# RADIATA PINE GROWTH RESPONSE TO WEED CONTROL AT TOKOITI FOREST - RESULTS AFTER SIX YEARS

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***NZ Site Management Cooperative Report Number 115***

*Last modified 27/4/01*

## INTRODUCTION

A trial was established on a fertile pasture site to determine the growth response of radiata pine to weed control treatments of varying area and duration. This information is required to identify environmentally sensitive weed control treatments that minimise costs and herbicide use while maintaining adequate crop survival and growth rates.

**Ultimately, these data will enable calculation of the most cost-effective and environmentally safe treatment options.**

## METHODS

The experiment was established in winter 1994 on exposed, rolling, ex-pasture coastal land in Tokoiti Forest, South Otago. It was designed to test short-term (7-10 year) responses to a number of weed control treatments. The site had high soil fertility, an average annual rainfall of around 800 mm, and a predominant vegetation cover of improved agricultural grasses with some thistles.

The trial was planted with one year old, bare rooted GF26, radiata pine seedlings, at a spacing of 4 x 3 m (833 stems/ha). Plots were 24 x15 metres in size with the central 12 trees used for assessment purposes. A range of treatments was applied in the following spring, comprising combinations of spot size and duration of weed control (Table 1). To determine maximum productivity, an additional weed-free plus fertiliser treatment was included in the long-term experiment. Weed control was achieved with a range of herbicides: Versatill, Gallant, Velpar, and Gardoprim. Tree height and diameter, growth, survival, degree of multi- leadering, and the size of weed-free areas around individual trees were measured annually.

**Analysis**

Mean tree height, diameter, stem volume and volume per hectare (which includes the effect of mortality) were analysed using analysis of variance for age 6. Under-bark stem volumes of trees were estimated using a simple relationship suggested by P. Beets (pers. comm.), $V = 0.25D^2 Hp/4$, where $D$ is collar diameter and $H$ is height.

Growth trends were analysed by fitting sigmoidal growth curves to the diameter, height and volume (mean and per hectare) measurements for the weed-free treatments in each replicate. For diameter and volume, the Weibull function was used, while for height, the Chapman-Richards function was used.

To quantify the competitive effects of weeds in the six herbicide treatments and the control treatment, the proportion of growth lost annually compared with the weed-free plot was calculated for each year and replication. By summing these, the cumulative total of years growth lost was calculated. Analysis of variance was then used to test the significance of the treatments on growth loss, and least significant differences were calculated.

**Table 1:** ***Same as for previous COOP Report on Tokoitit (No. 109) except long-term trial data are to be omitted.***

## RESULTS

### Survival

Tree survival was lowest (60%) where there was no weed control and highest (88%) with a 1 m diameter spot maintained for 2 years (Figure 1). However, there was no strong pattern of mortality with respect to area and duration of weed control. Survival was also poor (77%) with complete weed control indicating that factors other than weed competition (e.g. wind exposure, browsing) were also influencing survival.

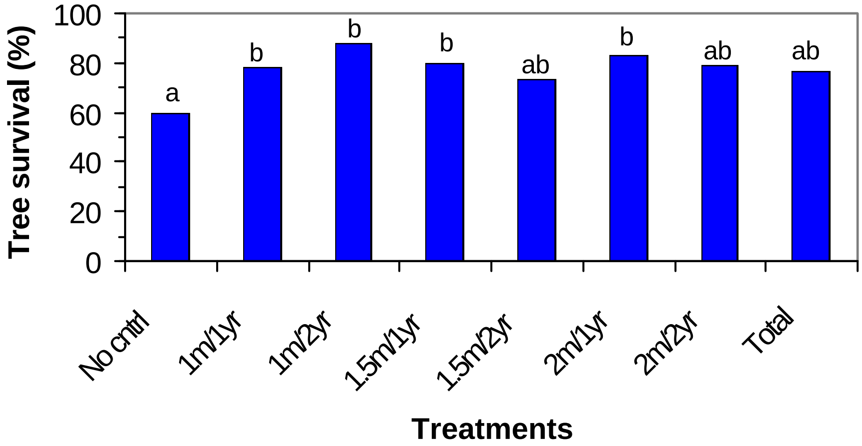


Figure 1: Effect of weed control treatments on mean tree survival, 6 years after planting. Bars topped by the same letter are not significantly different (P > 0.05).

