

# New Advances to Narrower Canopy Systems: Transitioning from 3-D to 2-D Canopies or Fruiting Walls – Part 3

Mario Miranda Sazo

Cornell Cooperative Extension, Lake Ontario Fruit Program, Newark, NY

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Over the last three years, progressive growers in the Lake Ontario fruit region have transitioned from the traditional 3-foot in-row to 2- or 2.5-foot in-row planting spacing – using row middles as narrow as 9–11.5 ft. There have also even been a few multileader plantings and a few on-farm test rows using 9, 18, 20, and 28 inches in the in-row planting

**“Narrower (2-D) fruit canopies can help growers take full advantages of orchard mechanization, future robotics, and simplified canopy management techniques. The recent transitioning or adoption to narrower canopy systems is indicative of the breakthroughs now emerging in modern horticultural practices.”**

spacing. Most of this current transition to higher planting densities has occurred by using a one-leader tree per root. There has also been a significant amount of learning from top-working trees and growing the new cultivar on two- or three-leader trees instead of a one-leader tree.

Advances in and practical applications of motorized platforms for pruning and hand thinning, mechanization of summer pruning by hedging, mechanical blossom thinning, and economic benefits of harvest mechanization of apples for the tall spindle apple orchard system were described five or more years ago (Miranda Sazo 2010; Miranda Sazo and Robinson 2013; Robinson and Miranda Sazo 2013;), as well as more recently (Miranda Sazo and Robinson 2015; Miranda Sazo et al. 2016; Wells et al. 2017). The recent transitioning or adoption to narrower canopy systems is indicative of the breakthroughs now emerging in modern horticultural practices. Here, I summarize some of the new developments in orchard mechanization and provide schematic drawings showing (1) how to transition to an apple fruiting wall system, (2) practical tips to avoid pitfalls when attempting multileader apple fruit production, and (3) a summary of why a 2-D canopy is a smarter choice for future technologies.

## Transitioning from 3-D to 2-D

When managed correctly, a 3-D spindle apple system at maturity should give a narrow, tall fruiting wall with high fruit

quality due to good light exposure in the narrow canopy. However, 3-D spindle orchards that have not been properly managed have produced dense, “bushy” canopies, especially for vigorous trees on fertile soils.

**Canopy Management.** In some cases, it has been a challenge for growers because the minimal pruning concept for the first four or five years has been easily misunderstood, and as a consequence, this has delayed the renewal pruning process of big limbs. This lack of systematic pruning for the lower, middle, and top portions of a single tree has created excessive shading and loss of fruitfulness, especially in the lower fruiting zones of the tree. The growth habit of some cultivars, such as ‘McIntosh’ and all ‘Fuji’ strains, has brought challenges to the management of a 3-D spindle tree. Tall trees are not easy to reach without the use of ladders or platforms for pruning and other orchard tasks. Canopy uniformity is less consistent when winter pruning is only done by hand with ladders.

Finally, limb bending is required, but seldom practiced in NY, for vigorous cultivars like ‘Fuji,’ ‘Macoun,’ or ‘Linda Mac.’ Feathers that are not tied down soon after planting will develop as strong, upwardly arched limbs and will be problematic for the 3-foot in-row spacing of a 3-D spindle-shaped apple tree. These strong feathers will require severe (and unfortunately unneeded) limb removal pruning at an early age, which invigorates the tree and makes long-term canopy containment even more problematic.

In the last few years, more NY apple growers have adopted mechanical pruning in their orchards. Mature 3-D spindle orchards on a dwarfing rootstock that used to have a significant number of long, big limbs and were less productive and uniform have been transitioned or converted to 2-D fruitful canopies via mechanical pruning (Figure 1).

**Step 1:** The first part of this transition or conversion strategy is to manually remove unproductive, big limbs and get renewals through winter pruning (leaving a stub of “2 fingers” length). This pruning effort of two to four cuts per year (during two, three, or even four winters to prepare the orchard for mechanical winter or “pink” pruning) has been conducted in “calm” moderate-vigor orchards with the aim of shaping the trees.

