Root Manipulation in Containers©

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Good roots are the primary objective of any plant propagator. This might not be so true with quick-growing annuals but is particularly so with any perennial or woody plant, and especially trees. However, the majority of containers in use today do not do a good job of developing good root systems.

We need to aim to produce a root system as close as possible to the one the plant would develop when grown from a seed in its natural environment. Figure 1 shows a natural root system on a tree, note the dominant tap root plus strong lateral roots to give support and adventitious feeder roots to take up water and fertilizer.

Figure 1. Natural tree root system with dominant tap root plus strong laterals.

Figure 2, by contrast, shows the type of root system that is found all too often in container-grown nursery stock, this being an example of a tree root circling in a black pot. A plant with such a root system will never establish successfully and growth will never be fully healthy. The culprit here is the black pot, it is cheap, practical, and most growers use them despite the fact that they know it produces a poor root system.

Figure 2. Typical root system in container-grown nursery stock.

Any type of root system growing in a container — including those in propagation cell trays or liner containers — is a manipulated root system. It is, however, possible to have good manipulated roots and in this paper I will outline some examples of positive root manipulation practice.

ROOT MANIPULATION TECHNIQUES

Mechanical Root Pruning. This has been used for many years to manipulate the roots or, more precisely, to get rid of the bad roots. This is still used very extensively today as part of the guidelines for producing an adequate quality of root system for trees in Florida, for example. However, one problem is that it obviously causes a large check to plant growth which in turn has effects on both speed and percentage establishment.

Chemical Treatment. Another way of stopping bad roots developing in a container is to treat its inside surface with a copper compound. This works because

copper is toxic to any roots that grow towards the surface of the container and touch the wall, killing the root tip and thus stopping it becoming a bad root. The logic here is that killing the roots that come to the edge encourages more secondary roots in the centre of the root ball which, after transplanting when removed from the influence of copper, will produce a large number of good roots growing out into the soil. This system is used extensively in forestry propagation in the U.S.A. and Canada. I am not keen on it as you are basically training the root system by poisoning it. However, it does work in the sense of removing some roots that will end up in the wrong place.

Light Pruning. This uses a container with a white translucent wall that allows light to pass through, so that when roots come to the edge of the root ball they are exposed to the light and their reaction is to head downwards. As they grow directly downwards on the side of the container they do not get away from the light and therefore the root becomes subdued and other secondary roots are encouraged to develop behind the tip — poor roots are minimised and secondary roots encouraged.

Container Shape. A very common way of manipulating roots is using ribs on the inside of the container that force roots to grow directly downwards and help to discourage root circling, etc. You will still, however, get root circling at the base of the container if the roots are still contained inside the pot or tray.

Another concept is to use a container with what is known as a side-slot design, which is often claimed to air-prune the root system. However, as most of the roots grow directly down they avoid the slot and so the slot actually acts a little bit like a rib on a tray. It does also help drainage and aeration of the grow-

Figure 3. Todd planter flat with basal hole for air pruning.

Figure 4. Air-pruning container with lateral ribs to direct roots downwards.

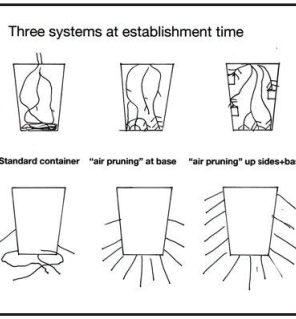

Figure 5. Effect of root system quality on growth after transplanting. The top row shows the container roots, the bottom row shows root growth after transplanting: a) a typical container root system with circling roots; b) a container with air pruning at the base only; c) a cell with air pruning at the base and up the sides of the cell.

ing or rooting media, which is a positive factor, and some roots do stray out of the hole in the side slot and so do get air-pruned, so there are some secondary roots developed here.

Air Pruning. This is a much misused term. Air pruning is the killing of a root tip by exposing it to dry air that desiccates and kills the root tip and then removes its dominance to allow many secondary roots to develop. Air pruning was first used commercially by George Todd in the 1960s. Figure 3 shows a Todd planter flat, which has no bottom inside the cell so the roots all grow out of the hole into the dry air and their tips are killed.

