The Role of Clonal Propagation in Forestry and Agriculture in Australia©

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INTRODUCTION

Clonal propagation in the form of grafting, marcotting, cuttings, or tissue culture is not new to forestry or agriculture. In Australia today, orchards of grafted citrus trees, banana plantations based on tissue culture stock, and softwood pine plantations based on cutting production are commonplace. Nowadays who would even think of establishing a commercial citrus orchard from seed? Nevertheless, there are some areas of forestry (e.g., hardwood eucalypts and acacias) and agriculture (e.g., new crops such as essential oils) in Australia in 2005 where clonal propagation is not yet established, and this paper is directed towards these crops.

Clones are identical copies of an individual. Clones have the same set of genes as each other. Seedlings on the other hand, while derived from the same parents, are different to each other and to the parents. Each seedling has its own unique set of genes.

In Australia, hardwood forestry plantations and agricultural crops such as tea-tree, are traditionally based on seedlings and so consist of trees which, while similar to each other, are genetically different. Variation to a greater or lesser extent is therefore a feature of seedling plantations, and so seedling plantations typically contain both vigorous plants and runts, fast growers and slower growers, well-formed trees and trees with poorer form.

A clonal plantation consists of trees that are all genetically identical to each other and which, barring differences due to varying environmental influences within the plantation, are all of the same vigour, form, and growth qualities.

PLANTATION IMPROVEMENT

The extent of the variation exhibited in seedling plantations can be reduced, and the quality of the plantation thus improved, by using techniques such as careful provenance selection of the seed, and by rigorous culling of inferior seedlings prior to planting. In addition, many timber companies employ tree breeders to further improve the genetic character of their plantations through the development of seed orchards and controlled pollination. However, the degree of improvement that can be obtained is limited compared to clonal selection, and all the seedlings will still be different to each other to some extent.

In contrast, the clonal approach to plantation improvement is to identify an individual tree which is superior in some way (e.g., wood quality, speed of growth, tolerance of salinity) and to reproduce it clonally so as to plant a plantation of trees all identical to this superior individual.

THE ADVANTAGES OF CLONAL PLANTATIONS

Clonal plantations confer many advantages over traditional seedling plantations.

Qualities selected by breeders for the mass-production of superior clones include:

- Increased **growth rate** or **vigour**;
- Increased **yield**;

- Superior **form/shape** (e.g., apical dominance for sawn log production);
- A particular **flavour** or **chemical composition** (e.g., in food crops);
- Superior **timber qualities** (e.g., strength, durability, density, paper quality);
- **Pest**, **disease,** or **drought** resistance;
- **Salt** tolerance;
- Suitability to specific **soil types** or **climatic zones**.

Uniformity is a natural feature of clonal plantations because the plants are genetically identical, and also because the clonal production process incorporates extensive sorting for age, development, height, vigour, etc. of the individual plants produced.

This, combined with the genetic superiority of the plants themselves, offers the plantation owner additional flow-on benefits over traditional seedling plantations, such as:

- Low levels of **runts and misses**;
- Reduced need for **re-planting**;
- Lower **stocking rates**;
- Lower plantation **establishment costs** (excluding the cost of the plants);
- Cheaper **harvesting costs**; and
- Increased **profitability** and **returns**.

THE CLONAL PRODUCTION SYSTEM

The method of clonal production best suited to mass producing clones at a commercially viable price in very large numbers for forestry and agriculture is **cutting propagation.** The process of mass production of clonal crops by cuttings is vastly different from that of traditional seedling production, and this impacts on price and production scheduling, which in turn impacts on ordering timetables and payment schedules and structures.

As a simple comparison, seedling production involves receiving an order, taking the seed out of storage, and planting the order in one operation over a short period of time. The plants then grow-on for a few months until dispatch. The entire batch is sown at the same time, all the plants are the same age, and are all ready for dispatch at the same time. Thus seedling nurseries do not (in simplistic terms) require sophisticated technology or equipment, or highly trained staff, and they can operate on reasonably low levels of capitalisation. Seedling production lends itself to mechanisation, and is not particularly labour intensive.

In contrast, clonal cutting production is almost the exact opposite to seedling production.

Motherstock. Clonal cutting production is based on harvesting cutting material from motherstock such as hedge gardens. Motherstock requires constant intense management while in production mode so as to ensure maximum yield and optimum strike rate. When not being used for production motherstock still requires maintenance, albeit in a "holding pattern mode" so as to reduce maintenance costs. Since motherstock is expensive to maintain, clonal nurseries aim to obtain maximum yield from the minimum amount of motherstock, and to keep motherstock in continuous production mode without any "down time."

