ADVANCES IN CONTROL OF WOODY WEEDS IN RADIATA PINE PLANTATIONS IN VICTORIA

D.W. FLINN and G. MINKO

Forests Commission Victoria
G.P.O. Box 4018,
Melbourne Vic. 3001

Summary. Methods used by the Forests Commission Victoria (FCV) to control regrowth of silver wattle *(Acacia dealbata)* and eucalypts *(Eucalyptus* spp.*)* in young plantations of radiata pine *(Pinus radiata)* are discussed. Recent advances in woody weed control are outlined and results of two field experiments presented. It was shown that 3,6-dichloropicolinic acid and hexazinone are promising herbicides for control of the target species, especially if applied at an early stage of weed development. Results indicated that liquid hexazinone is more effective than the granular form when broadcast at equivalent application rates, and that efficacy of liquid hexazinone may be improved by the use of a petroleum oil in the carrier.

INTRODUCTION

Sites converted from native eucalypt forest to plantations of radiata pine in Victoria are generally recolonised soon after planting by a wide range of herbaceous and woody plants. Of these, eucalypts and silver wattle exhibit rapid early growth rates and compete with radiata pine. At the highest density of woody weeds studied by Jack (1970), merchantable volume of a 51 year old stand of radiata pine had been depressed by 80%.

Manual, mechanical and chemical methods have been used to control woody weeds in young plantations of radiata pine in Victoria. The method adopted has been largely based on available technology and economic and environmental factors. This paper reviews past and present practices used by the FCV for control of woody weeds in radiata pine plantations and provides details on current research.

PAST PRACTICES FOR WOODY WEED CONTROL

Until the early 1960's, native forest was felled and broadcast burnt prior to planting of radiata pine. Repeated manual methods were needed to control woody weeds. Heaping and windrow burning then replaced broadcast burning allowing many sites to be ploughed before planting. This reduces the eucalypt component; temporarily controls many herbaceous weeds and provides a favourable microenvironment for establishing radiata pine seedlings.

In 1968 aerial application of 2,4,5-T approximately three years after planting was introduced to control silver wattle, followed by basal bark spraying or stem injection of the eucalypts with mixtures of 2,4,5-T and picloram (Flinn and Hopmans 1977). Since this control of eucalypts is labour-intensive, ploughing significantly reduced the total cost of woody weed control.

Aerial application of 2,4,5-T has not been made by the FCV since 1977, and there has been increasing pressure on all 2,4,5-T based herbicides including those commonly used for stem injection. Since new plantations of radiata pine

are being established by the F.C.V. at about 2000 ha per year on sites cleared of native forest, and as the cost of hand slashing woody weeds can be prohibitive, there was an urgent need to find alternatives to 2,4,5-T.

RECENT DEVELOPMENTS IN WOODY WEED CONTROL

Flinn and Minko (1980) compared the efficacy of 2,4,5-T with hexazinone, an ester of triclopyr and a salt of 3,6-dichloropicolinic acid applied as broadcast sprays to two year old radiata pine containing a dense population of silver wattle and a sparse cover of eucalypts. There was a 79% reduction in the silver wattle population using 2,4,5-T at 1.1 kg ha^{-1} compared with 71% for hexazinone at 4 kg ha^{-1} and 62% for 3,6-dichloropicolinic acid at 2 kg ha^{-1}. Height increment of radiata pine was not significantly affected by hexazinone, triclopyr or 3,6-dichloropicolinic acid.

Based on this and other studies with hexazinone (Bowers and Porter 1977; Cameron and Stokes 1977 and 1978; Davis 1977), the FCV and the manufacturers undertook an operational trial in November, 1978 on a 10 ha site at Myrtleford in north-east Victoria where a dense population of silver wattle and eucalypts 1 to 5 m tall was competing with radiata pine planted in winter 1976 (Flinn *et al.* 1980). Hexazinone was aerially applied at 3 kg ha^{-1} in water at 60 L ha^{-1}.

Sixty 2.5 m by 2.5 m plots were assessed at regular intervals, and 11 months after spraying 41% of the target population was dead and a further 12 to 13% severely defoliated. Damage to the pines was limited to minor needle chlorosis and scorch on a small proportion of trees. This acceptable result was achieved despite below-average rainfall during the four months after spraying, which may have reduced leaching of hexazinone into the root zone of the perennial target species.

CURRENT RESEARCH

Two field experiments were established in 1979 to further evaluate hexazinone and screen additional herbicides for control of woody weeds in young radiata pine plantations.

