SCREENING OF HERBICIDES IN HOOP PINE

M.J. LEWTY

Forest Research Centre
M.S. 483
GYMPIE 4570

Summary. Six herbicides were evaluated for selectivity to hoop pine. Each herbicide was applied pre and post-plant and at three rates of application. Hoop pine was found to be tolerant to pre and post-plant applications of fluazifop-butyl at 1.0 kg ha^{-1}, 2.0 kg ha^{-1} and 4.0 kg ha^{-1}, chlorsulfuron at 0.08 kg ha^{-1}, 0.15 kg ha^{-1} and 0.30 kg ha^{-1} and triclopyr at 1.0 kg ha^{-1}, 2.0 kg ha^{-1} and 4.0 kg ha^{-1}. Hoop pine was intolerant to sulfometuron-methyl applied pre-plant at 0.75 kg ha^{-1} and post-plant at 0.38 kg ha^{-1} and 0.75 kg ha^{-1}. Dicamba applied post-plant at 3.0 kg ha^{-1} and buthidazole applied post-plant at 0.5 kg ha^{-1}, 1.0 kg ha^{-1} and 2.0 kg ha^{-1} were both phytotoxic to the pine.

INTRODUCTION

Herbicides play an important role in the management of pine plantations under the control of the Queensland Department of Forestry. They are used from the time of pre-plant spraying to crown closure to achieve the best possible pine growth, and after crown closure to maintain access into the plantations. Since the 1960s, the phenoxy herbicides 2,4-D and 2,4,5-T have been relied upon heavily to provide the means of chemically controlling weeds. However, with the controversy over the continued use of these herbicides, their guaranteed supply is not assured. Therefore, it is imperative that substitute herbicides be found. With a systems approach being adopted for weed control (Wells and Lewty, 1984), there is much greater scope for the use of a larger range of herbicides than there has been previously. Along with the need to keep abreast of the continual development of new herbicides, there is a need to maintain an ongoing herbicide screening programme. The aim of such a programme is to build up a workable dossier on a range of herbicides, each of which may have a specific or a number of uses in a weed control system.

Early screening trials evaluated the selectivity of herbicides to pine trees and their weed control efficacy in a single experiment. This proved to be unsuccessful as uncontrolled weed growth within various treatments greatly confounded the results of such trials. A recent approach has been to screen herbicide selectivity to the pine and weed control efficacy in separate trials. This paper reports on the first of a series of trials which evaluate the selectivity of a number of herbicides to hoop pine (*Araucaria cunninghamii*).

MATERIALS AND METHODS

The experimental site was located at Yarraman, approximately 130 km north-west of Brisbane. The site sloped gently to the south-west and was on a soil described as a normal krasnozem (Stace et al, 1972). The rainfall recorded at the Yarraman forest station for the period of the study (January 1982 to May 1983) was 1764 mm. This was well above the average historical recording for this period of 1217 mm.

Kikuyu grass (*Pennisetum clandestinum*) covered the site prior to establishing the experiment. This was eradicated by first desiccating the grass by applying glyphosate, followed by burning the dead grass. Finally a complete disc ploughing of the area was carried out. The site was maintained in a weed free condition for the period of the study with spot applications of glyphosate to kill re-invading kikuyu or broadleaf weeds.

The experiment was established in a randomized complete block design with 36 herbicide plus 2 control treatments replicated three times. Plots were 20 tree line plots, with trees planted at 1.0 m spacing with 2.0 m between adjacent plots. This gave a 1.0 m isolation between the spray edge of adjacent treatments. Each replication had a 2.0 m isolation.

