Publication Series | 814A

Guide to Training and Pruning

Tender Fruit Trees

Ministry of Agriculture,
Food and Agribusiness

Ontario

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Publication 814 | Book A
Training and Pruning Tender Fruit Trees

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Information used in this guide has been compiled from a number of sources including Ontario Ministry of Agriculture, Food and Agribusiness technical publications.

This publication is the first in a series of Training and Pruning publications that will replace Publication 392: *Training and Pruning Fruit Trees*, *Pruning Fruit Trees Infosheet* and Publication 814: *Training and Pruning Apple Trees* when completed.

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OVERVIEW

Publication 814A: *Training and Pruning Tender Fruit Trees* is Part A of a new, updated series that replaces Publication 392: *Training and Pruning Fruit Trees* and Publication 814: *Training and Pruning Apple Trees*. This guide is designed to support growers, advisors and orchard managers with practical, research-informed strategies for managing tender fruit trees in Ontario.

Training and pruning are critical for the health, productivity and longevity of tender fruit trees. As a result, training and pruning have a significant impact on orchard profitability. Higher labour costs have resulted in an increased interest in adopting new training and pruning systems that:

- increase light penetration, increasing yields and fruit quality
- use land more efficiently
- require less labour
- are compatible with mechanization

This publication provides information to Ontario growers to help them select a training and pruning system that meets their needs.

Unlike general horticultural texts, this publication is production-oriented and specifically tailored to Ontario's growing conditions and practices. It is designed with the practical, day-to-day needs of growers in mind, offering guidance that is both relevant and applicable. This publication incorporates information on training and pruning that is appropriate for Ontario's market and climatic conditions for all tender fruit crops (peach/nectarine, pear, plum, cherry) from a

variety of resources into a single publication. The illustrations and comparison tables contained in this publication help to make complex concepts easier to understand and implement in the field. Additionally, the information presented here is closely aligned with Integrated Pest Management (IPM) principles.

Benefits for Growers and the Industry

This guide provides practical value to growers, advisors and researchers by supporting improved orchard productivity, better fruit quality and more efficient use of labour and resources. It promotes sustainable practices aligned with Integrated Pest Management (IPM) and encourages knowledge sharing across Ontario's tender fruit sector.

By offering clear, research-based tools, this publication helps strengthen the long-term success and resilience of the industry.

Integrated Learning and Additional Resources

This guide is part of a broader effort to support tender fruit growers through a combination of in-person learning opportunities and online tools. It complements workshops, field events and the ministry's digital resources — which offer practical, up-to-date information that extends beyond this publication.

For more information, visit our online tools:

- Tender Fruit | ontario.ca
- ONfruit Blog
- Ontario Crop Protection Hub
- CropIPM

Series Context and Future Topics

This guide is the first in a multi-part series focused on training and pruning systems for fruit crops in Ontario. While future topics are still being developed, the next publication in the series will focus on apples. Additional guides may explore other fruit crops, advanced techniques or innovations in orchard management.

For updates on upcoming releases and access to related resources, visit ontario.ca/crops.

The following is a summary of topics on the importance of training and pruning discussed in this publication.

What is Training and Pruning?

Training involves managing a tree into a desired shape and structure to improve productivity and fruit quality and includes the use of:

- pruning to selectively remove limbs and branches
- trellises, clothespins, weights and branch spreaders to manipulate branch angles and direct tree growth

Why Train and Prune Fruit Trees?

Promote Healthy Trees: Pruning removes dead, diseased, infested and damaged branches, allowing the tree to focus on healthy new growth. Pruning reduces the shading in the canopy, resulting in improved cold hardiness. Thinning removes excess branches, increasing air circulation and reducing the risk of fungal diseases.

Tree Architecture: Training and pruning fruit trees helps them to develop strong branches

that can support crop loads. Pruning helps manage the tree size and shape, making harvest and maintenance easier.

Crop Load: Pruning encourages the production of new, high-quality fruiting wood, which is essential for maintaining high yields of premium-quality fruit throughout the life of the orchard. Pruning is also used to reduce excess fruit buds, helping to balance vegetative (leaves and shoots) and reproductive (fruit and blossom) growth, resulting in benefits to fruit size and quality.

Improve Fruit Quality, Fruit Size and Yields: Thinning to remove excess branches increases light levels in the tree canopy, resulting in improved yields, fruit size and fruit quality. Training systems help trees bear fruit earlier, leading to higher yields over the lifetime of the orchard.