**Step 2:** The second part of the strategy is to form a square box (Figure 2a) by mechanical pruning at the end of the dormant season or at pink (to prevent vigorous regrowth), to pre-form the trees into a square shape or “box.” Mechanical pruning can be done vertically or at an angle, depending on the planting spacing. The orchard should receive an Apogee program to control

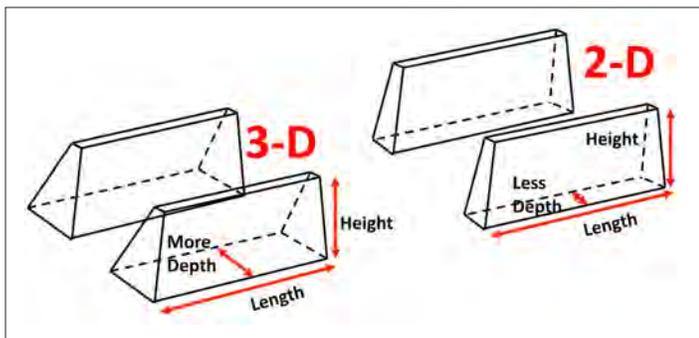


Figure 1. Transition from a 3-D to 2-D canopy.

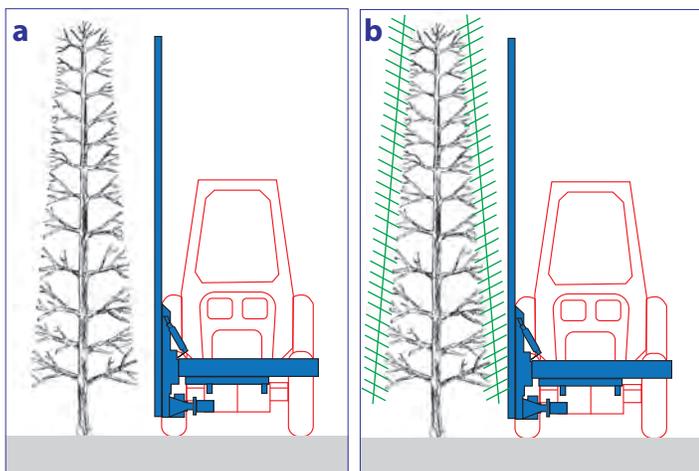


Figure 2. (a) The "box" concept is a system where hedging is conducted at the end of the dormant season or at pink to pre-form the trees into a square shape or "box"; (b) From the pre-formed "box", shoots (green color) grow during the season until they are hedged in the summer.

vegetative growth as the canopy transition or conversion is initiated.

**Step 3:** The third part of the strategy is to follow the mechanical dormant or pink pruning with a mechanical summer pruning the same season and every following summer (Figure 2b).

Once the orchard has completed the transition, manual dormant pruning should be continued and the canopy improved through the removal of any existing big limbs, if any. Growers should conduct precise and detailed pruning in the

low, middle, and top portion of the canopy every year, ideally with platforms.

It is important to note that with mechanical pruning – conducted during the winter, at "pink", or during the summer – does not mean hand pruning is not needed or is less important. On the contrary! Hand pruning can be improved and is critical, especially for the in-row spacing via hedging, as it shapes the trees and the fruit wall for winter pruning. Growers should not expect or try to save manual winter pruning costs by incorporating the use of mechanical pruning.

**Mechanical Pruning Tips for Tall Spindle System.**

With a tall spindle tree and a row spacing of 12 feet (3 x 12-foot planting spacing), the mechanical winter or pink pruning should be done 18 to 20 inches from the trunk to form the box. Then, from the pre-formed box, hedge the 1-year-old shoots that grow during the season at 22 to 26 inches from the trunk, leaving approximately a *semi-angled 4-foot wide wall* at the base of the canopy. There are usually 14 to 16 planar/horizontal fruiting units on one side of the canopy, each containing four apples and sometimes one more apple at the base of 1 year-old shoots, after mechanical summer pruning (Figure 3a).

