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Roots, Hormones and in-between - Back to Fundamentals

In this month's Nursery Paper NSW Industry Development Officer, Des Boorman presents a fundamentals review of the important aspects of a propagation system conducive to high quality plants with particular emphasis on root quality.

Roots, Hormones and in-between - Back to Fundamentals

Health Status

With few exceptions, high health status is generally under-appreciated in ornamental horticulture, while in production horticulture it is widely recognised as being critical to crop performance.

Industry schemes such as the strawberry clean runner, banana, potato, citrus, grape and passionfruit focus on supplying high health, disease free material to maximise the opportunity for long term crop success - not just in the propagation and container production stages.

Certain pathogen issues are obvious in a range of clonally propagated ornamentals yet are often poorly acknowledged or addressed. *Daphne odorata* is an example where viruses, latent or expressed prevented clonal propagation. Once material was "cleaned-up" through a process of re-culturing and heat treatment to destroy the virus it contained Daphne became readily available in commercial quantities.

Both root production and quality could be directly influenced by both latent and expressed pathogens. Additionally poor propagation and production tool hygiene and material selection may perpetuate or exacerbate such issues in commercial situations (Hygiene in plant Propagation, Nursery Papers December 2004, Issue no. 11).

One NIASA accredited grower imports fresh tissue culture stock each year of a range of plants with these being grown to be used as stock plants for that seasons cutting requirements. At the end of the season these stock plants are disposed of and the process repeated to reduce the risk of pathogens and disease transfer to production stock. Production at this nursery is some of the most uniform over a range that I have ever seen and is in some part attributed to the health status of the stock material used for propagating cuttings.

Image 1 : *Jagera* sapling showing a full trunk s-bend and obvious root issues after germinating on a rock ledge. In nature, trees such as this don't always fail, however this conformation is unacceptable in commercial practice

With the release of the **Australian Standard - Tree Stock for Landscape Use, AS 2303:2015** (April 2015), The knowledge and competency of tree growers in either sourcing and/or producing quality propagated material to grow on and/or sell is particularly important for immediate and long term compliance and the production of quality trees.

For production of quality plants and particularly trees, it is critical to focus on the root quality of both seed grown and clonal plant lines during propagation phases.

Why do we need to focus on roots so much?

GREAT ROOTS and root systems underpin the health and performance of plants and the integrity of the Nursery and Garden Industry (NGI). The move towards container-less growing media propagation systems such as Preforma®, Ellepot® and Oasis® from community seed/cutting trays and rigid containers containing growing media offers a positive step to achieving great root systems. Container-less propagation systems promote some air pruning of roots via the surrounding sides of the propagation cell being exposed to air.

The adoption of a convenient production system which may comprise quality should never be an option to the NGI. Rather the NGI needs to focus more on what makes a quality plant; i.e. **GREAT ROOTS**.

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Other systems such as Jiffy pots® require growing media but are a "free standing" propagation cell, so when prepared correctly can produce excellent root systems.

Image 2: While propagated in a suitable non-restrictive growing medium, this cutting has been held too long in the supporting tray, resulting in poor root structure.

Correct wetting up and irrigation of the Jiffy® and growing media is essential during the propagation phase to prevent the Jiffy® drying out and possibly causing root restriction by this product.

How do we address Plant Propagation Quality Issues?

Propagation environment
The level of environmental control and adequacy of propagation facilities and the range of crops grown in Australia's generalist production nurseries tend to be the major impediments for all round great propagation. Typically propagation environments are one size fits all, where depending on volume and frequency, often 3 or 4 specific environmental controls (bottom heat, light, relative humidity, air temperature, mist / fog) and propagation media/substrate combinations would deliver better results for the range of plants being propagated. Propagators should not focus on 'cost and convenience', but determine and adopt what is technically a good growing media and environmental combination for the propagation of their specific plants.

Propagation growing media
The choice of propagation growing media options are numerous and there is often a cross-over where the propagation cell contains the growing media, such as with Ellepots®, Oasis®, Jiffy® and Preforma® systems. Apart from Jiffy®, these systems negate preparation and filling propagation cells with growing media.

Image 3: Jiffy® cells showing root penetration through the wall.

The expectation now is the application of a universal propagation growing medium, container and environment which typically yields mixed results as such systems don't fit all propagation requirements. Some growers have gravitated towards whatever propagation growing media is cheapest rather than specifying or understanding the physical properties and interactions required within the propagation root zone to achieve optimum results. Other growers have implemented the newer unitised systems forgoing the "cost" per unit for the efficiency and ease of use. **Reader Note** – if ever there is a justification in the considerable investment and return from growing media, plant containers, propagation facility and environmental control being made, then it is the propagaton phase of production to establish the foundation for future quality plant production.