Labour Efficiency: Training systems are used to modify the tree architecture, making harvesting and maintaining fruit trees more efficient. Dormant pruning can reduce fruit set, resulting in reduced labour costs for fruit thinning.

Dormant Pruning

Most dormant pruning is done in fruit crops (pear, plum and tart cherry) from March to bud swell after the risk of cold temperatures is over. Dormant pruning establishes tree shape, size, architecture and crop loads. Peaches and nectarines are pruned from bud swell to fruit set, as they are more susceptible to cold injury.

Summer Pruning

Summer pruning helps to shape the tree, manage tree size and vigour and increase light penetration. Summer pruning is important in reducing the risk of bacterial canker in sweet cherries.

Pruning Cuts Used in Tree Fruit

Thinning cuts: Remove the entire branch at its base. These cuts reduce overcrowding, improve air circulation and light penetration.

Heading cuts: Remove the terminal portion of a branch to a bud or a lateral branch. These cuts are used to shape young trees, control the size and shape of the tree and encourage branching.

Tipping cuts: Are heading cuts that involve removing the tip of the branch to encourage branching and thicken growth.

Renewal cuts: A pruning technique used to rejuvenate trees by removing old, unproductive branches and stimulating new shoot growth from the base of the branch.

Stub cuts: Involve cutting back a limb and leaving a small portion of the branch (stub) to stimulate growth from buds below. Stub cuts are used to stimulate new growth and improve tree health and productivity.

Pruning guidelines: Pruning should be done annually to maintain tree shape and structure. Avoid excessive pruning as it can result in reduced root growth, delays in fruit production and excess vigour. Prune to remove crowded, dead, infested or diseased shoots. Pruning encourages shoot growth in the vicinity of the cut. Maintain branches with wide-angle crotches.

Selecting a Training System

Orchards are long-term investments and training systems play an important role in the profitability of the orchard.

When selecting a training system, it is important to take into consideration the following factors:

- natural tree growth and fruiting habits of the crop/variety
- impact of the training system on tree vigour, early fruit bearing, yields and fruit quality
- costs and labour involved in the system and the amount of land available
- availability of size-controlling rootstocks, access to irrigation, soil type and climate
- costs of establishing and managing the system and the impact on agricultural inputs
- markets — to ensure the fruit produced meets market demands

Additionally, the soil type, climate, irrigation, tree spacing, labour availability and grower experience all contribute to the success of the training system.

Training Systems Used in Tender Fruit Production

Below is an overview of the various training systems used for fruit trees. More details, including illustrations to help visualize the training systems, can be found throughout this publication.

Peaches

Peaches produce fruit on 1-year-old wood, so annual renewal of fruiting wood is important in ensuring optimal fruiting wood for fruit production. Peach trees should be pruned from bud break to fruit set to avoid cold injury. Peach trees are vigorous with spreading canopies that work well with the Open Vase training system. New training systems are being used in peach orchards to improve land use efficiency, increase light penetration and promote pedestrian orchards that do not require the use of ladders for harvest or management.

Pear

Pear trees are vigorous and early training and pruning are critical to establish tree structure, regulate vegetative growth, promote early fruit production and consistent yields throughout the life of the orchard. Pruning strategies for pear trees focus on managing strong apical dominance, keeping trees within their space (for high density orchards), managing fire blight, balancing tree vigour and fruit production. Pears produce the best quality fruit on 2-year-old spurs (short stubby stems that arise from branches).

Plums

Japanese plum trees are vigorous and have a spreading growth habit. European plums have a more upright growth habit. Fruit are produced on 1-year-old wood and on fruit spurs that are 2–3 years old. The goal of training and pruning plums is to manage tree height, crop load, optimize light distribution and manage diseases (black knot and bacterial canker).

Cherry

Tart cherries are a processing crop and the industry has been faced with challenging markets and increased costs of production (labour and agricultural inputs). Tart cherry training systems focus on developing large trees with sturdy trunks that are compatible with machine harvest.

Sweet cherry production is a fresh market crop and training systems focus on producing high yields of large fruit to meet market demands. Sweet cherry production is very labour intensive and requires production systems that produce pedestrian orchards or orchards that are compatible with mechanization.

