 cm intervals around the bases of treated trees.

The first trial tested the phytotoxicity of seven herbicides for the control of *P. radiata* (Table 1).

All chemicals were applied in undiluted form except MCPA, which was diluted in water to 250 g L^{-1}. The 2,4,5-T treatment of winter 1978 (6) was replaced by MCPA (6a) in the spring trial of the same year. Each treatment was applied to a separate plot, each plot consisting of 20 adjacent trees planted in a row. Each of the seven plots was separated from the next by three rows of untreated trees. Separate plots were established for winter and spring applications of each chemical in 16, 14, 12, 10 and 8 year old stands, the mean heights of which were 18, 17, 14, 16 and 8 m respectively at the time of treatment.

The extent of crown loss following winter application was measured 8 and 12 months later in January and May 1979, and for spring application 3 and 11 months later in January and September 1979. Crown mortality was measured by recording death or yellowing of foliage in each 20% section of the initial crown, and by counting the number of dead whorls and the total number of whorls in each crown section. From these measurements the percentage of the total crown affected was calculated and the effects of treatments were examined by analysis of variance. Measurements were made in January to obtain crown-loss data before results could be confounded by the effects of a possible attack on stressed trees by *S. noctilio*. In August 1979 (15 months after winter and 10 months after spring applications), it was confirmed that injected trees were attractive to *Sirex*.

In the second trial, the effectiveness of various rates of picloram plus 2,4-D, dicamba, and MCPA were examined when injected at 1 mL 10 cm^{-1} of circumference in spring 1978 (Table 2).

The effects of these treatments on crown loss and on susceptibility to attack by *S. noctilio* were measured using the same procedures as in the first trial.

Table 1
Herbicides tested for the control of *Pinus radiata*

1	picloram plus 2,4-D at 50+200 g L^{-1} as the tri-isopropanol amine salt (as Tordon 50)
2	dicamba at 200 g L^{-1} (as Banvel 200)
3	2,4-D at 800 g L^{-1} as the ethyl ester (as Estone 80)
4	glyphosate at 360 g L^{-1} (as Roundup)
5	amitrole at 250 g L^{-1} (as Lane Amitrol Liquid Herbicide)
6	2,4,5-T at 800 g L^{-1} as the butyl ester (as Butoxone 80)
6a	MCPA at 250 g L^{-1} as an amine salt (as Thistle Killem)
7	untreated control trees

Table 2
Rates of herbicides tested for the control of *Pinus radiata*

1	picloram plus 2,4-D at 50+200 g L^{-1}, both as the tri-isopropanol amine salt
2	picloram plus 2,4-D at 25+100 g L^{-1}, both as the tri-isopropanol amine salt
3	picloram plus 2,4-D at 13+50 g L^{-1}, both as the tri-isopropanol amine salt
4	picloram plus 2,4-D at 6+25 g L^{-1}, both as the tri-isopropanol amine salt
5	dicamba at 200 g L^{-1}
6	dicamba at 100 g L^{-1}
7	dicamba at 50 g L^{-1}
8	dicamba at 25 g L^{-1}
9	MCPA at 250 g L^{-1} as an amine salt
10	MCPA at 125 g L^{-1} as an amine salt
11	MCPA at 63 g L^{-1} as an amine salt

Results and discussion

Tree age had little effect on the results of the first trial, and was significant for application in winter only where the effect was more severe on older trees. Measurements of the effects of each chemical are therefore presented as means for stands of the five ages studied. The highest mortalities were obtained using picloram plus 2,4-D, and 2,4-D alone, for both winter and spring applications (Table 3); dicamba also showed promise. Glyphosate was also effective when applied in spring but not when applied in winter. MCPA was not tested in winter, but the spring application was reasonably effective. The other herbicides were ineffective. The results suggested that picloram plus 2,4-D, 2,4-D alone, dicamba, and perhaps MCPA and glyphosate were worthy of further investigation.

Severe loss of crown occurred following both winter and spring applications of picloram plus 2,4-D, 2,4-D alone, and dicamba, and spring application of MCPA. Winter application of glyphosate resulted in initial damage to apical buds which was followed by slight recovery of the injected trees in spring and by severe needle cast in the following summer, whilst glyphosate applied in spring resulted in severe crown loss. The other herbicides applied caused insufficient crown loss and were re-

Table 3
Mean mortality and crown loss of *Pinus radiata* trees injected with herbicides in winter and spring 1978

