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Tree Root Management Trials at NVK Nurseries

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Summary

Root growth, especially during container growth is critical to transplanting success. Various container designs were evaluated for their ability to modify root systems in crops like oaks, honeylocust, and conifers. Studies compared traditional solid wall plastic containers with alternative paper and fiber containers.

INTRODUCTION

NVK Nurseries is a wholesale grower of trees, evergreens, shrubs and perennials operating on over 1,200 acres of field and container farms about an hour southwest of Toronto, Ontario, Canada. Our nursery is committed to continually improving our growing practices, and in the last few years we have pursued several growing methods to

improve the tree root systems in our propagation and container field-liner departments. The primary motivations behind these efforts are to: 1) improve transplant success of 'hard to transplant' tree species; 2) eliminate major root deformities, such as stem-girdling roots and matted, pot-bound root systems, and; 3) save labour costs associated with trying to correct (e.g. slice, shave, tease apart) these deformities.

While bare root field-liners can easily be assessed for root defects before planting, container-grown trees can possess a range of root issues that are not easily observed. The root quality of container liners from suppliers can be variable, so we are beginning to develop our own container tree liner production system to ensure a higher and more uniform quality. Our testing over the last 2 years has been highly focused on tree species known to be difficult to bare root transplant; for example, most conifers and tap-rooting deciduous trees, which are commonly sold/grown in containers to be lined out. Our efforts have involved the testing of 2 different air-pruning systems in propagation (tulip bulb crates and AirTrays) and 4 different air-pruning/woven fabric containers (Pioneer Pots, RediRoot pots, RootPouch fabric pots, and Ercole pots).

Traditionally, the only way to control the growth of tree roots in production was through pruning. Since almost all trees in the first three quarters of the 20th century were field-grown, this meant that roots could either be hand pruned before planting, during field-growing with implements, or after harvest again. As more tree production has steadily shifted to container growing, various techniques have been employed to manage root growth within the constricted space of a pot. This has included chemical control (lining pots with copper hydroxide), entrapment (using woven natural and synthetic fibres to trap and stop root growth) and air-pruning (allowing air to desiccate root tips). Since most of our trialing has revolved around newer air-pruning tray and pot designs, I'll provide a bit more detail here. Air-pruning is simple in concept: allow enough air to regularly interact with the periphery of the root system in order to stop roots from growing, while initiating fine root development within the existing root ball. However, in practice, it is challenging to implement in a nursery production setting, since it necessarily requires greater exposure of the root system to desiccating air. Striking the balance between allowing enough air to consistently 'prune' roots, while avoiding too rapid and sustained dry-out periods, is critical for success at a large commercial scale. Since root quality starts as early as seed propagation, that's where I'll begin.

In the spring of 2023, we began testing a couple different air-pruning systems for our tree seedlings. First, we used readily available tulip bulb crates, of which we have hundreds, compliments of our perennials department. The slotted sides and bottom of the crates is ideal for allowing for consistent air-root pruning, and we kept the crates elevated off of the floor to help with this. We sowed mainly *Quercus* spp. in the bulb crates in the fall and overwintered them in a minimally heated greenhouse. We left them in these crates and allowed them to grow over much of the growing season (**Fig. 1**). We found this method to work very well for producing well-structured root systems with a moderate amount of fine absorptive roots, especially due to the reliable and consistent air-root pruning of the seedlings' taproots. Importantly, dry out speed

was moderated by the large volume of potting media held in the bulb crates. Another positive aspect of this method is that it is inexpensive and simple to execute; however, the seedlings are still considered bare root upon removal, which does limit the timing and ease of potting up/lining out.