### Age 6 tree height, diameter, and volume

Conclusions from examining treatment effects on growth were similar with respect to mean tree height, diameter, volume or total volume per hectare (including mortality effects), therefore only results for mean and total volumes have been illustrated. Mean tree growth, assessed using any parameter, was lowest in the no weed control treatment (Figures 2a,b). Even the smallest amount of weed control (a 1 m diameter spot maintained for 1 year) produced large growth benefits. The highest value of any growth parameter was always found in the complete weed control treatment, but this was not significantly different from the more intensive weed control treatments. The benefit from a second year of spot weed control was marginal in all cases except the 1 m spot treatment, and was only statistically significant for the 1 m spot.

(a)　　　　　　　　　　　　　　　　　(b)

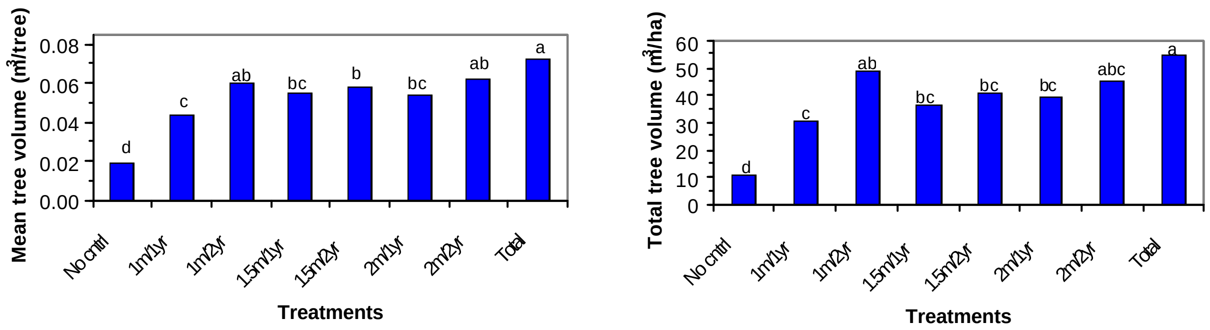


Figure 2: Effect of weed control treatments on (a) mean tree volume and (b) total tree stem volume per hectare (including mortality effects). Bars topped by the same letter are not significantly different.

**Multi-leadering**

The incidence of multi- leadering increased as the area of weed control increased (Figure 3). This was probably related to rabbit or hare browsing in the first year. In addition, the lack of shade on the lower part of the tree in weed-free plots encouraged vigorous growth of the lower branches. This effect may have been particularly important because the seedlings were planted deeply, sometimes resulting in steeply angled side branches.

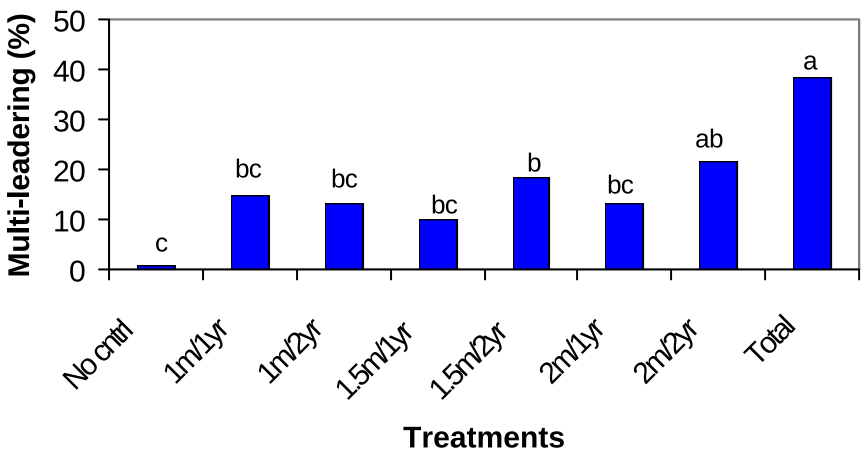


Figure 3: Effect of weed control treatments on percentage multi- leadering. Bars topped by the same letter are not significantly different (P > 0.05).

**Growth trends over time**

Modelling of growth trends allowed calculation of the time difference (in years) between trees given a particular treatment and trees given complete weed control. In other words, this represents the years of growth lost by trees in a given treatment compared to trees in the best possible treatment (total weed control).

By age six, the untreated control was lagging 1.8 years behind the weed-free treatment in diameter (Figure 4). The next least-effective treatment (1m diameter spot maintained for 1 year) was 0.9 years behind the weed-free treatment, while the best treatment (2m diameter maintained for 2 years) was only 0.2 years behind. Effects on tree height had a more complex pattern, with some evidence of slight growth stimulation with low levels of competition in the first two years. Overall, effects were similar to but of smaller magnitude than diameter (Figure 5).