	Mortality (%)		Loss of green crown (%)			
Season and date of injection	Winter (May 1978)	Spring (Oct. 1978)	Winter (May 1978)		Spring (Oct. 1978)	
Timing and date of assessment	12 mths (May 1979)	11 mths (Sept. 1979)	8 mths (Jan. 1979)	12 mths (May 1979)	3 mths (Jan. 1979)	11 mths (Sept. 1979)
Treatment						
picloram plus 2,4-D	80	90	94	97	94	98
2,4-D	80	80	92	95	85	92
dicamba	65	55	83	88	89	92
glyphosate	10	75	35	36	93	96
amitrole	0	0	25	15	20	15
2,4,5-T	5	—	15	15	—	—
MCPA	—	65	—	—	84	89
control	0	0	0	0	0	0
L.S.D. ($P < 0.05$)	25	10	13	17	6	9

garded as unsuitable for non-commercial thinning.

None of the treatments adversely affected surrounding untreated trees.

Most of the trees treated with picloram plus 2,4-D, 2,4-D alone, dicamba, and MCPA were attacked by *Sirex*, suggesting that chemical thinning of plantations which are highly susceptible to *Sirex* attack may not be appropriate. In this trial, 128 out of a sampled 450 injected trees were colonized by *Sirex* and nearly all 450 trees showed symptoms of the presence of the symbiotic fungus *Amylostereum areolatum* (Fries) Boidin, which is associated with *Sirex* attack.

In the second trial, it was found that there was a general loss of phytotoxicity with application doses less than those used in the first trial (Table 4). Picloram plus 2,4-D was the most effective chemical, but its phytotoxicity was significantly affected by application dose. On the other hand, a 50% reduction in the dose of dicamba and MCPA made little difference to the phytotoxicity of these chemicals.

When used at the highest application dose in these trials, prices per litre (1978) of the three chemicals tested were picloram plus 2,4-D \$7.90, dicamba \$5.98, and MCPA \$1.30. There was little difference between the effectiveness of the two higher doses of either dicamba or MCPA, so the cost of 1000 effective 1 mL injections (causing at least 40% mortality and at least 85% crown loss) for picloram plus 2,4-D was \$7.90, for dicamba \$2.99, and for MCPA was \$0.65. The cost of each herbicide in proportion to the total cost of such thinnings (including labour) was 18%, 7% and 2% respectively. In economic terms MCPA is the most viable treatment. Its relative chemical cost would remain lower even if application dose or the number of injection points per tree were increased.

Trees defoliated by the use of picloram plus 2,4-D, or 2,4-D alone did not recover, whereas those severely defoliated by dicamba, glyphosate, and MCPA showed signs of new growth in September 1979, although this recovery was followed by further deaths or severe needle cast by January 1980. The growth of trees which had survived treatment with any of these herbicides was generally halted, subsequent growth was suppressed, and eventual death was hastened. It is possible that some trees which survived otherwise effective treatments may have survived because of dilution of the herbicides by rain following winter and spring applications, insufficiently deep injection of the chemical, or greater than specified spacing between injection points. Control over the quality of application is thus important.

Table 4
Mean mortality and loss of crown of *Pinus radiata* trees injected in spring 1978 with picloram plus 2,4-D, dicamba, and MCPA (measured in spring 1979)

Chemical	Treatment dose (in g L^{-1})	Mortality (%)	Crown loss (%)
picloram plus 2,4-D	50+200	90	98
	25+100	25	76
	13+50	10	66
	7+25	10	31
	(L.S.D. $P < 0.05$	10	14)
dicamba	200	55	92
	100	55	89
	50	30	73
	25	10	48
	(L.S.D. $P < 0.05$	20	19)
MCPA	250	65	89
	125	40	87
	63	10	23
	(L.S.D. $P < 0.05$	25	11)

Conclusions

The use of herbicides for delayed non-commercial thinning of *P. radiata* stands is feasible by basal stem injection. In order of their effectiveness, suitable herbicides are: picloram plus 2,4-D, 2,4-D, and dicamba, with MCPA and glyphosate suitable in spring injections. When cost is considered, and excluding 2,4-D about which there is currently some public concern, MCPA is the most viable herbicidal treatment.

Basal stem injection is a much more convenient method of herbicide application to tall trees than foliar spraying and gives a better result at lower rates, at least with glyphosate (Cameron and Stokes, 1977). It also allows the selective treatment of individual trees.

At Myrtleford, *P. radiata* trees treated with phytotoxic herbicides attracted and provided habitat for *S. noctilio*. The effects of such attack on *Sirex* population levels and on subsequent attack on retained trees are unknown at present, and therefore the use of such chemicals cannot be recommended. Further studies will be necessary to assess the feasibility of using phytotoxic herbicides in stands susceptible to *Sirex* attack.

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