Six herbicides[1] were trialled at three rates of active ingredient application: fluazifop-butyl at 1.0, 2.0 and 4.0 kg ha^{-1}; sulfometuron-methyl at 0.19, 0.38 and 0.75 kg ha^{-1}; chlorsulfuron at 0.08, 0.15 and 0.30 kg ha^{-1}; dicamba[2] at 0.25, 1.0 and 3.0 kg ha^{-1}; buthidazole at 0.5, 1.0 and 2.0 kg ha^{-1}; triclopyr[3] at 1.0, 2.0 and 4.0 kg ha^{-1}. A wetting agent, Agral 60, was added to fluazifop-butyl at 0.1% of the spray volume. Herbicides were applied by Forestry Spot Gun™ pre-plant to a referenced planting spot, and post plant "over the top" of the pine. Calibration was based on a 30 ml application of herbicide mixture to a 1.0 m diameter spot, giving an application rate of 382 L ha^{-1}. Pre-plant treatments were sprayed on 13 January 1982 and tubed hoop pine stock were hand planted into sprayed and unsprayed planting spots on 29 January 1982. Post-plant "over the top" spraying of the pine was completed on 23 February 1982.

The height of the pine was measured periodically for 16 months after planting. At each height measure, plants were visually categorised into one of six health classes: 1. healthy, 2. affected by herbicide, 3. severely affected byherbicide, 4. dead from herbicide, 5. affected by agents other than herbicide, and 6. dead from agents other than herbicide.

Pine survival and height data were submitted for analysis of variance as a 19 herbicide treatment by 2 replication time factorial. Pine categorised into stem classes 4, 5 and 6 were excluded in the analysis of height data.

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[1] Trade names are: Fusilade®, Oust™, Glean®, Banvel®, Ravage® and Garlon® 3A respectively.

[2] as the oleyl propionic diamine

[3] as the triethylamine salt

Table 2. Percentage survival of 16 month old hoop pine as affected by rate and time of herbicide application. Mean of 3.

Time of Application	Herbicide kg ha^{-1}																			
	Fluazifop-butyl			Sulfometuron-methyl			Chlorsulfuron			Dicamba			Buthidazole			Triclopyr			Control	Mean of 57
	1.0	2.0	4.0	0.19	0.38	0.75	0.08	0.15	0.30	0.25	1.0	3.0	0.5	1.0	2.0	1.0	2.0	4.0		
Pre-plant	98	98	100	97	100	92	98	97	95	97	95	98	88	93	97	98	95	100	98	97
Post-plant	95	93	98	95	92	95	97	100	98	97	98	85	83	58	20	90	98	93	98	89
Mean of 6	97	96	99	96	96	93	98	98	97	97	97	92	86	76	58	94	97	97	98	

LSD P = 0.05 Mean of 3 = 9.0
Mean of 6 = 6.3
Mean of 57 = 2.1

Table 3. Mean height (cm) of 16 month old hoop pine as affected by rate and time of herbicide application. Mean of 3.

Time of Application	Herbicide kg ha^{-1}																			
	Fluazifop-butyl			Sulfometuron-methyl			Chlorsulfuron			Dicamba			Buthidazole			Triclopyr			Control	Mean of 57
	1.0	2.0	4.0	0.19	0.38	0.75	0.08	0.15	0.30	0.25	1.0	3.0	0.5	1.0	2.0	1.0	2.0	4.0		
Pre-plant	72.3	87.3	81.3	74.3	67.5	55.7	79.8	79.4	72.6	75.8	76.4	78.5	73.2	80.5	74.6	68.2	68.4	75.1	75.3	74.5
Post-plant	71.2	60.6	68.3	62.9	55.4	52.5	74.5	69.1	69.5	75.5	67.2	49.6	74.1	62.3	52.5	66.7	72.0	66.2	82.4	65.9
Mean of 6	71.8	73.9	74.8	68.6	61.5	54.1	77.1	74.3	71.0	75.7	71.8	64.1	73.6	71.4	63.6	67.4	70.2	70.7	78.9	

LSD P = 0.05 Mean of 3 = N.S.
Mean of 6 = 11.2
Mean of 57 = 3.6

RESULTS

The percentage survival and mean height of the hoop pine 16 months after planting are presented in Tables 2 and 3 respectively. The rate by time of herbicide application interaction for survival (Table 2) was highly significant (P 0.001). Pine survival for the pre-plant spraying of buthidazole at 0.5 kg ha^{-1} was significantly lower than the control. However, the most pronounced effects on survival were recorded for post-plant applications. Survival in plots sprayed with dicamba at the high rate of 3.0 kg ha^{-1} and buthidazole at all rates was significantly lower than the control. The rate of buthidazole application had a very marked effect on pine survival. Percentage survival decreased from 83 to 58 to 20 per cent as the application rate increased from 0.5 kg ha^{-1} to 1.0 kg ha^{-1} to 2.0 kg ha^{-1}. None of the other herbicides appeared to have adversely affected the survival of the pine.