Roots can sense the dryer zone of growing or rooting medium around the air-pruning hole and will tend to grow away from that if possible so we need a positive method of forcing a root out of the cell. Figure 4 shows an air-pruning container that uses a rib to catch the roots and direct them downwards to the hole where they are forced out into the dry air to be air pruned.

I believe air pruning is the best system for manipulating roots. Containers or container systems are available that provide air pruning just at the base of the cell, as with the Todd flat, or up the side of the cell: with both systems more secondary roots develop, especially up the side of the root ball. The objective here is to develop a large quantity of young vigorous roots throughout the vertical profile of the cell. The result is that each of these active root tips should explode into growth when the plant is transplanted. Figure 5 is a diagram showing the effects of root system quality on growth after transplanting.

The chief benefits of air pruning are:

1) The plant will work very hard on developing its root system during propagation so foliage growth is held in check and doesn't get out of control.
2) Quick establishment because large numbers of roots develop quickly into the soil, which leads to rapid uptake of water and an improved chance of survival for the plant, with close to 100% success in establishment.
3) Due to the rapid development of the roots the plant stand also tends to be more uniform.
4) The high numbers of roots allow the plant to take up more nutrient so after transplanting the shoots grow more. With trees, caliper growth improvements of more than 20% in the first year have been documented with an air-pruned root system.
5) The root system will fill a pot more quickly as there are more roots and thus it is ready for sale sooner.

PROPAGATION CONTAINER DESIGN FOR OPTIMUM ROOT SYSTEMS

The ideal propagation container should enable good air pruning at the base and sides but also use a tray that fits into current systems on nurseries: growers do not want a tray that needs a special benching system to allow air flow for air pruning. The tray must also be economical, as few growers are able to justify extra costs for a container that produces a better quality root system.

Such a container is not currently available at the time of writing but systems that meet the requirements outlined are in development with a number of manufacturers.

It is certainly possible to adapt popular propagation systems to produce better roots and trays. Insert-type systems are a good example.

Inserts are any plug that holds the soil together until the root system develops, examples being Ellepots, Jiffy plugs, Fertil, glue plugs, card pots, etc. These have become popular because they create a very good micro-climate around the base of the cutting, producing good aeration and drainage in the inserts. This in turn leads to quicker, more uniform growth of new roots on the cuttings.

Inserts are generally used in thermoformed plastic trays with a gap that allows for aeration and drainage but the roots still go straight down and circle at the base of the cell. At Proptek we have been developing an alternative tray which will air prune the root system very extensively at the base and the sides of the insert — a "foot" on the base of the cell elevates it to allow the air flow necessary for air pruning of the root system. Figure 6 shows a Jiffy plug in this type of cell.

Figure 6. Plug tray being developed at Proptek for air pruning the root system with a "foot" on the base of the cell.

CONCLUSION

Despite the benefits of root manipulation by air pruning most growers still use black pots and regular propagation trays.

It takes three qualities in a container to make people change. First is root system quality; second, the container must be practical and fit into the nursery system with minimal disruption; third, the container must be economical, ideally the same price or cheaper than existing containers. Bringing together these three qualities in a tray is a challenge.

How can an air-pruning container be cheaper than a regular thermoformed tray? To give an example, Proptek is working on injection-moulded plastic trays to provide the required qualities. Injection moulding is a versatile technique and produces trays with a long lifespan — some growers are using injection-moulded trays that are over 20 years old and even when they are finished they can be recycled, which means that although dearer than thermoformed trays to buy, the cost per crop can be lower.

The cost per crop might be lower but there is still an up-front capital cost. This can be removed by introducing financial packages similar to vehicle leasing, with the grower making a payment every month over, say, 5 years so that in cash-flow terms the cost per crop is what counts.

Manufacturers need to work harder and have a lot more dialogue with growers to make sure we overcome the practical barriers to improving plant root quality. IPPS members with views are welcome to contact the author.