GRASS CONTROL FOR RADIATA PINE ESTABLISHMENT ON DROUGHTY SITES

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ABSTRACT

*Survival and growth of radiata pine (*Pinus radiata *D. Don) seedlings in the warm dry-summer climate of Canterbury are markedly influenced by competition from grasses and other herbaceous weeds. Weed control not only produced an immediate increase in growth but also had a positive effect on tree growth for the following eight years.*

Site improvement by either ripping or weed control had a marked effect on tree growth. A combination of the two further increased survival, height growth, and total basal area. With the option of either ripping or weed control, the results suggested that post-planting weed control would give better value for money.

Further work on the effects of fertiliser application in the presence or absence of weed competition indicated that failure to achieve good weed control will result in an increase in weed competition and may reduce the survival and growth of radiata pine seedlings.

Broadcast vegetation control resulted in better survival and growth of tree seedlings. If, however, spot application is desired because of costs, then the "Spot Gun" applicator may be used with hexazinone. Best results can be achieved with the flat fan nozzle. Costs for such an operation on hill country are around $45/ha.

INTRODUCTION

In regions where summer rainfall is low and the water storage capacity of the soil limited or reduced, early survival and growth of planted seedlings often depends on the degree of competition for available moisture between the seedlings and other vegetation.

The basis of weed control is the diversion of part of the resources on the site from weed species to the crop. If site resources are diverted at a rate in excess of the ability of the crop to use them, then weed control is excessive. The key is

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to divert resources of a kind, in a form, and at a rate that the crop trees can use. These resources are light, moisture, and nutrients, any or all of which may be denied to the crop trees by growing weeds.

Weeds can be eliminated entirely if sufficient quantity of herbicide is used but limits are imposed by tree tolerance and practical and economic considerations. The extent to which it is worth changing an ecosystem has to be decided on the basis of local research. Evaluation of a weed control technique or chemical must be carried out until the results of a treatment can be predicted with confidence. At this stage practical and economic evaluations become important; the cost and effect of various levels and durations of weed control must be assessed. However, the cost of the control operation cannot be considered in isolation, it must be related to other costs and benefits to the crop involving evenness of growth, changes in the rotation, regularity of stocking and influence on silviculture (Balneaves, 1976a, b; Watt and Tustin, 1976). Davenhill (1971) describes some obvious effects of grass on radiata pine seedlings. The most obvious is physical smothering; in high rainfall areas in particular, heavy growth of saturated grass may collapse and form a mat which will eventually kill many of the trees. Lesser smothering can lead to malformation and butt sweep, and may have some bearing on tree toppling.

As rainfall decreases, the effect of root competition for moisture and nutrients becomes more marked; in dry climate regions it is often impossible to establish trees unless grass is rigorously controlled or eliminated (Revell, 1976). This has been aptly demonstrated by Balneaves (1976a). At Balmoral Forest an area planted in 1973 had a survival of 95% in March 1974. A mild wet spring in 1974 induced excessive weed growth (grasses and broadleaf weeds) but also good growth of the radiata pine seedlings. However, an almost rain-free period from November 1974 till mid-January 1975 had disastrous consequences. The drought stress, compounded by weed competition, resulted in seedling survival dropping to 54% by March 1975. In other areas of the forest, where weed competition was not evident, survivals were unaffected by the drought. The 1974 plantings in grass areas suffered a similar fate and only 40% survival was recorded. Smail (1975) gave an account of a similar experience on his farm in inland Canterbury.

The more troublesome grasses are Yorkshire fog (*Holcus lanatus*), tall fescue (*Festuca arundinacea*), cocksfoot (*Dactylis* *glomerata*), browntop (*Agrostis tenuis*), sweet vernal (*Anthoxanthum odoratum*). Other species may present problems in some areas.

INFLUENCE OF EARLY GRASS CONTROL ON LONG-TERM GROWTH OF RADIATA PINE

A trial described previously (Balneaves, 1976a) was continued for 8 years to determine the long-term effects of grass control. More recent information on the same trial was published by Chavasse (1979).