**Mechanical Pruning Tips for Super Spindle System.**

With a super spindle tree and a row spacing of 11 feet (2 x 11-foot planting spacing), the mechanical winter or pink pruning should be done 12 inches from the trunk to form the box. Then, from the pre-formed box, hedge the 1-year-old shoots that grow during the season at 13 to 14 inches from the trunk, leaving approximately a 2-foot wide *vertical wall* at the base of the canopy. There are usually 18 to 20 planar/horizontal fruiting units on one side of the canopy, each containing two apples. For this system, there will be no fruit production in 1-year-old shoots after mechanical summer pruning (Figure 3b).

**When to hedge or not in the summer?** The effect of timing on mechanical summer pruning on 1 year-old shoots with 12 to 15 leaves has been studied in June, July, and August. The sidewall shearing treatments did not induce vigorous shoot regrowth, regardless of the timing of the mechanical pruning. However, with the earliest timing – in early June – we saw the development of short re-growths (approximately 8 inches) with a terminal bud, which often resulted in a flower bud next spring. Hedging in July saw regrowth of about 5 inches, and at the August timing there was no regrowth at all. There were no significant differences in return bloom among the different timings of mechanical summer pruning the following year.

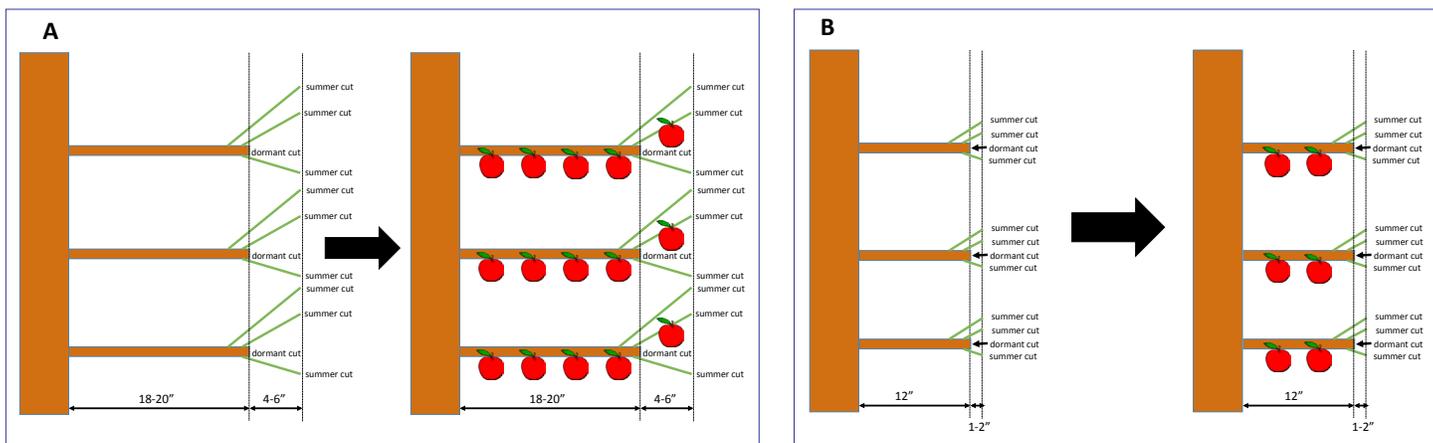


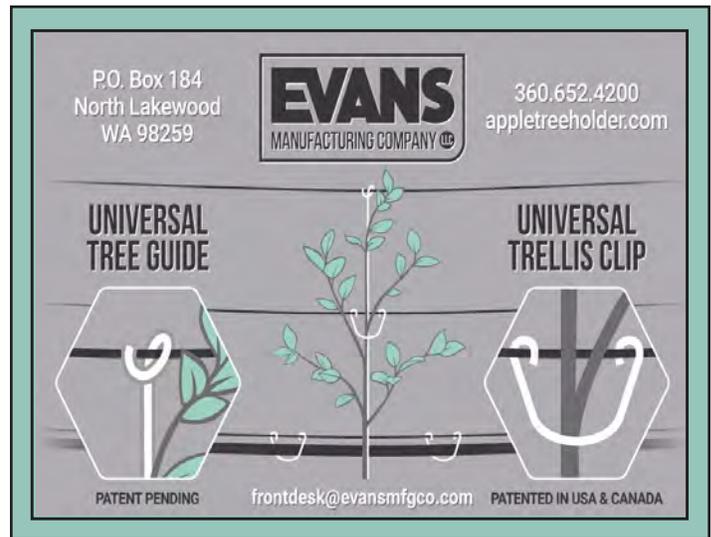
Figure 3. (a) A 3-D tall spindle tree converted to a 2-D narrow fruiting wall, (b) a super spindle tree converted to a 2-D narrow fruiting wall.