Experiment 1. This was at Myrtleford on a site planted to radiata pine in 1977 with a dense population of silver wattle and a sparse cover of eucalypts 1 to 3 m tall. The treatments were liquid and granular hexazinone, triclopyr, MCPA amine and sodium salt, 3,6-dichloropicolinic acid ester and amine and liquid hexazinone mixed with an emulsifiable petroleum oil at a rate of 50% by volume with water. MCPA was included since stem injection studies had shown it to be effective on the target species (Minko and Flinn - unpublished data).

Hexazinone granules were bulked with oven-dry sand of a similar particle size prior to spreading by hand. A knapsack and 2 m boom was used to apply the liquid formulations, each plot being sprayed twice at right angles with a spray volume of 1000 L ha^{-1}.

Detailed methods and results will be presented elsewhere. The two formulations of MCPA produced a low mortality of the target species and moderate to severe damage to radiata pine. Dead topping was common, particularly at the highest application rate (4 kg ha^{-1}). However, no radiata pine deaths were recorded and slow recovery of the damaged trees occurred. Triclopyr at 1 kg ha^{-1} also caused severe phytotoxicity with damage symptoms similar to those described by Flinn and Minko (1980). This herbicide produced limited mortality of silver

wattle and severely retarded height growth of the survivors, but overall control was not satisfactory. Although a higher rate may improve the control, it is likely that damage to radiata pine would also increase to an unacceptable level.

Both formulations of 3,6-dichloropicolinic acid caused severe damage and mortality to silver wattle, whereas damage to eucalypts was largely restricted to scorch of young shoots. The herbicide was generally associated with only minor phytotoxicity to radiata pine, and although some dead-topping was observed at 4 kg ha^{-1} of the amine formulation, the affected trees rapidly recovered. The results confirm earlier findings (Flinn and Minko 1980) that this herbicide is worthy of detailed evaluation for control of silver wattle in young radiata pine plantations. Rates of 3 to 4 kg ha^{-1} of the amine formulation need to be tested at various seasons and growth stages of the target species.

Control of both silver wattle and eucalypts increased with increasing rates of granular and liquid hexazinone, although rates of 4 to 8 kg ha^{-1} were needed to effectively control the well-established target species. In all cases damage to radiata pine was slight and largely restricted to minor needle chlorosis and necrosis at the higher application rates. In contrast, hexazinone at 6 kg ha^{-1} mixed with a petroleum oil and water caused total scorch of all vegetation on the plots within four weeks of application. The target species did not recover, and this was the only treatment which provided total control. Radiata pine was also severly damaged soon after spraying, with scorch of entire crowns and a 15% mortality. Trees which recovered initiated new shoots along the main stem and lateral branches within six weeks of spraying, and by April 1980 the radiata pine was actively growing and free of abnormalities. This encouraging result is being evaluated in follow-up field studies using lower rates of hexazinone and was tested by the FCV in spring 1980 under operational conditions.

Experiment 2. This explored observations by the authors that the target species are most susceptible to hexazinone during their early stages of development and examined the mode of application. The experiment was undertaken at Myrtleford on a site planted to radiata pine in 1978. Treatments in Table 1 were applied to 10 m by 10 m plots in mid-August 1979 in a randomised block design with three replicates. The site was densely populated with silver wattle and eucalypts of less than 1 m tall at treatment. Liquid and granular hexazinone treatments were applied as described in experiment 1. A "Velpar Forestry Spotgun" was used for spot applications of hexazinone. Line drenching (Cameron *et al.* 1980) was achieved by applying a solid stream of the herbicide to the soil surface in a band less than 5 cm wide, parallel to and 30 cm from one side of each row of radiata pine.

A count was made of dead and living (classified according to extent of defoliation) target species on each plot four months after treatment. A statistical examination of the data was not made due to a low number of target species on some plots. Results in Table 1 show that the broadscale application of both liquid and granular hexazinone provided a high level of woody weed control at moderate rates with minimum phytotoxicity. Liquid hexazinone tended to be more effective than the granular form at equivalent application rates, indicating the presence of some foliar activity. The level of control measured in this study was substantially better than that observed in experiment 1 where the target species were taller. Small plants of the target species (e.g. less than 50 cm tall) were observed to rapidly defoliate and die following overspraying with only 2 kg ha^{-1} hexazinone. This supports the hypothesis that silver wattle and eucalypts can be more readily controlled when hexazinone is applied at an early growth

stage.