Figure 1 summarises height growth trends for four of the treatments tested: (1) burn/plant only; (2) burn/multiple disc and plant; (3) burn/plant/release spray with 2.16 kg/ha of 2,2-DPA

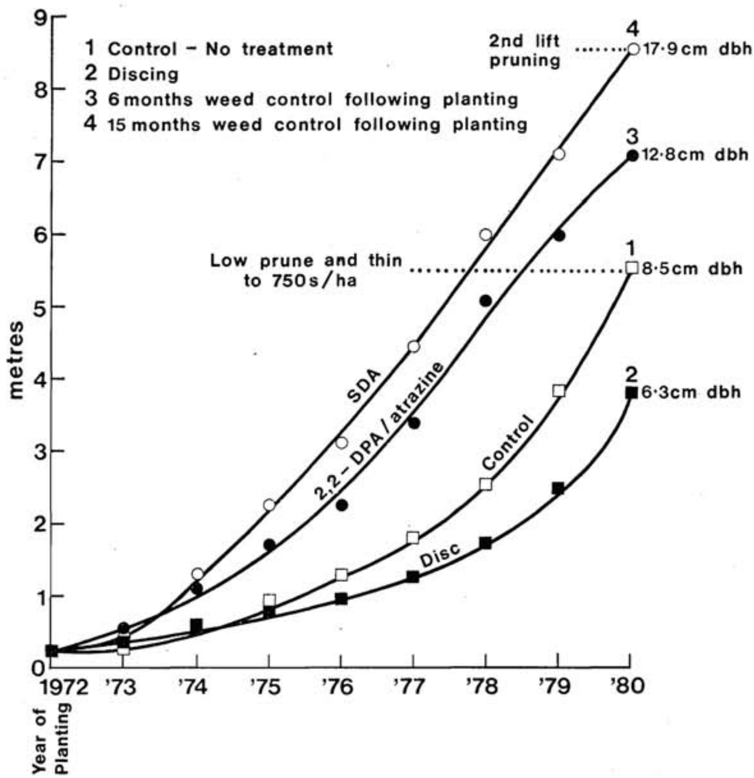

FIG. 1: *Mean height growth response of radiata pine to four weed control treatments.*

and with atrazine at 4.32 kg/ha; (4) burn/spray with a mixture of simazine (8.4 kg/ha), 2,2-DPA (5.397 kg/ha) and amitrole (2.625 kg/ha).*

The growth differences were spectacular. It was found that discing actually induced a denser grass sward than in the controls in the first three years following planting (Balneaves, 1976a), resulting in a setback of height growth equal to one year's increment. When post-planting weed control was undertaken with 2,2-DPA/atrazine (3 above), tree growth was enhanced so that by age 8 years they had a height advantage equal to 18 months' increment over the controls. Treatment (3) gave good weed control for one season only. Treatment (4) resulted in good weed control extending into the second growing season. Growth of radiata pine in treatment (4) was so improved that, by 8 years from planting, height growth was greater by 3.1 metres, or 27 months' growth increment, when compared with the controls. Diameter growth by age 8 years was similarly affected, namely (1) 8.5 cm, (2) 6.3 cm, (3) 12.8 cm, and (4) 17.9 cm.

Timing of initial low pruning and thinning differed as a result of growth differences. Treatment (4) was pruned (0.2 m) and thinned at age 5¾ years, treatment (3) at 6½ years, treatment (1) at 8 years while treatment (2) had yet to attain a size suitable for pruning and thinning. By age 8 years treatment (4) was ready for pruning to 4 metres.

Table 1 summarises the costs of these site preparation and weed control options.

TABLE 1: COST ($)/HA FOR FOUR SITE PREPARATION AND WEED CONTROL OPTIONS

Trt No.	*Burn*	*Cultivation**	*Weedicide†*	*Application‡*	*Total Cost*
1	10	—	—	—	10.00
2	10	69.20	—	—	79.20
3	10	—	84.17	18.50	112.67
4	10	—	204.75	18.50	233.25

*Based on machine hours to do the job + operator cost + fleet cost + supervision.

†Assuming blanket application — cost based on Aug. 1980 retail price list.

‡Aerial application on an hourly contract basis using total volume of 330 litres/ha applied half overlap via helicopter at Ashley Forest — January 1981.

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*All herbicide quantities are in terms of active ingredient per hectare.