So when should growers hedge their trees? We encourage growers to target their mechanical summer pruning time based on the fruit-size characteristics of the apple cultivar instead of the exact number of leaves per shoot at a particular time during the growing season. This new timing approach to mechanical summer pruning has become a more practical method for some NY growers. For large-fruited varieties such as ‘Honeycrisp’ – where we intentionally want to control or reduce fruit size at harvest and especially during a rainy summer – we recommend an “early” timing for mechanical summer pruning and a “late” timing for small-fruited varieties such as ‘Gala’ to avoid a negative effect on fruit size before harvest. Medium-size fruited varieties should be mechanically summer pruned after ‘Honeycrisp’ and before ‘Gala’ to have the same controlling effect on fruit size. Under New York weather conditions, a mechanical summer pruning program should be started for ‘Honeycrisp’ as early as June 20–25, and for ‘Gala’ approximately 4–5 weeks later. In some cases, a ‘Gala’ block could even be hedged 7–10 days before harvest to facilitate the use of harvest platforms.

### Multileader apple production

If a grower decides to grow more than one leader per root, he/she must devote significant attention and energy to implementing a more rigorous, labor-intensive and time-sensitive management program, especially in the first two or three spring and summer seasons. If trialed or done suddenly without much previous experience or little help, it can present a challenge to even the most skilled apple growers. There is a step-by-step process as a grower learns to execute, uniformly train, fill, summer-prune, manage, and finally crop a more tight spacing in and between rows. This new, practical knowledge of growing more and more single spindle trees is very applicable, and fundamental, for the successful adoption and management of two-, three-, or four-leader trees, or multileader trees.

Ideally, growers should first master the growing of the traditional spindle tree at 3 x 12-foot spacing. Once they get used to the training needs of the traditional system, feel comfortable, and realize the full benefits of the technology, they may or may not decide to plant more trees in the in-row spacing. For growers who have recently increased the tree planting density (especially for high-value cultivars), this critical step has forced them to figure out how to grow and manage a tighter, planar, more two-dimensional canopy. From this moment, they have started using short pruning techniques instead of long pruning techniques. Some of the principles for short pruning techniques will also



be very useful and applicable to the production of multileader trees.

Growers who have recently attempted to grow a multileader tree and have not previously mastered the management of higher planting densities or the training of two- or three-leader trees via grafting, have sometimes struggled and learned “the hard way” when establishing a multileader system. If done properly, the multileader system requires a lot more training of leaders, and consequently, is much more labor-intensive in the first two or three years than traditional spindle trees. In some cases, the lack of multileader canopy uniformity (due to irregular leader height, spacing between leaders, absence of leaders, or poor development of short fruiting units along the leader) has required the use of more intensive spring and summer pruning to influence, correct, or redirect the growth where it is needed to quickly maximize canopy growth and uniformity. This lack of proper management can delay first cropping for at least one or two more years.

Before you embark on a big multileader project, I recommend you first get very familiar with growing spindle trees at 2 x 11-foot or 2.5 x 11.5-foot spacing. You can also gain valuable experience by top-working (via bark grafting) old and/or underperforming apple blocks with a high-value cultivar.