While cuttings prior to root initiation may require moisture to satisfy transpiration requirements and turgidity, the growing media doesn't need to be overly wet. A well maintained humid environment will help address transpiration loss with occasional top up watering to the growing media to satisfy water uptake through cut basal end of the cutting/stem.

The initiation of roots and their development require oxygen, and it is important to maintain uniform air exchange within the growing media to promote sufficient root numbers rather than just one or few roots. The air exchange within and through the growing media and propagation is usually supported by water entry and drainage (top to bottom) and by the surrounding air around all sides of the exposed growing media, i.e. from the top and bottom of community tray or exposed growing media in container-less propagation systems.

In larger and shallow community trays, air diffusion is much lower and the interface and variation in the sides and centre of the community trays from air/water retained is much less uniform across the tray than that in individual propagation cells without rigid containers.

Air filled porosity (AFP) is a term that doesn't get discussed nearly enough and a lot of specialist propagation knowledge has also been lost or fails to be adequately communicated to where it's needed.

Propagation containers

The type of container used has a great effect on both root quality and air exchange to the propagation growing media, where root restriction could possibly lead to structural root issues later in the production cycle.

Traditional 50mm plastic tubes, either round or square, with or without root trainers all have the potential to either direct roots downwards or around when contacting the rigid container wall. Inserting cuttings at the edge of the tube is likely to exacerbate this problem.

This early formative root training leads to root systems not inclined to spread laterally when subsequently potted-on or planted out. Without proper pre-pot preparation this could lead to root issues later in the production cycle as well as end use structural issues. Either way, a 90° root bend near the base of any seed or cutting grown dicotyledon is undesirable. Physical remediation of these formative root systems at each potting stage by manually teasing out the roots is beneficial, however it is costly, time consuming and may cause significant plant set-back so should be avoided if possible.

Image 4: Root trainers in a 50mm square tube have directed these roots down however ≤90° kinks close to the stem are likely to cause stability issues in later production stages.

Ideally the propagation systems used by the NGI should allow roots to radiate outwards from the inserted section of the cutting during propagation and then facilitate air pruning or unrestricted root extension. Such a system is more likely to produce a high quality root system. These containers usually allow greater air exchange at the base of the cutting which seems to promote better root development and numbers. Ideally a cutting should produce numerous radial roots around the inserted section that allow for quicker establishment, increased stability and performance of the plant throughout the production cycle.

Image 5 : While older than ideal, this cutting in an Oasis® cube demonstrates the radial development of roots around the cutting base.

When cuttings produce poor or non-uniform root systems it is often difficult to get early plant stability and as a result staking has to be utilised. Compared with 20 years ago, staking is now common and is a significant cost in the production cycle. Staking may impact the long term plant stability and potentially yield false economies of a faster and taller plant at the expense of more robust and qaulity plants.

Plant propagation hormones

Artificial phytohormones used in propagation are designed to initiate adventitious roots on cuttings. Adventitious roots are those that have arisen from other than from the seedling root system, that is inducing stem and leaf tissue to form roots. In dicotyledons, there is a meristem responsible for bark production and also

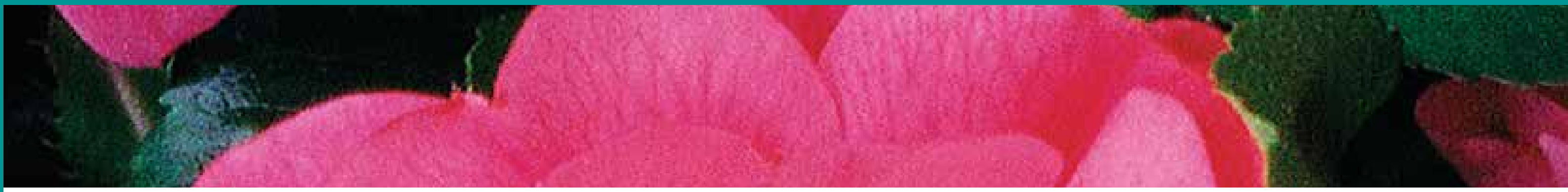
Image 6: Poor root development will likely cause stability issues with this plant

the vascular meristem immediately below this region. Roots can initiate from the base of a cutting or up the stem where a hormone response is achieved, and typically callus (Scar tissue) can be seen swelling under the bark and forcing it off the stem at the basal cut and roots may subsequently initiate from this area.

