Timber Species Propagation

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INTRODUCTION

The propagation of tree species for timber production is governed by the same basic principles and objectives that govern the propagation of tree species for horticultural use. Furthermore, the same methods of propagation are also used. What will vary, however, is the emphasis placed by a nursery on the number of species to be propagated. Forestry nurseries often focus on only one or two species. As timber production enterprises are usually large-scale programs over long rotations, the propagation of a timber species not only must be cost efficient, but at a scale capable of consistently producing large numbers of uniform, high quality propagules able to survive and grow under field conditions.

What, then, are the techniques used to propagate timber species? In a broad sense, they can be grouped under two headings:

1) Natural (or in situ) methods from seed in the soil, seed trees, or direct seeding; and coppice

2) Artificial methods, all of which require transplanting propagules into the field, include: grafting, seedling production, cutting propagation, and micropropagation

While it is important to recognise that extensive forest areas are still established by natural means, this paper will focus only on the artificial methods identified above. Species relevant to Australia and New Zealand will be used as examples wherever possible, with only brief reference being made to other important timber species.

GRAFTING

Although used infrequently as a method of propagation for timber production per se, grafts continue to be used almost exclusively for the production of clonal seed orchards. The major advantage of using grafts in establishing clonal seed orchards is that they can be successfully produced from relatively old parent trees. Often, trees selected for further breeding or seed orchard purposes are so old (often greater than 15 to 20 years) that the production of rooted cuttings is either impossible, or much more costly than the production of grafts. While graft incompatibility can at times be a serious problem, and even a barrier in the production of grafted stock for some species, it remains a quick, straight-forward, and cost effective way of establishing seed orchards where graft incompatibility is not a serious problem.

In Australia, grafted stock has been used for the establishment of seed orchards for radiata pine (*Pinus radiata*), hoop pine (*Araucaria cunninghamii*), slash pine (*P. elliottii*), and Caribbean pine (*P. caribaea* var. *hondurensis*). A number of eucalypt species, including *Eucalyptus nitens* and *E. globulus*, also have been successfully grafted to establish clonal seed orchards.

SEED PROPAGATION

The use of seed to produce nursery-grown plants is still the major method for propagating timber species, and remains the simplest and most cost-effective way of providing large numbers of uniform seedlings (Menzies and Arnott, 1992; Ritchie, 1991). Vincent (1991) maintains that seed has the advantage of being well proven to perform predictably under a wide range of conditions. Importantly, major efficiencies have been achieved through mechanisation, beginning with seed bed preparation, through tending and physiological conditioning to lifting, packaging, and transporting the seedling crop (Duryea and Landis, 1984; Trewin and Cullen, 1985).

There are three plant production systems used to produce seedlings. These are bare-root, container, and transplant systems, the latter being a combination of both containerised and bare-root systems (Menzies and Arnott, 1992). The use of any one of these depends on the species to be propagated and its inherent growth rate, the climate and length of growing season, the size and pre-sowing requirements of the seed, the morphological criteria placed on the crop, and the number of seedlings required.

In Australia and New Zealand, radiata pine is the major plantation species grown. Although rooted cuttings are often used, the production of radiata pine as bare-rooted seedlings continues to be the preferred method of propagation.

The propagation of eucalypt species for timber production in Australia and New Zealand is also predominantly from seed. But, unlike radiata pine, this is often as containerised, rather than bare-rooted stock. The reason for this is twofold. Firstly, the survival of outplanted containerised seedlings is often higher than for bare-rooted seedlings. Secondly, eucalypt seed is very small and expensive to obtain and seed is commonly sown onto germination trays; the seedlings are subsequently pricked out using tweezers and transferred into containers while still at the cotyledon stage.

For the northern hemisphere, propagation of timber species from seed using bare-root, containerised, or transplant production systems is very much dominated by location and species. This is due to the large number of species used, the large differences in environmental conditions, and the variation in facilities available. Excellent reviews on seedling production of both bare-rooted and containerised stock include those by Duryea and Landis (1984), Scarratt et al. (1982), and Tinus and MacDonald (1979).

CUTTING PROPAGATION

The last 15 years have seen a dramatic rise in the use of vegetative propagation for timber species. According to Ritchie (1991), prior to 1974 only three programs existed where more than 100,000 rooted cuttings per year had been produced: in Japan which produced 120 million rooted cuttings of sugi (*Cryptomeria japonica*) in 1966/1967, and in Finland and Lower Saxony where 150,000 and 1 million rooted cuttings respectively of Norway spruce (*Picea abies*) were produced in 1973.