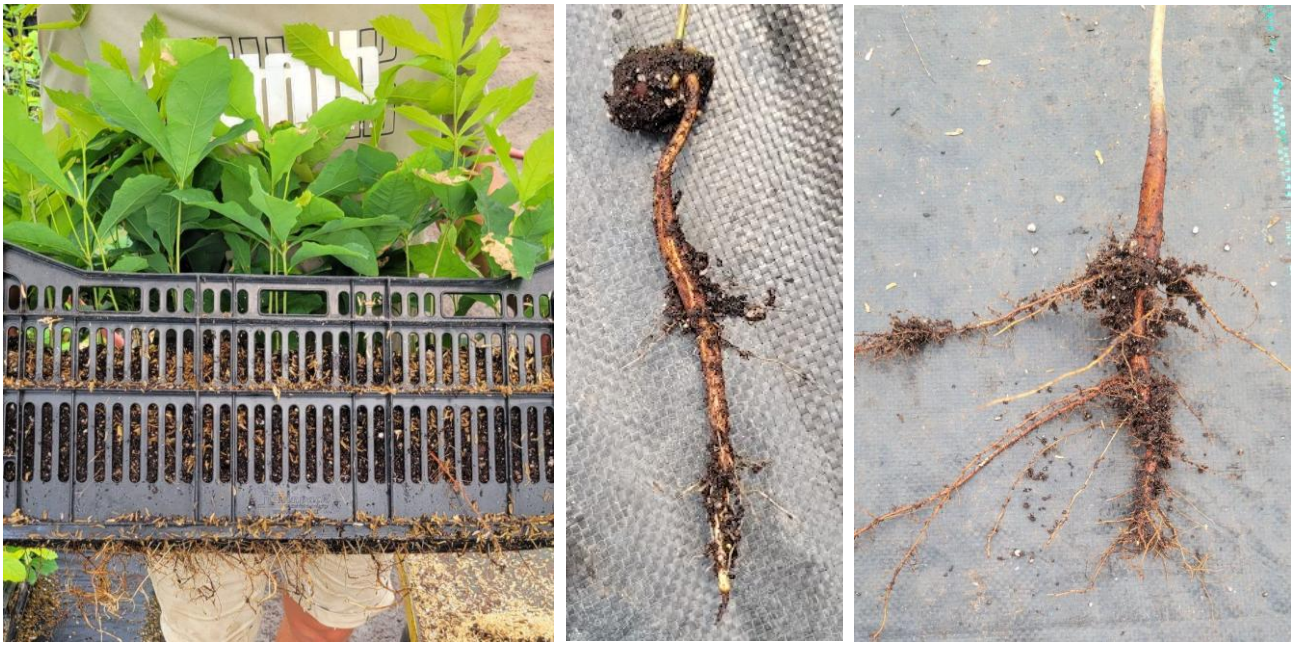

Figure 1. The tulip bulb crate method, showing the entire crate of *Quercus* spp. seedlings on the left, a young seedling in the middle and the root system of a 1-year-old seedling on the right. Notice the brown, desiccated bottom of the tap root of the middle photo, which helped initiate early growth of lateral fine roots along the tap root.

We also wanted to test an air-pruning plug system, which led us to AirTrays®. These are a relatively new line of propagation trays. In 2023, we trialed *Quercus rubra*, *Gleditsia triacanthos* and *Pinus strobus* in the deep, 18-count deep trays pre-filled with 60x120mm Ellepots (FP paper), as seen in Figure 2. In this particular design of AirTray®, the only contact between the tray and the plug is a small plastic spike at the very bottom which suspends the plug (**Figs. 2 and 3**). This allows for air-pruning because it elevates each plug several centimeters off the tray and provides a sizable air gap around the sides.

Although there was an adjustment required to manage irrigation properly in this open-tray design, the use of an even-watering boom system allowed us to provide the consistent moisture needed to avoid patchy dry-out. The results were very positive overall, with growth and root quality in all three trial species deemed excellent by our head propagator. Importantly, the AirTrays® strike a good balance between allowing substantial air flow, but still retaining relatively high humidity within each cell of the tray.

Figure 2. *Quercus rubra* seedlings grown in 18 count deep AirTrays® in 60x120mm Ellepots. Notice the desiccation of the tap root in the middle photo, as well as the brown root tips around the plug in the far-right photo, which contains root growth largely within the plug.

