Some New Research Into Container Design©

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INTRODUCTION

In Australia the vast proportion of nursery-grown trees spend some part of their life containerised, usually in a rigid plastic pot of some type (Lawry and Gardner, 2001). The challenge facing nursery growers producing these trees is to not only optimise canopy growth but to ensure that the root system has been managed to ensure that it doesn't have a negative impact on long-term growth and even survival.

Historically, container production systems in Australia have been quite successful (May, 2002) but nevertheless there are serious concerns about the quality of the root systems of many trees that are being produced by some container nurseries that use smooth (or almost smooth) sided plastic, frustum-shaped containers. This is despite a substantial body of research related to this issue and the many products and techniques that have been developed to improve root systems, e.g., Harris (1967); Whitcomb (1988); Appleton (1995); Struve et al. (1994); Arnold and MacDonald (1999).

When this project was conceived, there were two commercially available alternatives to the widely used black plastic pots of various sizes, which seemed to have considerable potential for use with our unique woody flora. The Rootmaker® and Spring Ring®, air-pruning containers whose design was based on the work of Whitcomb (1984) and Spin Out®, a copper-based root pruning agent. A wealth of industry-funded research in the U.S.A. suggested Spin Out® was able to reduce or completely eliminate root circling in a wide variety of tree species (Struve et al., 1994). These were two exciting developments that had not been trialed with Australian taxa.

It was decided to examine the suitability of these two new technologies in the nursery propagation and production of *Corymbia maculata* (syn. *Eucalyptus maculata*) by quantifying root growth both in the nursery and subsequently after transplanting into the landscape to determine:

A) Does air pruning, using Rootmaker® containers, or chemical root pruning using Spin Out® reduce container-induced root distortions compared with the widely used 50-mm plastic tube in the seedling propagation stage?

B) What effect does air pruning, using Spring Ring® containers, or chemical root pruning using Spin Out® in nursery production systems above have on root growth and architecture in the landscape?

MATERIALS AND METHODS

Seed of *C. maculata* was direct sown into Rootmaker® containers, standard 50-mm black plastic tubes, and the same 50-mm tubes with Spin Out® applied to the inside walls. Thinning to one strongly growing seedling per container was carried out with scissors. They were grown under standard greenhouse conditions for 18 weeks using a randomised block design.

Five replicates of each treatment were carefully potted up (to ensure no root disturbance) into 200-mm plastic pots and grown on in the aforementioned glasshouse for 1 week and then destructively harvested. The height increment was measured and then the propagation-production container interface was examined after careful removal of the media and the number of roots that had emerged from the original propagation container's rootball were recorded.

At the same time, 15 plants from each propagation container were carefully potted up into each of 200-mm plastic pots, 200-mm plastic pots coated with Spin Out®, and 200-mm Spring Ring® containers and grown outdoors under standard nursery conditions for 8 months. Five plants from each treatment adjudged to be of poorest quality were not considered, five plants from each treatment were then randomly selected and destructively harvested. An assessment of the propagation/production container interface was undertaken (after careful removal of the container medium) by counting both the number of emerged lateral roots and also counting the number of roots circling that interface.The remaining five trees per treatment were transplanted into the field, grown on for almost 4 years and carefully excavated and assessed for a number of root system quality parameters.

RESULTS AND DISCUSSION

Without undertaking an exhaustive analysis of the data above, it is apparent that both chemical pruning and air pruning do have an effect on the number of new roots emerging from the propagation containers rootball both in the short term (7 days) and the longer term (8 months). Seven days growth following potting up saw the development of almost 4 times the number of emerged roots from the Rootmaker® than the Spin-Out® -coated tube (Table 1). Interestingly, the implication from this data is that the air pruning Rootmaker® container caused more root initials to develop than the either the standard tube or the tube coated with Spin Out®.

The data gathered relating to the production/propagation container interface at 8 months does not reveal any apparent relationship between the number of emerged roots at 7 days. Nevertheless, both the Rootmaker® and Spin-Out® -treated tubes achieved increased lateral root development compared to the standard plastic tube which produced seedlings with an average of only 0.9 lateral roots. This data suggests that untreated 50-mm tubes really shouldn't be considered as appropriate propagation containers for *C. maculata.*

Table 1. The effect of propagation container on a number of seedling quality parameters.