**Creating opportunities by grafting.** After the grafts start growing, use two or three plastic ties (or pieces of bamboo, fiberglass, or wire stabilizers) to quickly train the new shoots to the most vertical position possible for a multileader system (Figure 4). The basic idea is to produce a two-dimensional planar



**Figure 4.** (A) a grafted tree to a two-leader tree with two angled and long pieces of bamboo for leader training, (B) a grafted tree to a three-leader tree supported with two green plastic fiberglass for leader 1 and 3 and with a conduit pipe for leader 2, and (C) a headed feathered three to produce a two-leader tree supported with two wire stabilizers.

tree canopy, comprised of several thousand leaders per acre. Ideally, space the leaders every 18–20 inches in the in-row spacing. Carefully place and twist the new shoot to the plastic twine or tape it (preferred) gently as it grows, to prevent breakage from the wind. If the orchard is not protected with a deer fence, place a piece of soap on each leader tip and reposition it every 7 to 10 days as the terminal tip grows during the season. A well-supported leader will always grow faster and more vertically than one that is unsupported. Always tape the leader 4 to 6 inches below the wire and use a tree clip as the leader passes each successive wire.

Don't leave too many nurse limbs, because excessive shoot growth will outcompete and weaken the leaders. A nurse limb is one of the main scaffolds temporarily left to reduce the shock and help feed the grafts in the year of grafting. Leave only one or two nurse limbs and prune off the rest. Make sure the new leaders will get full sun exposure during the summer, and if possible, leave only nursing foliage in the opposite side of the row. Maximize the growth of the two or three leaders and remove anything that outcompetes each leader. Always leave a longer stub when summer pruning and, if needed, contain any excessive vegetative regrowth with directed Apogee sprays.

Continue supporting the terminal leader as many times as needed during the summer. Summer prune to influence growth to where it is needed. Make sure the canopy is calm so flower induction and return bloom is secured for the following year. Lastly, because the existing orchard grafted over had a less than ideal support and training system, if any, it will need to be re-engineered by installing a more robust trellis with taller (12-foot or higher) in-line posts and more horizontal wires spaced not more than 25 inches apart (use at least five to six wires). Maximize future multileader fruit yields by making sure the two-dimensional canopy is tall enough to get the full benefits of the wider spacing between rows.

### Making the leaders

If, after grafting in the orchard the first year, you only produced several whips and did not select and train two or three leaders for a multileader system, you can still select them during winter pruning. Later, you can spray Maxcel on the two or three leaders you left per root to stimulate their branching in



**Figure 5.** Old tree top-worked with three sticks to produce a 3-leader tree. Notice that the grafting occurred below the line of nursing limbs. Side shoots for each leader were pinched out later and left with a stub for limb renewal.

the orchard at 10 to 14 days after budbreak. Use 500 ppm or 3.2 ounces/gallon of formulated product. Maxcel can be applied with a backpack sprayer using a single nozzle or with a spray tower (direct nozzles to the lower part of the canopy).

Ideally, the closer to the ground you top-work the trees, the better for the multileader system. However, many times the new training of leaders starts at approximately 24 to 28 inches above the ground (based on the lowest positioning of a nurse limb) and the right vertical spacing between leaders (18 to 20 inches) is seldom achieved until around 3 to 4.5-foot height. I call this the “inverted triangle zone”, which makes canopy management and pruning a bit more challenging in the tight spacing between leaders in this zone.

A better approach to correctly grow well-spaced leaders, more evenly, vertical, and at a lower height, is to graft old trees below the line of nursing limbs, as has been done by Eric and Robert Brown III of Orchard Dale Fruit Company, LLC, in Waterport, NY. This grafting technique has also been successful in Washington apple orchards and is known as a “Notch” or “Beaver” graft (Tom Auvil, WA, personal communication). The Browns made a deep and angled fresh cut on one side of the trunk, which left a smooth, fresh cambial surface. Old trees were grafted with three sticks inserted on the outer part of the trunk at 6 to 8 inches above the ground in May (Figure 5).

The new leaders grew from 2 to 4 inches per week, more slowly at first, then more rapidly. A few new shoots were also formed along the existing stock. These were removed as they appeared through the growing season. Side shoots that developed on the three leaders were pinched out by always leaving a long

stub (to secure limb renewal), and leader growth was maximized. All leaders were trained with plastic twine and additional wires. Tall in-line posts were installed to secure a robust trellis for future multileader fruit production. The old trunk section will be carefully removed during the 2018 dormant pruning season.