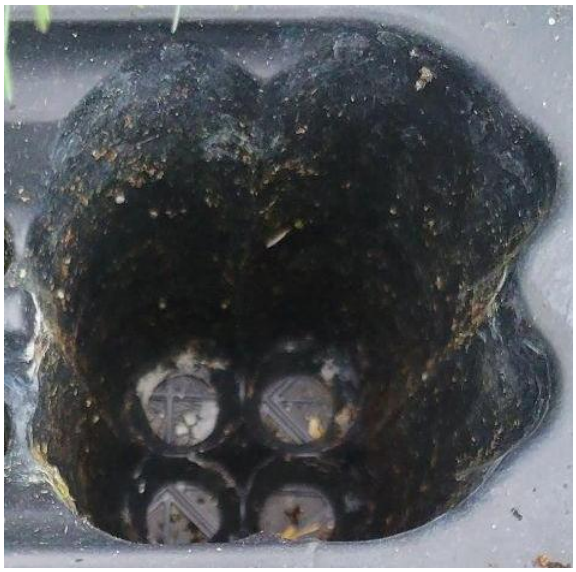

Figure 3. A photo of one cell of the 18-count deep AirTray®. Notice the 4 large holes at the bottom of the cell. If you look closely at the center of the bottom, you can see a spike which elevates the plug completely off of the bottom of the tray. The 4 ridges along the sides of the cell also ensure that there is minimal contact between the plug and the side walls.

The only modification that we wished to make for our 2024 propagation trials was to replace the pre-loaded Ellepots in the AirTrays® with alternative cell liners that we could loose-fill with our own growing media. To do this, we used FertilPots, which are 100% biodegradable wood fibre pots. After requesting samples of different pot sizes, we found that the 517.C 7x12cm pot fit very well into the 18 count deep AirTray® (**Fig. 4**).

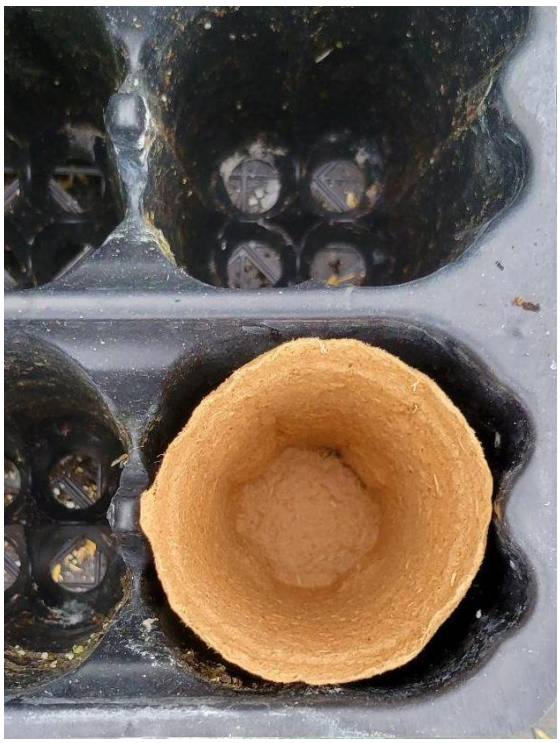

Figure 4. The 517.C 7x12cm wood fibre pot fit nicely as a replacement insert for the Ellepot in the 18-count deep AirTray® to allow us to loose fill our own potting mix.

The FertilPots also functioned well (Figure 5). The benefit of both the Ellepot and the Fertilpot is that their woven, porous structure allows roots to grow through them, as long as they are not too dry. We found that both worked well for developing good root structure, but that the FertilPots had the added benefit of capturing irrigation water more effectively, and more clearly showing differences in moisture (as is visible in **Fig. 5**).

During the 2023 growing season, we were also trialing different air-pruning systems and woven fabric pots in our container field-liner department. Our aims were to determine which pots would produce the highest quality roots, while also considering factors such as: dry-out, growing media temperatures, relative costs, ease of production, and reusability of different pots. The 3 alternative pots we used in our 2023 trials were the Pioneer Pot with holder, the RediRoot pot, and the RootPouch pot (Figure 6). We also included a standard solid-walled pot as a control. We used drip emitters to ensure equal irrigation volumes.

Figure 5. *Picea* spp. seedlings potted from smaller plugs and grown for several months in FertilPots in an 18 count deep AirTray®. Roots easily grow through the porous wood fibre pots and then air-prune once humidity drops.

Dry-out was an important factor to consider in this trial, and we found that the Pioneer Pot with holder performed similarly to the standard solid-walled pot in terms of having slower dry-out than the RediRoot and RootPouch pots. Although it is not depicted in **Figure 6**, the Pioneer Pot system nests the air-pruning pot inside of a holder, which was designed to maintain higher humidity levels and slow down dry-out. Growing media temperatures were another consideration, and we found that tem-

peratures were consistently lower in the Pioneer Pot with holder and RootPouch pots in comparison to the RediRoot and standard pots. While the Pioneer Pot was significantly more expensive than the other pots, its higher manufacturing quality gave it a longevity advantage. While the RootPouch pot only allows for a one-time use, the Pioneer pots can be reused up to 10 growing cycles, on average (personal communications with several growers across North America). RediRoot, in contrast, we were told by a number of growers, lasted only between 3-5 years.