It had become apparent that the cost of treatment (4) was too extravagant. In general, forest managers have a preference for post-planting application of weedicides for two main reasons. When spot applications are made to grasses and flat weeds in the autumn prior to planting, the spots become difficult to locate after winter frosts have browned the whole site. Dye added to the herbicide does not persist long enough to offset this difficulty. Secondly, some of the weedicide effect can be lost over the winter months and can offer less weed control in the first summer when compared with post-planting applications in the spring. Further trials were initiated to test a range of treatments to determine a cost efficient alternative to the pre-planting simazine/2,2-DPA/amitrole mixture.

A COMPARISON OF WEEDICIDES

Selective herbicides for grass control were not used in general forest establishment operations in New Zealand prior to 1969 (Davenhill, 1971). Initial trials conducted at FRI, Rotorua, in 1967-8 recommended the general use of amitrole-T and atrazine for spraying over Douglas fir and radiata pine. Other combinations which proved successful included mixtures of atrazine and 2,2-DPA; atrazine and prometon or atrazine with no additive. At that time the standard chemical treatment was a mixture of simazine, 2,2-DPA and amitrole applied prior to planting.

More recently, Bowers, (1976) reviewed the use of weedicides for grass control at N.Z. Forest Products Ltd. He concluded that amitrole-T and terbuthylazine/terbumeton mixture gave good control of Yorkshire fog and other grass species in their plantations. It was found that where Scotch thistle (*Cirsium vulgare*) and nodding thistle (*Carduus nutans*) did not germinate, terbuthylazine and terbumeton had been used but where atrazine had been used these thistles germinated and became a further weed problem. Paraquat and simazine has given adequate control of pasture species (Knowles and Klomp, 1976) where spot spraying is conducted prior to planting. However, where rhizomatous species occur — *e.g.,* sorrell (*Rumex acetosa*) or couch grass (*Agropyron repens*) — this treatment will generally prove to be inadequate, especially where long-term control is desirable. Glyphosate and simazine, however, do offer a good alternative to paraquat and simazine (R. L. Knowles, pers. comm.).

Table 2 gives results of the various chemicals tested by the writer on two sites in Canterbury. In both cases where weed

TABLE 2: RADIATA PINE SURVIVAL AND GROWTH RESPONSES ON TWO SITES FOLLOWING WEEDICIDE TREATMENTS AND FERTILISER APPLICATION, (F) ON THE BALMORAL SITE ONLY.

Treatment No.	Chemicals	Rates/ha	Pre- or Post-Planting Appl'n	2nd Year Survival % F	2nd Year Survival % NF*	1st Year Total Height (cm) F	1st Year Total Height (cm) NF	2nd Year Total Height (cm) F	2nd Year Total Height (cm) NF
(1) BALMORAL FOREST									
1.	Control			33	38	32	34	71	56
2.	Simazine	8.8 kg	Pre	89	100	70	58	162	94
	Amitrole wsp	2.75 kg							
	2, 2-DPA	5.65 kg							
3.	Paraquat	1.1 kg	Pre	60	81	46	44	88	102
	Simazine	4.0 kg							
4.	Paraquat	1.1 kg	Pre	90	90	58	52	130	112
	Simazine	8.0 kg							
5.	Paraquat	1.1 kg	Pre	75	82	65	56	118	106
	Atrazine	4.0 kg							
6.	2, 2-DPA	3.7 kg	Pre	64	94	50	68	91	104
	Atrazine	4.0 kg							
7.	2, 2-DPA	1.85 kg	Post	72	62	54	58	100	98
	Atrazine	4.0 kg							
8.	Amitrole-T	2.2 kg	Post	100	100	64	60	126	110
	Atrazine	4.0 kg							
9.	Amitrole-T	1.1 kg	Post	100	100	62	61	122	103
	Atrazine	4.0 kg							
10.	2, 2-DPA	1.85 kg	Post	76	81	54	53	97	82
	Terbumeton	3.0 kg							
	Terbuthylazine	3.0 kg							
11.	Amitrole-T	1.1 kg	Post	83	83	55	56	82	70
	Terbumeton	3.0 kg							
	Terbuthylazine	3.0 kg							

