Treenet Proceedings of the 4th National Street Tree Symposium: 4th and 5th September 2003
ISBN 0-9775084-3-9

INTRODUCTION TO AND FORUM FOR 25 YEAR TREENET CONTAINER TRIAL

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INTRODUCTION

The establishment of a well designed trial that will last at least 25 years to investigate tree root growth and how it's affected by various propagation and production systems is not only exciting, it's good science. We have an opportunity to establish a long-term trial with sufficient replicates and adequate controls to satisfy the needs of good experimental design. The reality is there will be expenses and logistical complications throughout the trial but what is possibly a uniquely extended time frame for an experiment will certainly enhance our knowledge of tree root growth and architecture following transplanting advanced trees.

If the trial goes ahead, I'll be about 75 years old by the time it reaches its conclusion ("I hope" to both things). It would be nice to get it right in the beginning. A longer term bonus will be an avenue of trees and an almost unique opportunity to establish experimental work with trees that is certain to last beyond the professional lifetime of any one researcher.

Those of us who have the good fortune to be "tree-literate" understand that trees live according to a time scale far different to a researcher's lifetime. The opportunity to get such a trial in the ground at the Waite Arboretum with the support of Australia's nursery industry, academia and everyone else with an interest in the quality of urban forests is possibly unique globally.

For the last ten years I have been involved in a number of studies relating to the root system of nursery grown trees and their subsequent architecture once planted into the ground (eg Moore 2001). Retrospect can be a powerful tool in contemplating the results of such research and I have had to acknowledge much frustration regarding the distance between ideal science and what has been achieved. It's my ambition in this paper to discuss generalisations that are based on my own research and knowledge of current horticultural and forestry literature regarding how such a trial could be established with appropriate experimental design. It's not intended to be a review of the various issues concerning the container production of trees destined for establishment in urban environments.

We all know trees grow slowly and we need to acknowledge that in what may be an unequalled opportunity to get the experimental design right before we start.

THE CONTAINER PRODUCTION OF TREES

It's logical to now briefly examine containerised tree growing with a description of the stages of the process involved. A typical tree grower would follow a production schedule, which could be divided, into the following phases:

1. Propagation phase (where the seed is germinated or the cutting struck);
2. Transplant or tube phase (where the newly propagated plant is established in a container with a relatively small volume). It needs to be noted that many growers

of seed propagated trees now direct sow the seeds into containers of relatively small volume, to avoid the problems of inducing kinking or j-rooting.

3. Production phase (where the product of stage 2, once established, is planted into a larger container to grow on to a larger size for eventual use in the landscape), (May and Moore, 1999).

In summary:

After seed germination, the major issue of concern is the impact of the container on the development of the root system. An ideal container, whether it be used for tube or liner production, or for growing-on, should be able to stop the extension of a root tip as soon as it contacts the wall or base of the container.

In the case of a tap root, if it is stopped at the container base, the cessation of root tip extension would trigger branching of the tap root. Whitcomb (1988) argued this will result in a seedling which is more stable in the container with more root tips to establish into the next production phase.

In the case of lateral roots, if they are not stopped at the wall of the container, they can be deflected sideways and give rise to circling roots which are clearly implicated in many cases of poor tree performance and even tree death (WWW ref). Such circling roots that develop during this phase of production are very difficult, if not impossible, to correct.

There are basically three approaches built into containers to try to change root development patterns in attempts to overcome both taproot dominance and circling root development. A fourth approach seems to involve the mechanical pruning of the root system at key points throughout the production of the tree.

KEY ISSUES???

In Australia there is still much debate regarding the effect different nursery production practices have on the root system of advanced trees. The key issue regarding roots for both growers and the end point users of trees should be the elimination of circling roots during the nursery production phase.

It’s no longer arguable that root system architecture at planting can have a profound influence on long-term issues such as tree growth and vigour, root system symmetry and tree stability. Notwithstanding a considerable body of research related to these issues and many products and techniques developed to improve root systems eg Harris (1967); Whitcomb (1988), Appleton (1989,1993 &1995, 1998); Arnold and McDonald (1999) Struve et al (1994), there is still room for improvement in production systems for quality container-grown trees and their root systems.

Tree root system architecture can clearly be engineered in the nursery production phase (whether deliberately or otherwise). The use of air root pruning containers, coating the inside of containers with a chemical root pruning agent and physically pruning roots can significantly reduce the number of circling roots. Containers with smooth or nearly smooth sided walls (including bags) can significantly enhance the development of circling roots. Poor handling and holding trees beyond their 'use-by-date' can also induce serious root deformation.

The generalisations above are made acknowledging that different species respond differently to different production systems and that some trees (even of the same species) respond differently to the presence of circling roots.

What is more important in the context of the proposed trial is that the effects of neither air pruning nor chemical pruning on the root system architecture of "mature" or "nearly mature" trees have ever been published. To the author's knowledge, the oldest nursery grown trees produced using air pruning technology whose root systems have been examined are 4 years old. The oldest trees in the ground produced using Spinout are at Ohio State University, have only been in the ground for 14 years and have yet to be examined (Struve pers comm).

THE VISION

A 4x3 factorial design (4 propagation systems and 3 production systems) with a eucalypt as the species under consideration and harvest dates of 1 year, 5 years, 10 years and 25 years after planting. It will also be worth giving serious consideration to direct seeding at the site simultaneous with sowing in the nursery to provide the control (ie trees that have never been containerised).