The RootPouch pot performed well on laterally rooting, fibrous tree species, but sat too wet and didn't effectively manage root growth on the bottom of the pot in the taprooting tree species we grew. Both the Pioneer and RediRoot pots performed much better in this regard due to their elevation of root systems off the ground. Ultimately, based on the criteria of root quality, costs of production and reusability, we decided to advance with the Pioneer and RediRoot pots for our more extensive 2024 trials.

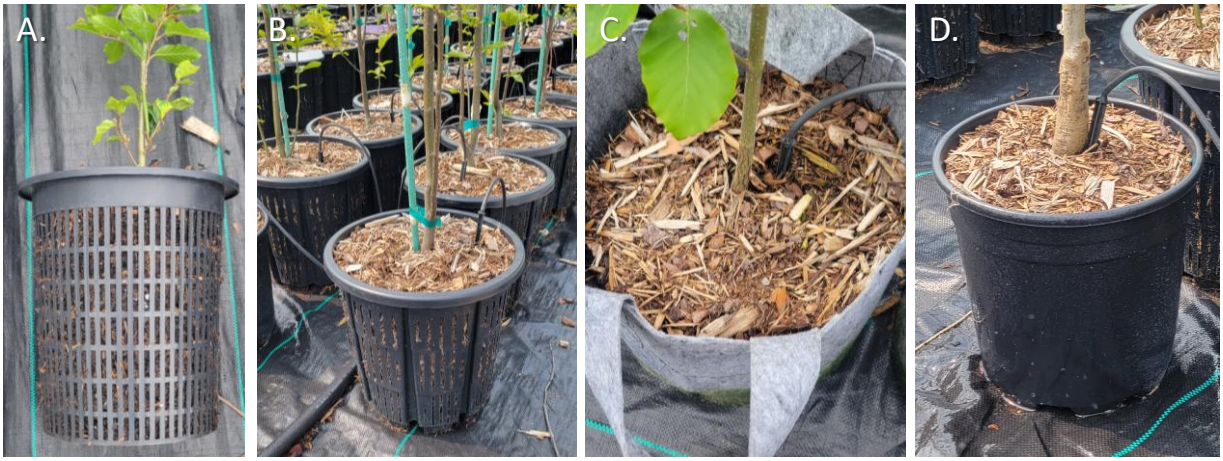

Figure 6. **A**) Pioneer pot with holder (holder not depicted above); **B**) RediRoot pot; **C**) RootPouch pot; **D**) Standard solid-walled pot. We used these pots in our root quality trials to grow several different tree species in 2023 in our container field-liner department. Pots range in size from 2 to 4 gallons.

In 2024, we scaled up our research and development efforts, in part thanks to support from the Barborinas Family Fund Tree Fund Grant, which we were awarded in Spring 2024. We continued testing the Pioneer and RediRoot pots with over two dozen different tree species and cultivars, and we also included the 5L Ercole pot into our trialing, since FertilPots' largest 580.C (18cm x 16cm) offering fit very nicely (**Fig. 7**).

The perforated sides of the Ecole pot, in addition to the small air gaps separating the FertilPot from the Ercole pot, provided an ideal air root-pruning design along the sides. Unfortunately, the bottom of the Fertilpot still rested on a solid pot bottom. The results showed much faster dry-out in the RediRoot pot when compared to the Pioneer pot with holder, with the FertilPot inside the Ercole pot performing somewhere in between.