CHAPTER 1

Training and Pruning Tender Fruit Trees

Tender fruit (peaches, nectarines, cherries, pears, plums and apricots) growers have traditionally planted low-density orchards, with a smaller number of trees per acre. These orchards produce large trees that work well with the growth habit and vigour of the crop and have been profitable for growers. However, they have high labour requirements, low yield efficiency (fewer fruit per acre) and can have low-light distribution throughout the canopy resulting in more variability in fruit size, fruit quality and maturity.

To be profitable, modern orchards must be productive and efficient. Productive orchards consistently produce high yields of good-quality fruit throughout their lifespan. Efficient orchards optimize the use of land, labour and agricultural inputs (fertilizers and pesticides) to minimize production costs.

Increases in land, labour and production costs, in addition to market demand for large-sized, premium-quality fruit have resulted in growing interest in medium- to high density orchards. These orchards have a higher number of trees per acre and have the potential for higher labour efficiency, increased orchard productivity and better fruit quality.

While apple growers have been shifting towards planting higher density orchards for decades, tender fruit growers have lacked the

necessary tools to manage tree vigour and allow for medium to high density plantings. Recent advances in the development of size restricting rootstocks and innovative training systems to manage tree size, are facilitating closer tree spacing and eliminating the need for ladders for orchard management.

Training and pruning systems can enhance light interception, increase fruit yields, improve fruit quality and reduce labour costs, which can increase profitability.

There are many different training systems for tender fruit. The training system that works best for an orchard will vary depending on the crop, growing conditions, variety, rootstock, labour availability and grower management skills.

This publication reviews some of the most common training systems used for tender fruit production and highlights the benefits and challenges of each system.

What is Training and Pruning of Fruit Trees?

Training involves directing tree growth to a desired shape and structure. Pruning involves selectively removing limbs or branches to develop the tree height, width and structure (Figure 1). Pruning is part of the training process. Other training techniques might include the use of trellises, clothespins and branch spreaders to manipulate branch angles and direct growth.

During establishment and prior to bearing fruit, more time is spent training trees to develop the basic tree structure. Mature trees, with an established structure, require less training and more time is spent pruning. Training and pruning impact light distribution in the tree canopy, crop load management, vegetative growth, productivity and labour efficiency.

Figure 1. Pruning a high density peach orchard that is trained on a trellis.

Why Do Fruit Trees Need to Be Trained and Pruned?

Fruit trees require training and pruning to:

- develop strong branches that can support heavy crop loads and are less likely to break due to ice or snow loads
- manage the tree height, shape and size
- balance vegetative and reproductive growth
- increase light interception and distribution throughout the canopy to increase yields and fruit quality
- encourage trees to bear fruit earlier (precocious) resulting in faster economic returns
- increase air circulation and improve spray penetration into the canopy
- manage the number of fruit per tree (crop load) and minimize the labour required for thinning fruit to ensure adequate fruit size and quality
- improve tree health by removing dead or diseased/infested wood
- stimulate the production of young and productive fruiting wood (renew fruiting wood) to ensure production of high-quality fruit for the lifetime of the tree

Influence on Light Levels in the Tree Canopy

Orchard productivity improves with increased light interception and equal distribution of light throughout the canopy. When light levels in the canopy drop below 30% of full sunlight, flower bud formation is reduced. To produce high-quality fruit, it is essential to have 60%–70% light interception. Fruit that develops in shaded areas tend to be small and of poor quality. Shaded wood is also more vulnerable to cold injury.

Ensuring adequate light distribution into the interior canopy is critical for maintaining consistent fruit production and uniform fruit maturation throughout the tree canopy. Training and pruning systems change the shape, density and height of the tree impacting the amount of light intercepted and distributed within the orchard canopy.

Tree Shape

The shape of a tree's canopy affects the amount of light it intercepts and how light is distributed throughout the tree. Trees that are trained to fruiting walls or pyramid shapes allow for greater light penetration into the interior canopy. Fruit grown in narrow canopies (i.e., Bi-Axis peach) may be less resilient to heat stress and sunburn damage due to reduced shading and overexposure to sunlight.

Globe-shaped trees allow less light to penetrate the interior canopy (Figure 2). The highest light interception (and productivity) occurs in the top third of these trees, where fruit is often difficult to access. This can lead to increased labour costs when pruning, thinning and harvesting fruit trees.