(2) Ashley Forest

1.	Control			25	30	46
2.	Simazine Amitrole wsp 2, 2-DPA	8.8 kg 2.75 kg 5.65 kg	Pre	94	44	81
3.	Diuron Hexazinone	4.76 kg 3.24 kg	Pre	89	38	62
4.	Glyphosate	4.03 kg	Pre	58	36	58
5.	Hexazinone	4.0 kg	Pre	90	38	67
6.	Glyphosate	1.0 kg	Post	83	33	54
7.	Mon-0139†	1.32 kg	Post	90	39	55
8.	Hexazinone	2.0 kg	Post	92	44	85
9.	2,2-DPA Atrazine	1.85 kg 4.0 kg	Post	64	32	51
10.	2, 2-DPA Amitrole-T Atrazine	1.85 kg 0.40 kg 4.0 kg	Post	77	33	49
11.	Amitrole-T Atrazine	1.0 kg 4.0 kg	Post	82	31	50
12.	Atrazine Simazine Amitrole-T + surfactant	2.4 kg 2.4 kg 1 litre	Post	92	38	61

*No fertiliser.
†Mon-0139 is glyphosate without surfactant additive as found in the product "Round-up".

control was not carried out seedling survival was inadequate. In the better weed control treatments survivals ranged from 94 to 100%. The degree of grass control had a big effect on survival of radiata pine in these trials (Fig. 2). Data from both areas were combined to give the regression line. Each point represents mean ODW of 5 grass samples/plot and the number of living trees expressed as a % of total planted.

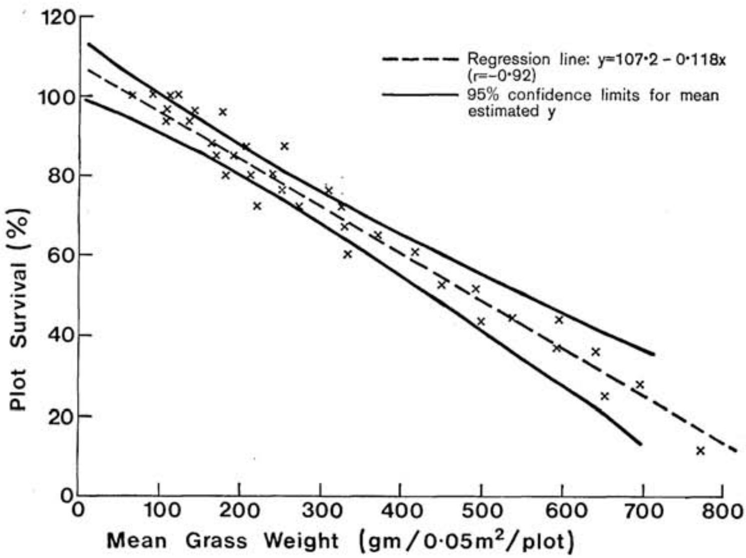

FIG. 2: *The effect on radiata pine survival of mean weed weight.*

In the Balmoral trial each plot was split into two subplots. In the September following planting one was fertilised with diammonium phosphate at a rate of 80 g per tree, notched into the ground 15 cm from the base of the tree and 15 cm deep. These treatments are denoted by the letter F in Table 2 while the unfertilised are denoted NF. In terms of survival, the better treatments were 2 (pre-planting application of simazine/amitrole/2,2-DPA), 4 (pre-planting application of paraquat and simazine), 8 and 9 (post-planting application of amitrole-T/atrazine).

The total height, assessed in 1979 (2 years following planting), also varied greatly with weedicide treatment; those treatments producing good survival also resulted in good height growth. Some treatments, however, did not result in adequate grass control. In such cases, where fertiliser was applied, weed regrowth was encouraged immediately around the base of the trees, increasing the competition. In most instances this stress is reflected in reduced survival and to a lesser extent reduced height growth.

In the trial established at Ashley Forest several treatments gave sufficient control to ensure adequate survival. However, only two treatments resulted in weed control sufficient to ensure that the trees could attain a marked improvement in height growth; they were treatment number 2 (pre-planting broadcast spray with simazine/2,2-DPA/amitrole) and treatment number 8 (post-planting spray with hexazinone). Here the most cost-effective weedicide was hexazinone ($105.06/ha) applied post-planting at 2 kg/ha. Site productivity (total height × total survival) was 5.6% better with the pre-planting treatment of simazine/2,2-DPA/amitrole but the cost ($204.75/ha) was 94% greater than hexazinone. The small advantage in using the former material is outweighed by its cost disadvantage when compared with hexazinone.