In other apple-producing regions with less severe and more predictable weather conditions for early top-working (i.e., Washington or Chile), some growers have completely eliminated the need for nursing limbs by grafting old trees with several sticks (40% to 50% more sticks to produce a three-leader or a four-leader tree) early in the spring. This method has also proved to be successful, as several of the shoots that grew from the sticks helped to absorb the excess vigor. Then, the best-positioned 3 or 4 shoots were successively selected (and the rest eliminated) and these became the leaders of the future multileader system.

## Summary

**Benefits of a Narrower Canopy.** The transition or conversion of a 3-D spindle-shaped canopy to a 2-D fruiting wall is well-suited to the majority of Northeastern apple cultivars. With some cultivars, the system may involve a 2-leader (bi-axis) or a 3-leader (tri-axis) tree to better manage vigor. It could also allow growers to have more economical production of a similar quantity and quality of fruit (size, color, and eating quality) than from current mature spindle single trees. Potentially, the size and color of fruit could be more uniform as a result of better light penetration and distribution. The water volume needed for good spray coverage for pest control could also be reduced. The uniformity of chemical thinning could also be improved and the fruit wall could be thinned mechanically with a string thinning machine (Table 1).

The 2-D fruit wall concept will help growers increase the performance of motorized platforms, future harvest equipment and robotics, and worker efficiency. To take full advantage of these advances in mechanization, new orchards using single spindle trees should be established at a spacing of 2 to 2.5 feet by 11 or 11.5 feet. The leaders or shoots of multileader trees should be spaced 18 to 20 inches in the in-row spacing. Growers should use 12-foot posts for trellising, a correct post spacing of not more than 30 feet apart, a minimum of four, five, or six wires (spaced not more than 24 to 26 inches apart), and a vertical element as a wire or a string tie to support the leader (for a single spindle tree) or several leaders (for a multileader tree).

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**Table 1. Benefits of a narrower canopy.**

A 2-D canopy is a Smarter Decision	
From a 3-D to a 2-D spindle-shaped canopy	Benefits <sup>1</sup>
<b>Why?</b>	<ul style="list-style-type: none"> <li>• Fruiting canopy structure is more efficient and simplified</li> <li>• Light penetration and distribution is improved</li> <li>• Fruit color and size is more uniform</li> <li>• Final pack out is increased (more dollars/acre) for a high value/high yielding cultivar</li> <li>• Hand pruning, hand thinning, and hand picking are improved</li> <li>• The benefits of orchard mechanization are maximized (including mechanical weed control, use of string thinners, use of platforms for several orchard tasks, robotics, tunnel sprayers)</li> <li>• The sustainability of the entire fruit production system is increased (less use of PGRs, less spraying volume, faster leaf drying, reduced drift)</li> <li>• It becomes a more friendly fruit production system to multi-task nets, and SSCDs (Solid Set Canopy Delivery Systems)</li> </ul> <p><sup>1</sup>Modified from Dorigoni and Micheli, 2015</p>
<ul style="list-style-type: none"> <li>• If you want to make a mature 3-D spindle orchard more uniform, efficient, narrower, and fully suitable for orchard mechanization</li> </ul>	
<b>When?</b>	
<ul style="list-style-type: none"> <li>• Start today, the sooner the better, the conversion won't happen instantly</li> <li>• If you misunderstood the minimal pruning concept</li> <li>• If you delayed renewal pruning too much</li> <li>• If you have done a poor pruning job</li> <li>• If you have created a dense, "bushy" canopy</li> </ul>	
<b>How?</b>	
<ul style="list-style-type: none"> <li>• Via detailed and precise manual and mechanical dormant and summer pruning</li> <li>• Set the box once you have removed all big limbs through renewal pruning</li> <li>• The entire process of conversion can take until 3-4 years</li> </ul>	

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**Mario Miranda Sazo** is an Extension Associate who specializes in orchard management and orchard mechanization with the Lake Ontario Fruit Program, Cornell Cooperative Extension.



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