Lead Time. Upon receiving an order, the clonal nursery may need to bring the motherstock back into "production mode" before starting to take cuttings, and this takes time. For a new crop, sufficient motherstock will need to be bulked up before mass production can begin in earnest. So, depending on the motherstock situation at the time of placing the order, there may be a significant lead time before production actually starts, and this needs to be taken into account at the time of ordering and determining delivery dates.

Clonal Production Is a Continuous Process. Clonal production is a continuous process of harvesting cuttings from the motherstock over a period of time. In contrast to seedling nurseries, cuttings are set continuously on a daily basis. Thus, in any one order, the plants are of different ages and will be ready for dispatch at different times. The older plants can be held in the nursery until all the plants are ready, but it is a feature of clonal production that the plants in the nursery and at dispatch will always be of varying ages from old to young.

Technology. Clonal propagation is well established in the softwood timber industry in Australia. The plant physiology of softwoods, however, is very different to that of hardwoods and this is reflected in the comparative ease with which clonal propagation can be conducted in softwoods, and the relatively low levels of technology and nursery capitalisation required. On the other hand, clonal propagation in hardwoods, and especially eucalypts, is a totally different ball game and is at the other extreme end of the spectrum regarding difficulty, technology, and capitalisation.

It is of little benefit to look overseas at the methods used in other countries such as in South America and Africa, since the economic and social climates in these countries dictate very different cost structures and their production processes are of limited application in Australia. Rather than copying a recipe from overseas, successful clonal nurseries in Australia have gone back to first principles and developed their own systems and processes which suit the particular economic and social climate under which we operate in Australia, not only in the technical field but also in the management and personnel areas.

Important factors that impact on clonal production in Australia compared to overseas countries are the high wages in Australia, the industrial relations system, the workplace health and safety laws, environmental laws, and the costs of our goods and services.

Staffing. Because of the level of expertise required of staff in clonal production, it is not an option for clonal nurseries to operate on a low core-level of staffing and bring in teams of casual staff in times of high demand, as often occurs in seedling nurseries. Clonal nurseries need to be able to retain their trained staff on a permanent basis year-round.

Nursery Location. Location is an important, and vastly under-rated, factor in the success of large-scale commercial clonal cutting production.

- Clonal cutting production depends on the harvesting of motherstock for the material used in the production process. In northern Australia, the tropical climate allows for year-round regrowth and continual harvesting of motherstock, and hence year-round production, compared to only the summer months in southern Australia.

- The time between setting the cutting and the plant being ready to plant in the field in northern Australia is less than half the time taken in southern Australia.

These two factors combine to allow for large, year-round production runs in tropical Australia, and work against locations in temperate southern climates. For large-scale production, freight to plantations throughout Australia is very cost-effective and is not an impediment to location.

Partnerships. For a successful clonal plantation programme, it is essential that there is a close relationship between the plantation owner, the breeder, and the nursery. While it is possible to propagate pretty well any plant clonally, some plants (and in particular eucalypts) are definitely much harder than others. Plant breeding and plant propagation are quite separate disciplines, and expertise in one field does not automatically convey expertise in the other.

It is important, therefore, that the breeder establishes a close relationship with the clonal nursery so that the breeding programme and the propagation trials run in parallel from the start. Where possibly millions of dollars ride on the outcome, it is critical to ensure that the integrity of the propagation trials is not inadvertently compromised by factors other than the inherent rootability of the clone.

Cost Structure. Clonal production is a highly labour-intensive, highly technical, and highly capitalised operation. Every cutting has to be prepared and set individually, and plants have to be sorted and moved through the system on an individual basis. The cost structure of clonal production bears virtually no comparison to seedling production, and as a rough ballpark, the price of clones is about 2 to 3 times the price of seedlings.

CONCLUSION

It is not difficult to do the sums and see that, provided the clone has been carefully selected for its superior qualities, the additional cost of purchasing the plants for a clonal plantation is offset many times over by the flow-on savings and the increased returns, and that clonal plantations are very cost-effective operations.

Forestry and agriculture in Australia, through plant breeding and clonal technology, are poised for enormous growth as Australia strives to make maximum returns from limited arable land and to retain its share of the increasingly competitive global market.