The three reasons most responsible for focusing attention on vegetative propagation since 1974 were:

1) An overall shortage of seed for many commercial plantation species due to the rapid expansion of forest plantations;

2) The limited production of seed orchard seed from superior genotypes identified in breeding programs (Mason, 1989); and

3) The interest in clonal forestry (Carson, 1986; Libby, 1983).

Rooted cuttings have been successfully produced from root sections, for example the black locust (*Robinia pseudoacacia*) (Keresztesi, 1988), from leaf sections in eucalypts, and from needle fascicles in radiata pine.

However, lateral and terminal shoots from stool and hedge plants, and from seedlings remain the most commonly used vegetative material.

In Australia and New Zealand, plantation conifer species including radiata pine, slash pine, Caribbean pine, slash pine × Caribbean pine hybrids, and hoop pine are commonly propagated vegetatively. A number of eucalypt species also are being propagated vegetatively, including *E. nitens*, *E. globulus*, and *E. nitens* × *E. globulus* hybrids.

However, while the interest in and use of vegetative propagation continues to increase, its success remains limited. This is because the importance of the physiological age of the donor plant has resulted in the almost exclusive use of juvenile donor plants for cutting production (Ritchie, 1991). In order to overcome the problems of poor root formation and seedling growth loss that commonly arise due to maturation of the donor plant, plants with a physiological age less than 4 to 5 years are generally used. Two methods that have had some success in maintaining physiological juvenility are the hedging of seedlings and taking cuttings from cuttings (serial propagation). While the latter method is more successful in arresting maturation, it is both costly and laborious. So long as the problem of assessing and maintaining juvenility in donor plants remains unresolved, the use of vegetative propagation will be used mainly to multiply up cuttings from limited amounts of control pollinated seed.

Leaving aside the problem of maintaining juvenility, the cost of producing rooted cuttings can be two to three times greater than for seedlings (Menzies and Arnott, 1992), due largely to the labour intensive nature of collecting and setting cuttings. For the use of vegetative propagation to gain a wider acceptance, production costs will have to approach those achieved in seedlings systems. But for this to occur, most of the labour-intensive steps will need to become automated.

MICROPROPAGATION

The use of micropropagation by organogenesis (tissue culture) and embryogenesis is gaining widespread interest as a method for propagating commercially important timber species. Two reasons in particular make it attractive. Firstly, it allows the maximisation of genetic gain from breeding programs using both juvenile and mature trees. Secondly, it provides a very rapid means of propagating scarce genetic material. This opens up the potential for clonal forestry. Aitken-Christie and Connett (1992) and Dunstan (1988) have reviewed micropropagation of forest trees, viewing it as a delivery system for the clonal propagation of genetically superior and possibly genetically transformed trees.

When considering the use of micropropagation, the differences between organogenesis and embryogenesis need to be understood. In organogenesis adventitious shoots are developed first while roots develop later to form complete plantlets. In embryogenesis, however, somatic embryos (complete with cotyledons and root axes) are formed and these "germinate" to form plantlets (Aitken-Christie and Connett, 1992). Although still in its infancy, embryogenesis does open up the possibility of producing "artificial" seed to further propagate superior genotypes.

Although the use of micropropagation is still largely in the research and development phase, at least one New Zealand forestry company is using organogenesis at an operational scale to establish clonal forests of radiata pine, producing 1.5 million tissue culture seedlings in 1991, and increasing this to 2.5 million in 1992 (Darling, 1991). In both Australia and New Zealand, organogenesis also has been successfully used to propagate a number of eucalypt species and their hybrids, including *E. nitens*, *E. globulus* and *E. regnans*.

However, while delivery systems have been greatly streamlined and automated, production costs of tissue-cultured seedlings remain considerably higher than for seedlings or rooted cuttings. Still, Menzies and Arnott (1992) consider that somatic embryogenesis offers the potential for higher multiplication rates and lower costs relative to organogenesis. While the use of embryogenesis as a method of propagating timber species is still relatively new, somatic seedlings of important timber species have already been planted in field trials, including Norway spruce, Douglas fir (*Pseudotsuga menziesii*), and radiata pine (Aitken-Christie and Connett, 1992; Menzies and Arnott, 1992).

Research into the use of artificial seed as a delivery system for somatic embryos is also under way. However, before embryogenesis is used for the large-scale production of forest trees, considerably more work is required to evaluate the field performance of somatic seedlings, particularly with regard to production costs.

CONCLUSION

For forestry to continue as a sustainable and cost efficient industry, new and harvested forests must be replanted. Because of the need to maximise productivity per unit area of land, relying on the least expensive method of propagation is no longer sufficient. While the production of seedlings from seed of genetically superior genotypes will continue to be the most attractive and cost efficient method of providing planting stock, the use of vegetative propagation as well as micropropagation will increase. This will be inevitable if the gains from tree breeding and genetic engineering are to be realised.

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