INTERACTION OF RIPPING AND WEED CONTROL

A further trial at Okuku Block in Ashley Forest again demonstrated the advantages of using hexazinone as a post-planting weed control measure. The main species in competition with the pines included browntop, sweet vernal and silver tussock (*Poa laevis*). The rate used was 3.6 kg/ha to ensure adequate control of tussock growing in competition with radiata pine seedlings. The application was in 1 metre wide bands along the row of seedlings. Alternate lines were ripped. Hexazinone applied post-planting gave the best results. A post-planting application of 2,2-DPA/atrazine (2 and 4 kg, respectively) gave very good results too. Pre-planting applications of 2,2-DPA and hexazinone gave poor results as did the post-planting application of atrazine/simazine/amitrole-T.

Figure 3 summarises the results of four indices for measuring the response of radiata pine seedlings to ripping and weed control. The control and ripped treatments gave unacceptable survival though ripping did encourage height growth. Good weed control alone resulted in 100% survival and a marked improvement in the growth parameters shown. The combination of ripping and good weed control also gave 100% survival, but resulted in greater height increment when compared with weed control only.

Faced with the option of either ripping or weed control only, then the results of this work suggest that money would be better spent on post-planting weed control. Ripping, however, has

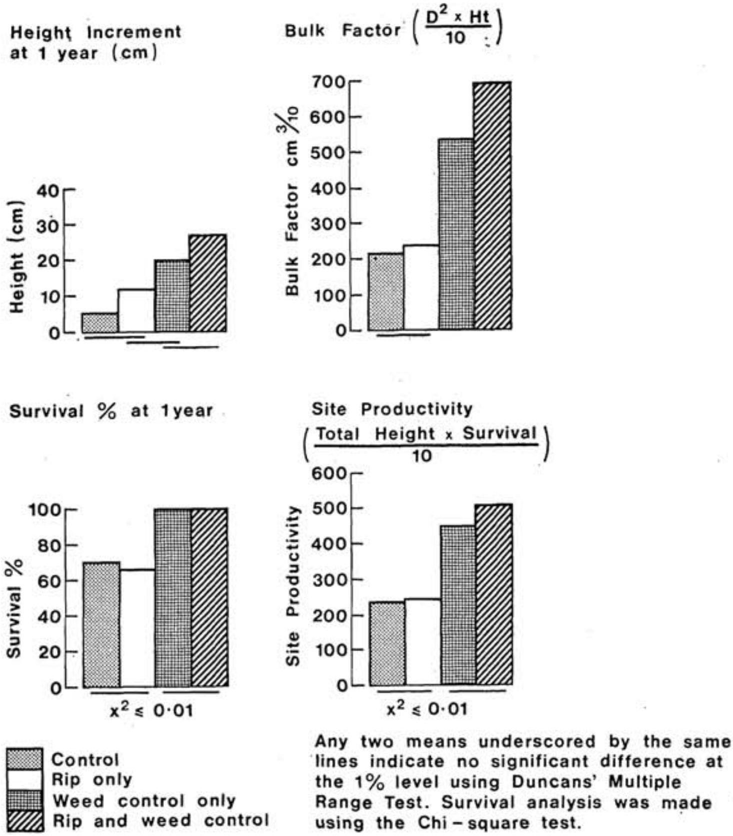

FIG. 3: *Responses of radiata pine seedlings to four combinations of ripping and chemical weed control.*

functions other than boosting height growth. It serves to improve the site, to facilitate planting, to allow a freer soil which encourages rapid root development, and may, in many instances, reduce the incidence of tree toppling. Because it is a form of soil cultivation, in some situations, especially where browntop is the dominant species, ripping can encourage a vigorous spring emergence of grass weeds along the line of the rip.

Thus a combination of ripping and weed control will serve a variety of functions all of which aid high quality establishment. Eliminating one or other in an attempt to cut costs could have severe repercussions as the plantation develops. Where ripping is not done, poor root distribution and toppling can result from difficulty in planting; when weed control is omitted, unthriftiness, or even mortality can lead to uneven growth and poor stocking.

INTERACTION OF WEED CONTROL AND FERTILISER APPLICATION

The results of comparing (1) no weed control, (2) no weed control + 80 g diammonium phosphate (DAP), (3) effective weed control, and (4) effective weed control + 80 g DAP are given in Fig. 4. The site had been ripped to a depth of 45 cm prior to the establishment of this trial.