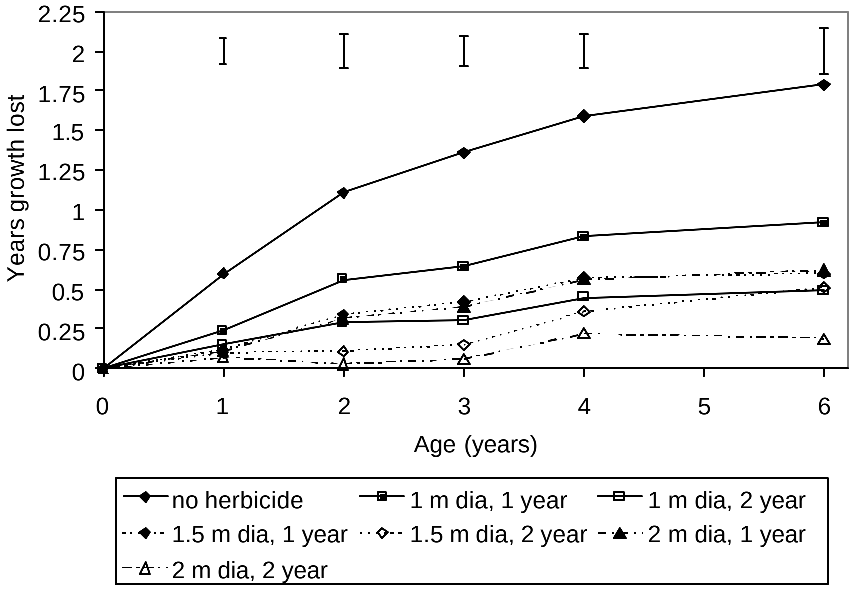


Figure 4: Years diameter growth lost in each treatment compared to weed-free treatment. Least significant differences (LSDs) are shown at each age in this and subsequent graphs. When differences between lines are greater than the LSD, they are statistically significant at p=0.05

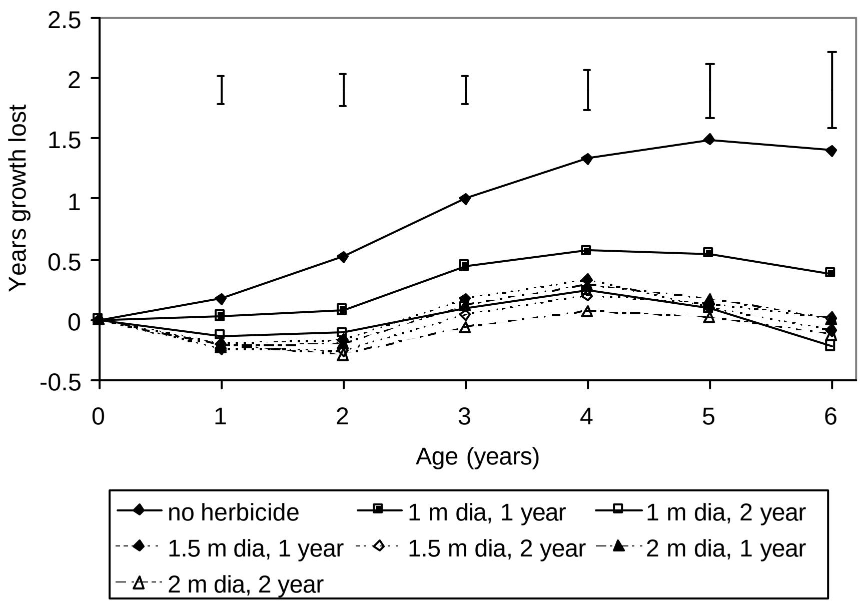


Figure 5: Years height growth lost in each treatment compared to weed-free treatment.

All treatment effects on growth (including mortality) appear to have reached a plateau by age 6 (Figure 6). This strongly suggests that no further significant growth losses will occur for any treatment. In other words, there would be no growth gain from maintaining weed control beyond this point in time – growth curves are following parallel trajectories. Economic analysis, where stand growth is projected to the end of the rotation, would be required to determine the most cost-effective treatment. However, either a 1.5 spot maintained for 1 year or a 1 m spot maintained for 2 years would be good candidates.