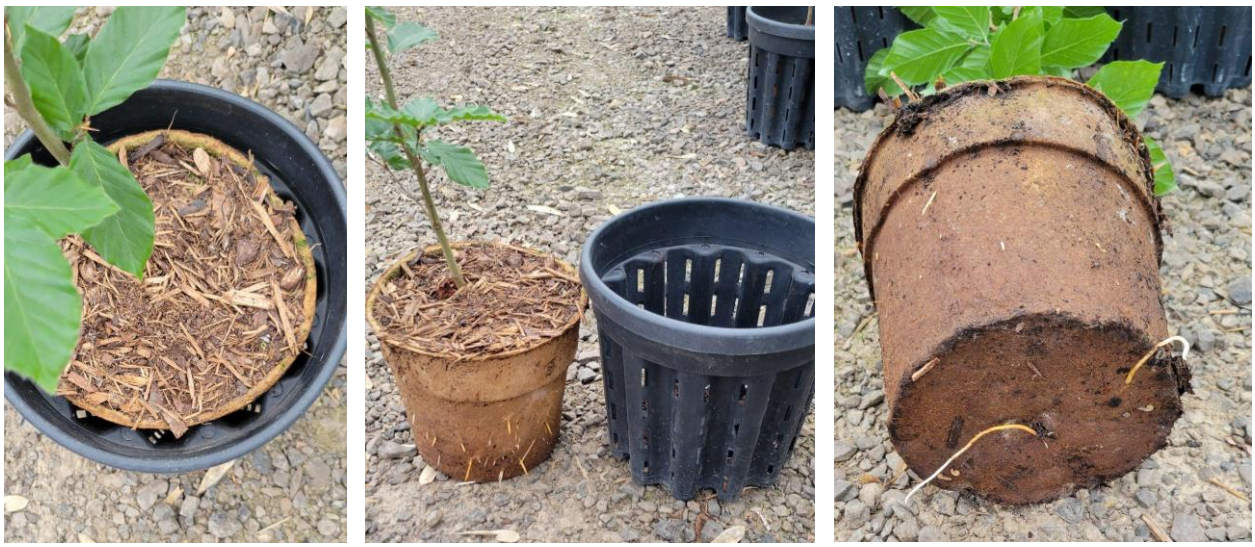

Figure 7. The 580.C Fertilpot (17x16cm) (Pictured by itself on the right) fits perfectly into the black 5L Ercole pots. *Fagus sylvatica* plugs were potted 3 months prior to this photo.

Fagus sylvatica was one of the species we used in these pot trials, and we photo-monitored the progress of their growth in the different pots across time. In **Figure 8**, we show *F. sylvatica* seedlings that we started growing in the spring of 2023. Only the solid-walled pot produced root systems with significant root deformities after one season in 2023.

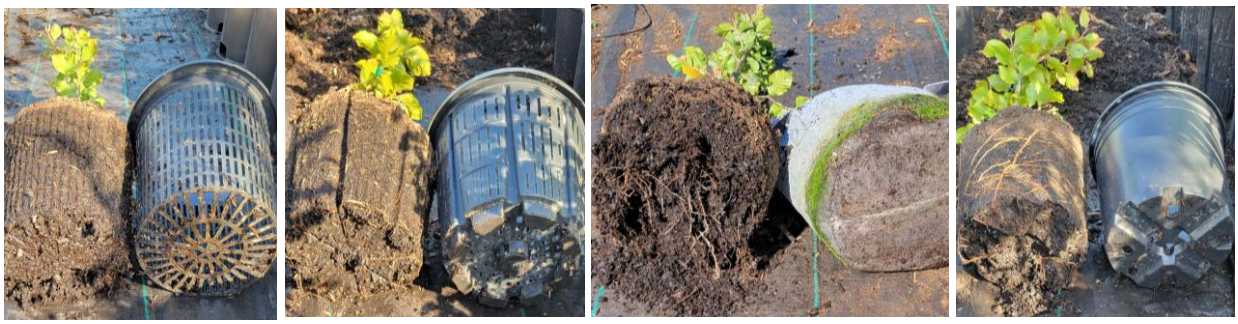

Figure 8. Root systems of 2023 grown *Fagus sylvatica.* Trees were grown for one season in the following pots from left to right: Pioneer with holder, RediRoot, RootPouch, and Standard. Notice the lack of visible roots on the exterior of the 3 air-root pruning and fabric pots and the circling and descending roots on the exterior of the standard pot.

In **Figure 9**, we show the same trees in a Pioneer and standard pot at the end of the 2024 growing season. By 2024, the visual difference between the two root systems is even more stark. In the standard container grown trees, you can see an abundance of circling and matted roots. In the Pioneer pot-grown trees, while you can't see many roots on the periphery of the root ball, it is packed with fine roots, which is the result of two seasons of air-pruning.