	50-mm tube	50-mm tube + Spin Out®	Rootmaker®
Average seedling height (mm)	238	202	216
Average no. roots emerged after 7 days	30.6	71.4	281
Average no. lateral roots at 8 months	0.9	9.4	10.8
Average number of circling roots per plant at 8 months	6.8	3.9	2.6
Plants with circling roots (%)	93	80	40

Regarding circling roots, the data clearly suggests that there is a high risk of the development of circling roots at the propagation stage no matter which container system is used. Viewed in percentage terms propagation in the plastic tube resulted in 93% of all seedlings having circling roots, Spin Out® completely prevented root circling in 20% of all seedlings, while the Rootmaker® containers completely eliminated root circling in 60% of all plants. Clearly the chemical root pruning of Spin Out® and the air-pruning Rootmaker® have reduced the incidence of circling roots at the propagation stage but these data suggest that problems with root circling have not been entirely overcome in *C. maculata.*

Table 2. The effect of production container on root circling in *Corymbia maculata* 4 years after planting out.

	Plastic pot (200 mm)	Plastic pot + Spin Out®(200 mm)	Spring Ring® (200 mm)
Trees with any roots < 180º (%) circling	92	35	36
Trees with any roots > 180º (%)circling	46	21.4	0

It is important to note that the number of circling roots recorded in Table 2 were circling above all of the lateral roots.

The choice of containers used in the nursery has clearly had a measurable effect on the root system's architecture almost 4 years after planting out when considering the percentage of trees with circling roots. Such circling roots can girdle the trunk or other roots as they grow radially and lignify and restrict the flow of water and metabolites through the root-crown area and have been clearly implicated in tree stress, decline, and lack of stability (Whitcomb, 1988).

After almost 4 years of growth in the landscape, circling roots occurred most frequently in those trees grown in the standard black plastic pots with sloping sides, where 92% of all of the trees had some form of circling roots. This data above suggests that untreated 200-mm pots really shouldn't be considered as appropriate production containers for *C. maculata.*

Neither of the alternative production containers had completely eliminated circling roots, although it is very interesting to note that there were no roots found circling the trunk for more than 180º in those trees grown in the air-pruning Spring Ring® containers.

In the data reported here, air root pruning (using Rootmakers® and Spring Rings®) and chemical root pruning (using Spin Out®) have been shown to improve root system quality of *C. maculata* way beyond that achieved in the widely used standard plastic tubes and pots. It should be noted though that neither has been shown to eliminate all the problems associated with the container production of trees.

The challenge to containerised tree growers is still simply stated: "Produce container-grown trees with a root system that has the potential to develop those architectural, engineering, and biological characteristics approximating those of a natural root system." This will ensure the tree has the best chance to become fully and successfully established. A good first step is to stop using untreated, truncated cone-shaped, black plastic pots of varying sizes.

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Root Deformation in Plantations of Container-grown Stock: Consequences for Growth, Stability, and Stem Quality©

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INTRODUCTION

During the 1970s many forestry nurseries in Scandinavia changed from bareroot to containerised plant production. In the late 1970s we received the first alarming reports about poor stability and root development in plantations of container-grown plants. Since then several different types of container systems have been introduced to the market, and a number of these systems cause more or less strong root deformation.

The consequences of root deformities are complex and can in the long term lead to significant economic losses. Root deformities can affect the growth, stability, and stem straightness of young stands. Poorer tensile strength and internal deformities increase the risk of fibre breakage, which increases the risk of fungal attacks, primarily on the root system. Once the trees vitality is reduced, the risk of fungal attacks on stems or shoots also increases.

The ultimate result of root deformities is that the tree falls over and dies because impeded root development results in poor anchorage of the tree. The tree can also break at the stem base.

DEVELOPMENT IN CONTAINER DESIGN

In the 1970s the dominating container types were Kopparfors and Paperpot containers. These containers caused a special type of root deformity, root spiraling, which occurs in container systems with smooth inside walls. These container types