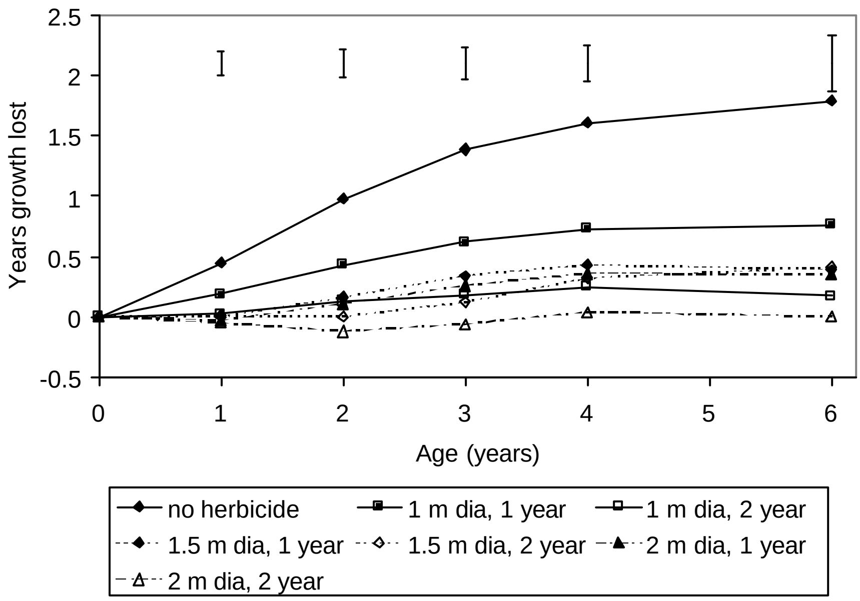


Figure 6: Years stem volume per hectare growth lost in each treatment compared to weed-free treatment.

The annual loss in growth for all treatments compared with the weed-free treatment converged at age 3-4 (Figure 7). This is an expected outcome, given that all treatments (except the untreated and complete weed control treatments) ceased to be maintained after age 2. It is even possible that the significantly lower diameter growth for the control treatment during the final increment (10% less growth than the control, Figure 7) can be attributed to the competition effect of neighbouring trees, given the small plot size. If this is so, competition effects actually ceased for all treatments at age 4.

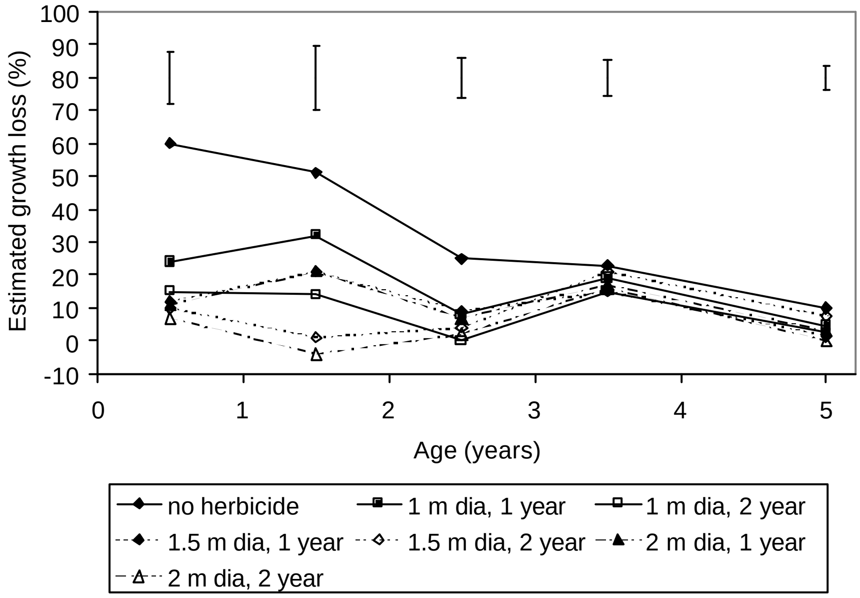


Figure 7: Percentage diameter growth lost in each year for each treatment compared to weed-free treatment.

## CONCLUSIONS

Measurements of tree growth after five years on a fertile pasture site in South Otago showed:

- Weed control was essential to ensure maximum survival and growth of radiata pine seedlings.
- Where a spot size of 1.5 m diameter or greater was applied, there was no significant benefit from a second year of control.
- Without weed control, tree volume growth was approximately 1.7 years behind trees given complete weed control.
- Spot vegetation control around newly planted *Pinus radiata* seedlings resulted in similar tree growth to total control (time difference about 0.5 years or less), as long as the area and duration of weed control was greater than a 1 m spot maintained for 1 year.
- Total weed control, significantly increased multi leadering compared with less intensive weed control treatments.
- The effects of vegetation control on tree growth had stabilised by age 6 years. In other words, trees from the vegetation control treatments are growing at a similar rate to weed free trees of the same size.
- Economic analyses would be required to identify the most cost-effective treatments, but at this stage it appears that either a 1.5 spot maintained for 1 year or a 1 m spot maintained for 2 years would be good candidates.

## ACKNOWLEDGMENTS

Funding for this work was provided by NZ Site Management Cooperative and the Foundation for Research Science and Technology, Contract No. CO4X0006. City Forests provided land for the trial and additional support for field work.