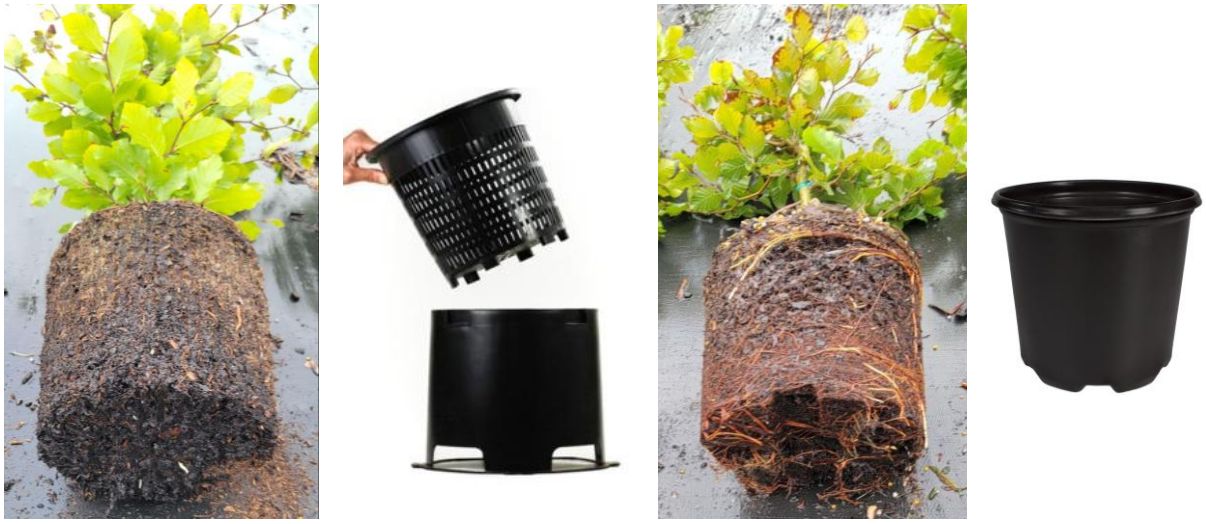

Figure 9. *Fagus sylvatica* trees grown for two seasons in a Pioneer Pot with holder (left) standard smooth-walled plastic pot (right). Notice the matting and circling roots on the tree grown in the standard smooth-walled plastic pot compared to the lack of visible roots on the sides of the Pioneer Pot-grown tree.

In general, when we compared the growth and health of the many trees grown in the different pots during our 2024 trials, we found few obvious differences. Some exceptions occurred, such as when trees in RediRoot pots, which were prone to faster dry-out, were under irrigated and resulted in decreased tree growth. Although we didn't take quantitative measurements of stem or root growth, we were able to draw these conclusions from regular observation and extensive photo monitoring.

Conclusions

These series of trials have been very useful for us to test out not only the impacts of different air-pruning designs on root quality, but also to help answer bigger picture questions around economic viability, production efficiency and overall plant performance. We will be using our observations from 2023 and 2024 to guide our growing practices moving into the spring of 2025. In propagation, we will scale up the use of the AirTrays with FertilPots because of the flexibility of this system, both in terms of producing plugs with superior root systems, and because of the ease of use with our existing irrigation boom to efficiently manage dry-out. Our results from the previous years will be useful in knowing which species to plant in the FertilPots, because we found that the highly degradable Fertilpots, if used for longer than 6 months, disintegrate and require a fibrous root system to hold the plug together. Therefore, certain slow-growing, heavy taprooting trees such as *Carya glabra*, which we grew in 2024 trials, will not work well in this system.

In our container field-liner department, we will move forward in 2025 with the #2, #5, and #7 Pioneer Pots because of their superior longevity, the high quality root systems they produce and less severe dry-out experienced when utilizing the holders. With the Pioneer Pots, we are trying to create our own system that replaces the need to purchase the pot holder, making production less expensive, while still retaining the benefits of the microclimate created by some form of protective holder.

We acknowledge that the implementation of a new practice or new technology always requires adjustments; some large and others small. Overall, the benefits of growing high quality root systems that can establish and root out faster in their growing next stage continues to motivate us to work through the challenges associated with these production changes.

At NVK, we are always striving to innovate better growing practices, and we look forward to see what 2025 holds.