A 25 year time frame will allow future researchers to gather and interpret data that is meaningful in a time scale appropriate to trees. Furthermore, if this trial is established, there will be a resource available for future tree root research.

THE SITE

The Waite Arboretum has kindly offered the use of a site some 200m by 20m. This means that if trees are planted at 5m spacings there will be approximately 120 trees (3rows of 40) at the beginning of the trial. At 7m spacings there will be 56 trees (2 rows of 28). The final configuration isn't yet determined and we will work closely with a statistician to ensure the final design is statistically rigorous.

SPECIES SELECTION

There is likely to be little debate here because the major consideration should be the wishes of the managers of the Waite Arboretum regarding the landscape outcome they'd prefer throughout the trial and following its completion.

Which species? Likely suggestions include the following eucalypts *Corymbia maculata, Eucalyptus leucoxylon* subsp *megalocarpa*, or *Eucalyptus* 'Urrbrae gem'.

If vegetatively propagated material were available, it would eliminate an enormous source of variation from the trial. There is some interesting work being done at the National Tree Seed Centre in Canberra on the vegetative propagation of eucalypt species of importance to forestry where leaf tissue analysis is being combined with some form of hydroponic set-up. This work could eventually have an impact on Australian urban tree selection generally and if sufficiently well advanced on this trial in particular.

NURSERY PRODUCTION PHASE

It is my intention to outline some, though not all of the issues that will need to be tightly controlled here.

Logically the trees should be grown in one nursery so they will be exposed to essentially the same environment through their production. The number of trees grown in both the propagation and production phases should far outnumber those actually required for planting to allow for the selection of trees of even quality. This will be more important if the trees are propagated from seed.

Other issues that will need to be carefully controlled and will need to be addressed in some detail before the trial begins include

- the growing medium used,
- the spacing of containers,
- nutrition and fertiliser application,
- irrigation and other issues of water management,
- nursery hygiene (particularly including weed, pest and disease control),
- canopy management

A final variable that will need to be avoided during this key phase will be that of root death in dark containers induced by very high temperatures in the medium (Hight and Bilderback 1994). This will require further consideration once the layout of the production nursery is known and the number of trees required have been finalised.

PROPAGATION SYSTEMS

It's likely that the nature of the propagation phase of the production of trees is the most critical in determining the final nature of the maturing root system. A recent study (Moore, unpublished data) has shown that 100% of all 4 year old *Corymbia maculata* direct sown in 50mm tubes had included bark in their crown (the root-stem junction). It isn't known what impact (if any) such included bark might have on a tree's mechanical stability as it ages although it is postulated that it might be significant (Stokes 2000).

The container styles which should certainly be considered for inclusion in the trial include air-pruning containers, chemical root pruning (using Spinout) and possibly 50mm tubes or forestry tubes although they've been discredited are still in widespread use.

PRODUCTION SYSTEMS

The inclusion of an air pruning container, a container coated with Spinout and the production of trees according to the new Natspec specifications Clark (2003) would be sensible. They seem to be the best available alternatives to what were the widely used smooth sided black plastic pots which have now been clearly discredited. It could also be argued that plastic bags also be included because of their continued widespread use, I'm not sure whether there'd be anything to gain though.

Canopy management would also need to be tight with sufficient spacing between containers at different times during the production cycle to ensure that there was no inappropriate competition for light between containers

ESTABLISHMENT AND ONGOING MANAGEMENT

Best practice as we know it.

WHAT SHOULD OR COULD BE MEASURED?

Root systems are complex and a variety of methods have been used by researchers to study them (for a review of these see for example Smit et al 2000). There are a wealth of different root growth parameters that can be measured in both the nursery production phase and after each harvest. Realistically what is achievable depends entirely on the available budget, the time available, the equipment available and the expertise of the person doing the hands on work. Whatever the final arrangements regarding methodology, the number of parameters measured will be a compromise between what is practical, what is desirable and what is possible.

A case could be made for any or all of the following measurements to be made relevant to the project at hand: the number of circling roots, degree of circling, root number and diameter class at different radii from the trunk, root number and diameter class at 45° intervals, the presence or absence of included bark at the crown. Issues of tree stability should certainly be examined since anchorage is such a critical issue for all urban trees and the one that is most compromised by poor nursery practices.

EMBELLISHMENTS

Ground penetrating radar can be used to map the distribution of the root systems of large trees (Nadezhdina and Cermak 2003). The technology still isn't ideal, nevertheless, it might be possible to hire a GPR system and map the planting site before the trees are planted to establish baseline data that could be of great value in studying root distribution without any of the destructive techniques I've already listed.

Something else that would be worth considering by the arboretum is the establishment of a lysimeter (with a number of mini rhizotrons) underneath where one of the trees are to be planted. This would allow parallel research on tree root growth that would complement the major aim of this project.

OTHER ISSUES

There are a number of issues that deliberately haven't been addressed in this paper including the following, they have to do with money, not science.

Important things like what's the budget? Who's paying for the nursery production phase? Who's paying the costs of the tree's transport, their planting, their maintenance? Neither TREENET , the Waite Arboretum nor Charles Sturt University have funds available for the trial. There are alternative funding sources (including Horticulture Australia Limited) which can be investigated.

Who will be doing the work? An honours or post-graduate student? A technical officer? The answer will depend on ongoing funding sources.

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