Although line drenching caused high mortality of the target species, some radiata pine deaths were recorded and most were damaged, severe chlorosis and necrosis of older needles being the most common symptom. Reduced phytotoxicity would be expected with lower rates than that used here or with the line drench located further from the rows of radiata pine such as 1 m successfully used by Cameron *et al.* (1980) on a more sensitive pine. Line drenching has several operational and environmental advantages, especially the avoidance of total vegetation control which is desirable on soils susceptible to erosion. Spot application of hexazinone was unsuccessful in controlling the woody weed population. The objective of this treatment was to provide a weed-free environment in the vicinity of each crop plant, and to at least partially control the target species in the untreated surrounds following root encroachment to the treated spot.

Table 1. Effects of hexazinone on target species five months after application in August 1979.

Treatment	Application rate (kg ha^{-1})	Proportion of target species in each category (%)					
		Silver wattle			Eucalypts		
		Dead	> 50% defol.	< 50% defol.	Dead	> 50% defol.	< 50% defol.
Control	Nil	0	0	100	0	0	100
Hexazinone liquid overspray	2	39	33	28	18	48	34
	4	19	67	14	67	17	16
	8	38	62	0	86	14	0
Hexazinone granules broadcast	1	0	7	93	0	0	100
	2	17	28	55	7	22	71
	4	18	48	34	42	42	16
Hexazinone spot application[1]	4	0	3	97	0	0	100
Hexazinone line drench	8	42	33	25	73	23	4

[1] A 1.2 m diameter spot around each radiata pine sprayed at the rate of 4 kg ha^{-1}.

GENERAL DISCUSSION

Control of dense silver wattle and eucalypt regrowth in young radiata pine plantations is essential to ensure satisfactory survival and growth of the crop plant. Hexazinone has been shown to be active against eucalypts and to a lesser extent silver wattle, and young radiata pine plantations exhibit a high degree of tolerance. Results of field experiments indicate that the efficacy of broadcast hexazinone depends on the growth stage of the target species and the formulation and carrier used. Although high rates are required to effectively control advanced regrowth, plants less than 50 cm tall can be controlled by relatively low rates. Early treatment is therefore desirable, and this also has the advantage of avoiding severe competition between the crop plant and the weed

population. Application during the first spring (as advocated by Cameron and Stokes (1978)) or the second spring after planting is likely to be the optimum time depending on weed species and their development.

Observations by the authors supported by results from field studies reported here, indicate that liquid hexazinone is more effective than granular hexazinone on silver wattle and eucalypts when broadcast at equivalent rates. This suggests that foliar as well as root uptake of hexazinone makes a significant contribution to weed control. The importance of foliar uptake was highlighted by the use of a petroleum oil in the carrier, which resulted in total control of the woody weed population. Maximising foliar uptake is important on soils high in organic matter or on burnt sites where root uptake is likely to be reduced through the adsorption of the active ingredient in the surface soil.

Since hexazinone is more expensive than 2,4,5-T it is desirable to minimise application rates by improving efficacy. Results presented here indicate that a combination of early treatment and the use of a petroleum oil in the carrier will partly achieve this objective. Crop tolerance however was markedly reduced when a petroleum oil was used, and further evaluation is needed to determine the optimum timing, rate of hexazinone, and ratio of petroleum oil to water to reduce crop phytotoxicity to an acceptable level.

Hexazinone has a broad spectrum of activity and controls most non-target species when broadcast at rates necessary to control silver wattle and eucalypts. Although this further reduces competition for moisture, soil nutrients and light, control of all non-crop plants is undesirable on soils susceptible to erosion. The residual property of hexazinone also prevents rapid recolonisation of a site following broadcast treatment. Minimising rates through early treatment and the use of a petroleum oil could partly alleviate this problem by allowing more rapid recolonisation. Alternative methods of application such as line drenching could also be used on undulating sites with erosion-prone soils.

In 1980 the FCV tested a promising treatment from these experiments under operational conditions. Around 200 ha of young silver wattle and eucalypt regrowth less than 50 cm tall, in one to two year old radiata pine plantings at three localities, were aerially sprayed using 2 kg ha^{-1} hexazinone mixed with a petroleum oil and water. Spraying was undertaken by fixed wing aircraft in early November using a spray volume of 60 L ha^{-1} containing 40 to 50% v/v petroleum oil. Complete defoliation of silver wattle and total leaf scorch of eucalypts was observed within four weeks of spraying at each locality, and stem die-back was well advanced indicating effective control of the woody weed population. Damage to radiata pine was restricted to scorch of a moderate proportion of the needles, and active shoot growth had recommenced by mid-December 1980.

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