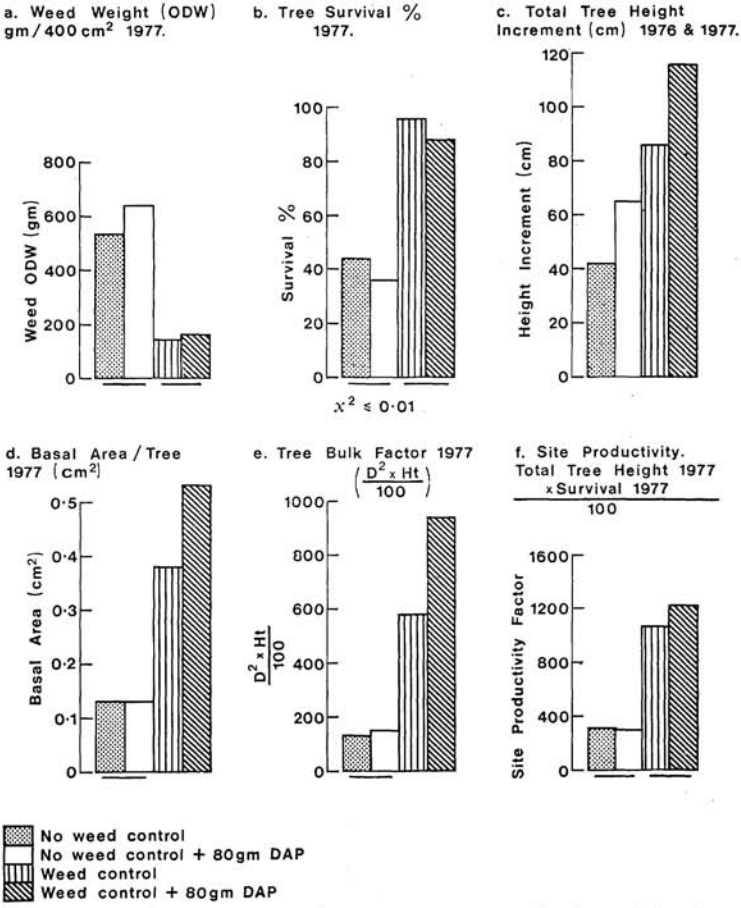

FIG. 4: *Weed and radiata pine responses to weedicide and fertiliser application, Balmoral forest (planted 1975).*

The addition of fertiliser in the absence of weed control (2) resulted in a 25% increase in weed mass as measured by oven dry weight (ODW). This resulted in a decline in tree survival relative to (1), no weed control. Even the relatively small increase in weed mass, as a result of fertiliser application, in the weed control treatment (4) resulted in a decrease in survival (Fig. 4b). Where good weed control was undertaken, the application of fertiliser (4) resulted in a 4% increase in weed mass over weed control in (3) (Fig. 4a).

The total height increments over two years (Fig. 4c) were all significantly different (0.01 level). When fertiliser was applied in the absence of weed control (2) the growth response was not as great as where weed control alone was undertaken. Good weed control coupled with DAP resulted in a further increase in height growth. A similar result can be seen in relation to mean basal area (Fig. 4d), although where fertiliser was applied in the presence of weeds no gain accrued. Weed control alone resulted in a 3-fold increase in basal area and weed control plus fertiliser gave a 4-fold increase in basal area.

Again, using the bulk factor and site productivity factor (Figs. 4e and f) the gains from weed control and fertiliser application at planting on this site are apparent.

METHODS OF WEEDICIDE APPLICATION

As stated earlier, pre-planting application of weedicides to control grass is not generally considered to be as effective as a post-planting application in the majority of situations. Therefore, because the mixture of amitrole, 2,2-DPA, and simazine can be generally used only as a pre-planting spray, it may be less favoured than other herbicides or mixtures. Data presented earlier in this paper suggested that hexazinone applied post-planting at 2 kg/ha resulted in the best weed control of all the weedicides tested and that the radiata pine exhibited much better survival and growth response as a result.