Applying all herbicides "over the top" of the pine leads to a general reduction in pine height (Table 3). Consequently, the main effect of application time (mean of 57) was very highly significant (P 0.001), with mean heights of 74.5 cm and 65.9 cm for the pre and post-plant applications respectively. Although the rate by time of herbicide application (mean of 3) was not significant, on examining Table 3, it is suggestive that post-plant spraying of some herbicides at the higher rates has adversely affected pine growth. This effect is reflected by a significant (P 0.05) difference in mean height between the herbicide treatments (mean of 6). The mean height of the pine was significantly lower than the control for the treatments sprayed with sulfometuron-methyl at 0.38 kg ha^{-1} and 0.75 kg ha^{-1}, dicamba at 3.0 kg ha^{-1}, buthidazole at 2.0 kg ha^{-1} and the low rate of triclopyr at 1.0 kg ha^{-1}. Although the mean height of the pine sprayed post-plant with fluazifop-butyl at 2.0 kg ha^{-1} and 4.0 kg ha^{-1} appears excessively lower than the pre-plant sprayed height, it is not judged to be different from the height of the control pine. Apart from pre-plant spraying sulfometuron-methyl at 0.75 kg ha^{-1} no other herbicide applications appear to have significantly affected pine growth.

DISCUSSION

The methodology employed in this study was much improved from that used in previous trials. With stems classes allowing the exclusion from analysis any stems affected by factors other than herbicides and the growing of the trees under weed-free conditions, the results obtained should give a true indication of herbicide selectivity to hoop pine. Both survival and mean height analyses need to be taken into account when considering herbicide selectivity. Any unexplained differences would most likely reflect genetic variation amongst the planting stock.

Buthidazole was the most phytotoxic of the herbicides used. Its use resulted in a significantly reduced survival at the low rate of 0.5 kg ha^{-1} sprayed post-plant, ranging to very low survival and a marked reduction in mean height at the high rate of 2.0 kg ha^{-1}. With the suggested rates for weed control of 2.2 kg ha^{-1} to 9.0 kg ha^{-1} (Anon, 1977), buthidazole as a post-plant herbicide would not appear to have any real potential for use in hoop pine weed control. Although the survival of the pine sprayed pre-plant with buthidazole at 0.5 kg ha^{-1} was significantly lower than the control, it is difficult to attribute this to the herbicide as survival at the higher rates was very good. Hence, hoop pine appears to be tolerant to buthidazole up to at least 2.0 kg ha^{-1} when the chemical is applied pre-plant. Therefore the herbicide may have some use for weed control prior to pine planting.

Hoop pine was also relatively intolerant to sulfometuron-methyl. Although not affecting pine survival, applied pre-plant at 0.75 kg ha^{-1}, it appears that the chemical will check hoop pine growth and it certainly depresses hoop pine growth when applied post-plant at rates greater than 0.38 kg ha^{-1}. Technical information provided by Du Pont indicates the control of established weeds is achieved at rates from 0.21 kg ha^{-1} to 0.63 kg ha^{-1}. This level of application which is required for weed control does not give a great safety margin for application near hoop. Hence, sulfometuron-methyl does not seem to have any real potential for use as a chemical weed control agent in hoop pine.

Dicamba sprayed post-plant at 3.0 kg ha^{-1} markedly affected pine growth, whilst there was no apparent effect of the 0.25 kg ha^{-1} and 1.0 kg ha^{-1} applications. With suggested rates for weed control from 0.14 kg ha^{-1} to 0.28 kg ha^{-1} (Swarbrick, 1982), dicamba applied post-plant at rates below 1.0 kg ha^{-1} may have some use in hoop pine weed control. Dicamba could be used safely up to 3.0 kg ha^{-1} pre-plant.

