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## A Review of the Propagation of *Pinus radiata* by Cuttings, with Emphasis on Juvenility

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### INTRODUCTION

Ritchie (1991) surveyed the production of forest trees from cuttings and reported that the annual world production at that time was more than 65 million rooted cuttings. He also noted that half of this production was in Japan where *Cryptomeria japonica* had been grown by this method for more than five centuries. Another 10 million or more cuttings of radiata pine (*Pinus radiata*) were reported to be grown in Australia and New Zealand at that time. Canada, Scandinavia, and the U.K. together were annually producing about 21 million cuttings of various spruce species (*Picea* spp.). New Zealand sales of *P. radiata* cuttings in 1992 were 6.1 million and this rose to a peak of 24 million in 1996 and have steadied to 19.8 million sold in 1998 (Anon., 1999).

The propagation of *P. radiata* in New Zealand was for many years based solely on raising open-ground seedlings. Seed was initially collected from existing forest trees to provide bulk seed. Then in the early 1950s breeding programmes were commenced based on the selection of superior types, which were then collected together in separate open-pollinated seed orchards. Grafts were taken from trees that showed high quality due to such desirable characteristics as high growth rate, good tree form, few stem cones, etc. Control pollinated (CP) seed orchards were introduced in 1986. In this system bags are placed over the female cones and only specific previously collected pollen is used on individual trees. Good pollination is ensured by several applications of pollen resulting in seed which can have a large proportion of potential high-grade individuals. Although plants had been successfully raised from cuttings in New Zealand by the early 1930s (Field, 1934), it was not an economic proposition until the cost of CP seed rose to high levels in the late 1980s. It was found that cutting production became economically viable when seed costs were greater than or equal to \$1800 per kg (Arnold, 1990).

## A UNIQUE PLANT

*Pinus radiata* is quite a unique conifer in its ability to be grown from open-ground set cuttings with no added hormone and with high success rates. One attribute is its strong apical dominance. A wide range of shoots can be selected and yet the plant still forms an upright single-leader tree. Other conifers like Douglas fir (*Pseudotsuga menziesii*) or Norfolk Island pine (*Araucaria heterophylla*) require careful selection of material to avoid unacceptable variations in growth habit due to topophytic effects.

*Pinus radiata* timber crops can be grown in relatively short cycles of 25 to 30 years in New Zealand. This is a reflection of the special genotype of this conifer, which comes from a small geographic area of coastal California and offshore islands. The northern most strain of a group of five principal types is thought to be the one most closely resembling that found in typical New Zealand plantations (Bannister, 1973).

## JUVENILITY

*Pinus radiata* is also unique in that it requires a quite precise level of juvenility for high-grade forest planting stock. The usual advantages of juvenility are present such as highest vigour and ease of cutting propagation when selected from the most juvenile material. However, there are certain advantages to be gained from using material that has a specific physiological age. Physiological age is the popular term used in forestry, which relates to the ontogenetic aging of an individual as it matures through the phases of its life cycle. It can differ from the chronological age, which merely states the elapsed time from germination of a seedling.

Success rates for cuttings at the Forest Research Institute, Rotorua, New Zealand, in 1984 were evaluated as 75% plantable cuttings, 18% dead, and 7% unacceptable grade cuttings (Menzies et al., 1985). Commercial nurseries may not always achieve these rates and figures can be expected to range from 50% to 70% plantable stock. Juvenility is a key variable in success rates and Thulin and Faulds (1968) stated that a strike rate of 90% from 1-year-old seedling stock could be expected to drop to about 80% by age 5 and to only 15% at age 15, i.e., full maturity. It was also found that there is greater variation in rootability of cuttings between mature clones rather than more juvenile material. A further propagation advantage of juvenility is that those plantable cuttings, derived from young stock, produce a stronger and more fibrous root system than those from more mature material. Cuttings from older stock tend to have fewer roots and poorer survival rates than those from juvenile material.

Work by Menzies et al. (1988, 1991) at the Forest Research Institute, Rotorua, has shown that, unlike many conifers where cuttings are selected from the most juvenile material, some increase in physiological age will improve the quality of the planting stock. There is an aging gradient whereby increasing physiological age gives improved tree form, including a range of desirable characteristics such as straighter stems, reduced tapering, less malformations and lighter branching, over seedling stock. Menzies et al. (1991) found that there was no consistent effect on height but cuttings from 4- and particularly 5-year-old stock plants usually had smaller stem diameters for about the first 6 years after planting, compared to seedling material. Holden et al. (1995) found that on fertile farm sites cuttings produced trees with substantially higher recoverable volumes than seedlings due to improved form, especially straightness. These advantages



have helped to maintain the use of cuttings.

### STOCK BEDS

Seedlings from control pollinated plants are usually used to produce stool beds for the production of cutting material. The mother plants can then be retained as a source of propagating material for up to about 8 years (Menzies and Aimers-Halliday, 1997), although in practice this may be for 4 to 5 years. The aging process is minimised by continual severe pruning. In fact physiological age is strongly related to height growth, which in turn links with genotype and growing environment. Physiological age increases most rapidly on fertile, warm coastal sites where growth is most rapid (Menzies and Aimers-Halliday, 1997).

Physiological age can be assessed by the morphology of the plants. Juvenile growth appears as tufted rosettes of short primary needles. In contrast a greater physiological age of say 5 years, is indicated by the growth of secondary needles that are much longer (7 to 10 cm). These long needles each have a fascicle, which is subtended by a short brown bract, and associated with a sealed bud at the growing tip (Menzies and Aimers-Halliday, 1997). Stock plants are trimmed in late spring with a hedge trimmer to 10 to 30 cm. Secateurs may also be used to trim off maturing shoots.

### PREPARATION AND SETTING OF CUTTINGS

Conifers benefit from being taken as large cuttings and *P. radiata* is no exception. The greater the stem diameter the more roots are produced (Faulds and Dibley, 1989). An ideal size for rapid subsequent growth is a cutting 25 to 35 cm in length and a diameter at the root collar of 8 to 10 mm but this provides a plant that is too big for planting operations. Shorter cuttings are usually used to keep the lifting size to a minimum. This again illustrates the quite unique potential of this conifer to adapt and grow.

Cuttings are pushed into the nursery bed to the point where the tips of the bottom needles are still left exposed. The bottom needles are best retained, as they remain a source of promoters for adventitious root formation to the adjoining sites (Faulds and Dibley, 1989).

### CONCLUSIONS

Cuttings are an important method for the propagation of *P. radiata* and juvenility is a key consideration with this method. This is a factor of unusual significance because it governs not only the success rate in various ways, but also the quality of the developing trees. Therefore the level of juvenility in the cutting material has to be carefully selected.

Field set cuttings provide an economic way of multiplying superior clonal material from control pollinated stock of *P. radiata*, which has been the corner stone of the New Zealand forestry industry for many years.

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