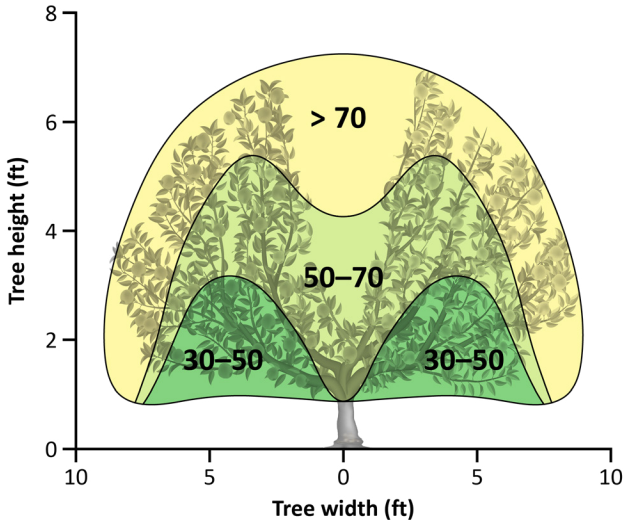


Figure 2. Light distribution in open centre tree showing three zones of light (% full sun). *Source:* Adapted from *Pruning Peach Trees*, Virginia Tech.[7]

Tree Canopy Density

Trees with narrow, open canopies (two dimensional canopies) such as fruiting walls (Figure 3) have good light interception and distribution throughout the canopy, resulting in increased yields, better fruit quality and more uniform ripening. Trees with large dense canopies have low light distribution and more shading, resulting in poor fruit quality, lower yields and inconsistent ripening throughout the canopy.

Figure 3. (A) Pear trees trained to a two-dimensional training system (Bi-Axis) with a narrow canopy. (B) Peach trees trained to a three-dimensional training system (Open Centre) with a large dense canopy.

Tree Height/Spacing

As tree height increases, the top of the tree is more likely to shade the lower portion of the tree and trees in adjacent rows, resulting in reduced productivity and inconsistent fruit quality.

Crop Load Management

Crop load management is one of the most important production practices affecting fruit production. Fruit trees often set more fruit than they can support. Leaving excess fruit on the tree has a negative impact on fruit size, fruit quality and the development of flower buds for next year's crop. Additionally, the excess weight of the fruit can lead to limb breakage.

Training and pruning play an important role in crop load management. Pruning eliminates potential flowers and fruit before they develop, which reduces competition for carbohydrates and nutrients for the remaining fruit. Reducing fruit load also reduces plant hormones that inhibit flower bud initiation for next year's crop.

Training systems that produce simple and uniform (regularly spaced branches) trees make it easier for orchard workers to calculate how many fruits should be set on each branch to achieve target yields and adapt their thinning and pruning practices accordingly. For additional information on using training and pruning to obtain target yields in peaches refer to Chapter 2, *Training Systems Used in Tender Fruit Production*.

Influence of Training and Pruning on Fruit Production

Training systems play an important role in balancing vegetative growth (vigour) and fruit production in orchards. They can encourage fruit production earlier in the life of the tree, which results in increased economic returns. Training systems can be used to develop trees with more horizontal branch angles that encourage fruit production and reduce excess vigour, resulting in well balanced trees.

Training and pruning systems increase light interception and distribution throughout the canopy resulting in the development of more flower buds, higher yields, increased fruit size, higher-quality fruit and more uniform fruit maturation throughout the canopy. Pruning is used to remove old unproductive wood and stimulate the production of high-quality fruiting wood to ensure future fruit production.

Pruning, Training and Labour Efficiency

Tree fruit production is labour intensive, since hand labour is required for pruning, training and thinning fruit trees. Pruning is one of the most expensive and labour-intensive tasks in orchards and accounts for 6% of the annual costs of producing peaches in Ontario. Pruning accounts for 27% of the hand-labour costs of producing mature peaches (Figure 4). Pruning also has a significant impact on the labour required for fruit thinning and raking brush.[9]