Hexazinone is considered generally to be a costly weedicide and it is this which influences its method of application for grass control only. Where a mixture of weeds occur — *e.g.*, bracken, gorse seedlings and grasses — the broadcast aerial application of hexazinone may be justified since it will control all three weeds but a rate of approximately 6 kg/ha is required. On sites where grasses and flat weeds alone are present, weed control is only required immediately around each tree seedling, providing a 1 m^2 spot free of competition. An inverted cone spray unit was developed and its operational use described (Bowers and Hawthorn, 1971). At that time the inverted cone sprayer proved to be the most efficient manual method for controlling grass species but was soon superseded by aerial release spraying. However, spot spraying, to control pasture grasses and weeds, can be cheaper than aerial spraying. It is most appropriate where labour is available, and access is good, and when the pasture is to be grazed or harvested following planting. Nevertheless, of some 17 000 ha of grass, herbaceous weeds and thistles treated with weedicides annually, only some 573 ha were treated by spot spraying with backpack units. This is about 3% of the total area sprayed, prior to 1976 (Chavasse, 1976).

TABLE 3: RADIATA PINE GROWTH RESPONSES TO THREE SPRAY APPLICATION TECHNIQUES, TWO YEARS FOLLOWING PLANTING

Hexazinone applied at 2 kg/ha.

Treatment	*Survival (%)*	*Height (cm)*	*Diam. (mm)*	$D^2 \times Ht$	*Site Productivity*
Control (unsprayed)	78	109 a*	20 a	44146 a	8502 a
Spot Gun (solid cone nozzle)	85	108 a	21 a	48529 a	9180 a
Spot Gun (flat fan nozzle)	90	123 b	23 a	67886 a	11070 b
Broadcast vegetation control	94	144 c	30 b	141289 b	13563 c

*Using Duncan's New Multiple Range Test. Working down the column, those treatments sharing a common letter are not significantly different (0.01 level.)

With the introduction of hexazinone and the "Spot Gun"* applicator much larger areas are now being spot sprayed to release radiata pine from grass and flat weed competition. The development of the "Spot Gun" applicator has been described elsewhere (Porter, 1979). Table 3 summarises the results of a trial adjacent to Ashley Forest and demonstrates the growth of radiata pine released with hexazinone using the Spot Gun applicator giving a 1 m^2 weed free area immediately around the base of the tree and it is compared with the total vegetation control on the whole site.

*Du Pont "Spot Gun" TM.

It appears from this one trial that the response to broadcast vegetation control is superior to that of spot spraying. The response to spot spraying may be a function of the area of control immediately around the tree. Further work under various conditions is needed to determine the spot sizes for maximum benefit from weed control at a reasonable cost.

Recent experience indicates that application rates, timing, method and formulation of hexazinone, are vital to its success and any misjudgement of one of these four factors can result in high tree mortality, especially where soil types are very friable or stony and are free draining. On heavy soil types — *e.g.*, clay/silt loams — radiata pine will tolerate very high rates of hexazinone; in excess of 16 kg/ha. On the friable or stony soil types as experienced at Balmoral and Eyrewell Forests, Selwyn Plantation Board areas and North Canterbury Catchment Board plantations, application rates above 1.8 kg/ha (*e.g.*, 3-4 kg/ha) in the spring following planting can result in browning of needles and loss of the first-year increment, with retardation of growth in the second year. Higher rates would result in significant tree mortality. It has been observed that careless or faulty application, particularly with the Spot Gun, has given a higher dosage rate per unit area around the tree resulting in severe damage. These factors have been compounded in the case of late applications of hexazinone 6 to 8 months after planting — that is, spraying for control of grasses and flat weed competition during the driest and hottest months of the summer. Trials put down in November 1980 over trees planted in winter 1979 have tolerated hexazinone at 12 kg/ha with no adverse effect on growth. Thus, if further weed control is needed in the second growing season following planting, then it appears that higher rates of hexazinone may be applied if necessary, provided that the various guidelines outlined above are followed.

COSTS OF GRASS CONTROL

Recent costs made available by Ashley Forest (N.Z. Forest Service) and the Selwyn Plantation Board (SPB) are shown in Table 4.

The two sets of costs shown in Table 4 are for hill country areas. Chemical costs may differ from these, depending on contract purchase pricing of hexazinone. Therefore total costs/ha may be less than those given.