Although the mean height of the pine sprayed with triclopyr at 1.0 kg ha^{-1} was lower than the control, this cannot be attributed to herbicide effect as the higher application rates of 2.0 kg ha^{-1} and 4.0 kg ha^{-1} do not appear to have affected pine growth. Hence, it appears it is safe to apply triclopyr at rates up to 4.0 kg ha^{-1} to hoop pine both pre and post-plant. Triclopyr as the triethylamine salt applied as a foliage spray has been shown to control a broad range of woody plants in the U.S.A. Rates used varied from 1.12 kg ha^{-1} to 6.72 kg ha^{-1}, with most woody species controlled at 1.12 kg ha^{-1} to 2.24 kg ha^{-1} (Byrd et al, 1975). Watson (1978) evaluated that most Australian species of interest would be controlled at rates below 4.0 kg ha^{-1}. This was also the case for the butoxyethanol ester formulation[1] of triclopyr. Triclopyr seems certain to have a place in forestry weed control, particularly to form part of an alternative for the phenoxy herbicides. This is already occurring, with the butoxyethanol ester formulation replacing 2,4,5-T in basal bark spraying operations. However, as it appears certain that only the ester formulation will be marketed in Australia (K. Webb[2], personal communication, 1984), evaluation of the selectivity of this formulation to hoop pine is also required.

A wide range of non-graminaceous crops have shown tolerance to fluazifop-butyl at rates at least twice those required for effective grass control (Plowman et al, 1980). This also appears to apply to hoop pine where there was no apparent effect on the pine at rates as high as 4.0 kg ha^{-1}. Fluazifop-butyl has controlled perennial grass weeds at rates of 0.5 kg ha^{-1} to 2.0 kg ha^{-1} (Plowman et al, 1980). Couch grass (*Cynodon dactylon*) is reported to be controlled by rates of 0.25 kg ha^{-1} to 0.5 kg ha^{-1} with a higher rate of 1.0 kg ha^{-1} required for control of drought-stressed plants (Anon, 1981). It would seem that fluazifop-butyl has real potential for use as a selective "over the top" herbicide in young hoop pine plantations where couch grass has been sown as a ground cover crop (Wells and Lewty, 1984). Further work with fluazifop-butyl will examine its control efficacy of couch grass.

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[1] Garlon 480

[2] Dow Chemical Representative

Depending on the weed species and time of application the effective rate of chlorsulfuron application varies from 8 to 32 g ha^{-1} (Campion and Tichon, 1981). This is much lower than the rates applied in this trial, where no detrimental effect of chlorsulfuron on hoop pine was apparent. Chlorsulfuron has a very high herbicidal activity at extremely low application rates, with field studies showing very little loss of activity on many broadleaved weeds with rates reduced from 70 to 280 g ha^{-1} to 5 to 60 g ha^{-1} (Palm et al, 1980). Laboratory studies have also shown activity at very low concentrations, where, in sensitive plants, the mode of action is the inhibition of plant cell division (Ray, 1982). Chlorsulfuron is readily taken up by the foliage and roots of both sensitive and resistant herbaceous species and moves rapidly through the plant. Apparently, metabolism is the basis of selectivity to chlorsulfuron. Sensitive plants show little or no metabolism, whilst tolerant plants convert the herbicide to inactive products (Anon, 1983). Hoop pine must be classed as a tolerant plant. The value chlorsulfuron may have for weed control in hoop pine plantations is questionable. Though non-phytotoxic to hoop pine, it appears that the weeds controlled are predominantly soft weeds (Anon, 1983). Whereas the major weeds of importance in hoop pine are woody weeds (C.H. Wells, unpublished data).

In conclusion, hoop pine is shown to be tolerant to pre and post-plant applications of the herbicides fluazifop-butyl, triclopyr and chlorsulfuron. Of these, fluazifop-butyl and triclopyr would seem to have the best potential for use in hoop pine plantations. Further trials on fluazifop-butyl's control efficacy of couch grass and the selectivity of the butoxyethanol ester formulation of triclopyr to hoop pine will be initiated.

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