In the case of callus production, excessive miss-shaped lumps on the cutting base can inhibit root production or a few roots may develop from these cuttings, however these tend to be not of good quality. Excess callus can also be a result of excess hormone concentration or cutting material selection and usually results in low or poor strike rates.

Personal experience propagating *Tibouchina heteromalla* 'Jules' revealed that using a basal dip of 1000ppm IBA also caused callus formation on the leaf surfaces along the veins within days of treatment and then soon after leaf abscission, usually resulting in cutting death. At 1000ppm, the IBA had a phytotoxic effect on the cuttings. Once concentrations were reduced to 150-200 ppm IBA, the cuttings reliably produced healthy roots without the detrimental effects observed at the higher concentration.

The two artificially manufactured hormones commonly used for root initiation of cuttings are;



Indole-3-YL-Butyric Acid (IBA) & Naphthylacetic Acid (NAA)
The ability for most nurseries to obtain and effectively use IBA and NAA hormones as actives makes the proprietary off the shelf products appealing for use. Three commercial available formulations are based solely on IBA and one contains both IBA and NAA.

As with any chemicals it is essential to understand risk factors involved with use and exposure so refer to specific product labels and Safety Data Sheets (SDS) for use conditions. Heat and UV light may cause degradation of certain hormone formulations so it is advisable to store them under refrigeration, however as with all other chemicals they should never be stored with foodstuffs.

Hormone formulations

Powder
Talcum powder is used as a filler to dilute the undissolved crystalline IBA concentration. At neutral pH, IBA is a relatively insoluble compound where only small amounts are likely to dissolve on the cutting base in sap or water to be available to initiate roots.

Alcohol
Rootex-L® consists of IBA dissolved in an ethanol base at 4000ppm. This can then be diluted with water to achieve the desired concentration. This product does work well and for some material it is a good option and where a convenient best fit solution is desired.

Gels
Clonex® is a potassium based gel formulation being available in various concentrations of 1000, 4000 and 8000 ppm IBA whilst being combined with some other ingredients such as vitamins and nutrients. Unlike alcohol based formulations, sensitive cutting material does not burn and being a gel there is improved potential for retention of the product and hormone on the base of the cutting after the cuttings are treated and stuck in the growing media. Gels can offer advantages over both the talc and alcohol based formulations and are extremely useful in the various concentrations available.

Detergent
Esi-root® is a detergent based liquid that can be used for dunking or soaking applications. The latter method of application has numerous benefits and few disadvantages. Compared to other hormones applied to the base of cuttings, application rates are significantly lower and often by more than a factor of 100. Esi-root® is a mix of both IBA and NAA. The inclusion of NAA notable as it is a strong root promoting hormone and works at low concentrations, noting that required concentrations vary depending upon cutting type. Cuttings soaked in this solution will take up NAA and IBA through all plant surfaces and be translocated to the base of the cutting. If cuttings are not fully turgid they may be reinvigorated once left in the solution.

Excess field heat may be removed from the material once soaked in the solution and this will aid early cutting survival and ultimately success.

Large numbers of cuttings can be prepared using the soaking method as cuttings are not deteriorating once prepared, allowing for more systematic propagation activities. Due to fully turgid material and sticking into well-watered propagation media, cuttings don't need to be watered in once stuck and placed in the propagation environment, allowing for more absorption of the hormones from the wet cutting surfaces.

Drawbacks of soaking cuttings in a hormone/hydrating solution
Any latent pathogens on the cuttings are more likely to be spread to other cuttings so selection of high health status material is essential.

Some plant material doesn't respond to being either saturated or in NAA and leaves will go glassy and shed from cuttings even when soaked for short periods of time. By example *Allamanda cathartica* 'Sunee' is one such plant, while cuttings of *Gardenia jasminoides* 'Radicans' and *Ixora compacta* 'Sunkist' have been left soak in Esi-root® solutions overnight with no observed deleterious effects.

Conclusion
There are numerous options and combinations for clonal propagation. To achieve excellent results it is essential to trial the range of options available to gain an understanding of the complex interactions between plant material, hormones, growing media and the propagation environment. While this may seem onerous it will ensure efficient space utilisation, optimum crop performance and ultimately it is an investment in long term profitability.

The ultimate goal is to produce cuttings with excellent roots that radiate unrestricted from the cutting to provide lateral support for the plant and faster, healthier more robust crops to be supplied to customers. Many other factors also affect cutting strike rate such as stock plant health, stage of growth and juvenility. These factors also need to be determined but have not been discussed here.

Further reading

Hartmann & Kesters Plant Propagation: Principles and Practices 8th edition by Hartmann, Kester, Davies and Geneve

Hygiene in plant propagation, Nursery Papers December 2004, Issue no. 11

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