TABLE 4: COST/HA OF SPOT SPRAYING A 90% WATER SOLUBLE POWDER FORMULATION OF HEXAZINONE IN 1979/1980

	N.Z. Forest Service Okuku Block Ashley Forest	*SPB Mt. Lomond Block*
Stems/ha	1250	1250
Spot Gun system	solid cone nozzle	flat fan nozzle
Chemical cost* @ 1.8 kg	$13.00	$13.00
Wages	$22.82 (5.28 man-hr/ha)	$22.35
Supervision	$ 4.87 (0.92 man-hr/ha)	
Fleet	$ 0.32	$ 2.33
Bonus	$ 3.40	$ 7.43
	$44.41	$45.11

*All chemical costs are based on retail price as at January 1981. Spot size 1 m².

The SPB also have considerable areas of flat land where strip spraying operations are undertaken, following logging, windrowing and machine planting. Strip spraying is carried out using a 22 kW tractor, tank and boom on a contract basis. Rows immediately adjacent to, and at the ends of, the windrows cannot be sprayed in this manner, therefore some spot spraying is necessary. These costs are given in Table 5 and compartive costs for aerial operations are given.

TABLE 5: STRIP SPRAYING AND COMPARATIVE BROADCAST CONTROL COSTS/HA

Stocking	*Strip 1250 Stems/ha or 4 × 2 m Planting Espacement*	*Total Vegetation Control*
Width of spray strip	1 m	
Chemical cost	$24.32	135.49
Application cost at 1.8 kg	6.67	18.00*
Supplementary spot spraying:		
Labour and fleet	2.03	1.25
Chemical cost	1.18	
Overall supervision	2.84	
	$37.04	$154.74

*Applied by helicopter in 200 litres water/ha.

Again, the chemical costs are based on retail price as at January 1981. Therefore the total operational cost may be less than that shown in Table 5.

It has been observed that 1.8 kg/ha of hexazinone gives good grass control for one season on the hill country. Control extends into the second growing season on the plains. SPB are investigating the benefits of conducting a further operation in the second spring following planting, and results on the plains forest, at least, are visibly favourable in terms of accelerated growth of radiata pine. The same may also be true for the hill country areas at Mt Lomond. Two applications of 1.8 kg/ha are preferred to a single application of 3.6 kg/ha. This gives weed control extending well into the third growing season. One application of 3.6 kg/ha in the first spring following planting will give weed control to the end of the second growing season only on the plains forest, and for only 18 months following planting on the heavy soils of the hill forest.

Thus there are some immediate advantages in the approach of the SPB, but as yet the long-term benefits to radiata pine in terms of accelerated growth have not been quantified. The SPB have adopted the use of the flat fan nozzle for the Spot Gun application as they experienced less tree damage and greater growth response with this than where the solid cone nozzle was used. This confirms the data given in Table 3.

Again, referring to Table 2, the poorer showing of spot spraying compared with broadcast treatment needs to be evaluated further in light of the spot and strip spraying experience of the Selwyn Plantation Board, and the two annual applications favoured by them.

CONCLUSIONS

Grass control in droughty conditions such as those experienced in North and Central Canterbury will improve survival, height and diameter growth of radiata pine seedlings following planting. It has been observed that these advantages can continue till the stand is at least 8 years old. The advantages are such that in one instance initial pruning and thinning was carried out 27 months earlier than those trees growing in competition with a heavy grass sward.

Trials to test the effectiveness of various weedicides indicated that a pre-planting application of simazine/amitrole/2,2-DPA resulted in excellent control of grasses. However, equally good results were achieved using hexazinone as a post-planting treatment in the early spring following planting. This latter treatment was only half the cost of the former.

Further trials indicated that a combination of ripping and good weed control not only improved tree survival, but resulted in greater tree growth when compared with weed control only. The results of the work described earlier suggested that if there were resources for either ripping or weed control only then money would be better spent on post-planting weed control.

If it is necessary to apply fertiliser to tree seedlings soon after planting, then good weed control is essential. Failure to do so will result in an increase in weed competition following fertiliser application. This in turn may reduce survival or growth of radiata pine seedlings.

Methods of application of weedicides are also very important and it is apparent from the trial described earlier that broadcast application resulted in better tree survival and growth. Of the Spot Gun treatments, a better result was achieved when the flat fan nozzle was used instead of the solid cone nozzle.

A comparison of costs of weed control using the Spot Gun applicator is given for two areas for Canterbury. The cost including wages, supervision, fleet and bonus payments was around $45/ha. On the SPB plains forest where strip spraying was carried out and supplemented with some spot spraying the cost was $37/ha. A cost-benefit analysis has not been done but will be the subject of a further paper currently in preparation.

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