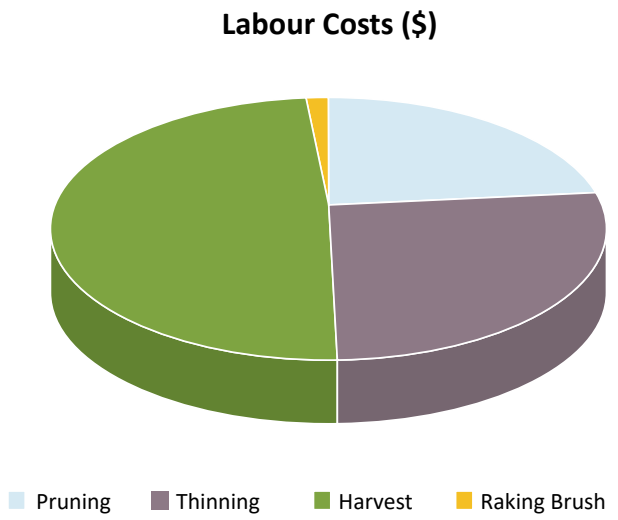


Figure 4. Hand labour costs in a mature peach orchard in Ontario.
Source: Ontario Ministry of Agriculture, Food and Agribusiness.[9]

Rising labour costs and the ongoing challenges of securing skilled labour have increased the importance of optimizing labour efficiency in orchards. Some methods of increasing labour efficiency include adopting training systems that produce:

- smaller trees that can be maintained (pruned, thinned and harvested) without the need for ladders (pedestrian orchards) help to increase worker speed and efficiency
- fruiting walls with open uniform canopies are compatible with the mechanization and use of platforms (Figure 5) for pruning and harvest, increasing worker speed and reducing labour costs
- trees that are simple and easy to prune, reducing the time required to train and prune fruit trees

Figure 5. Platform that can be used to increase labour efficiency by reducing the need for ladders.

Dormant vs. Summer Pruning

Dormant Pruning

Dormant pruning is used to establish tree canopy shape, manage tree size, enhance light distribution and air circulation, renew fruiting wood and manage the crop load. The optimal time to prune fruit trees (pear, plum and tart cherry) to reduce the risk of damage from severe freeze events is the period between leaf drop in late fall and bud swell in early spring.

Notes

Peaches, nectarines and apricots are sensitive to cold temperatures and are ideally pruned from bud swell to fruit set, after the risk of frost to limit the risk of cold injury. Pruning peaches at bloom also helps reduce the risk of canker, refer to Chapter 3, *Training and Pruning Peach Trees* for additional information.

Traditionally sweet cherries have been pruned in the dormant season, however new research suggests that summer pruning (after harvest) is preferred as it reduces the risk of canker infections and minimizes regrowth, refer to Chapter 6, *Training and Pruning Cherry Trees* for additional information.

Avoid pruning in the fall before the trees are dormant or in early winter as it can increase the risk of cold injury. Recently-pruned fruit trees are more susceptible to cold injury for up to 48 hours and can be damaged when temperatures drop suddenly. Monitor the long-range forecast and don't prune when a severe drop in temperature is forecasted. Delay pruning young or vigorous trees, until early March to reduce the risk of cold injury.

Pruning creates wounds on the trees making them more susceptible to diseases such as bacterial canker. Prune trees when they are least susceptible to diseases. To reduce the risk of spreading disease, prune when weather conditions are dry and when pathogens are less active.

Summer Pruning

Summer pruning involves the selective removal of leafy upright vigorous shoots that have grown during the current growing season. Summer pruning can be used to:

- manage tree shape, size and vigour
- increase light penetration into the canopy interior resulting in better fruit colouring and sugar accumulation (Brix) in fruit
- reduce branch crowding — improving air circulation and increasing spray coverage

Summer pruning is important in high density training systems to minimize shading and to manage the shape and size of the tree. The optimal timing for summer pruning varies depending on the crop.

In sweet cherry orchards summer pruning after harvest (August to early September) is recommended to manage excess vigour and reduce the risk of canker. For pear trees, summer pruning should be done after terminal shoots have set in mid to late August.

Summer pruning of peach trees should be done by late July or August. Pruning after this time is not recommended as it can promote new growth that is susceptible to cold injury.

Additionally late season pruning delays cold acclimation, which decreases the cold hardiness of fruit buds in the early winter, making them more susceptible to cold injury.

Notes

Excessive summer pruning will reduce leaf area and photosynthesis. It will also have a negative impact on tree longevity, fruit size and sugar levels.

Types of Pruning Cuts

The two basic types of pruning cuts are thinning and heading (Figure 6).

Thinning cuts remove an entire shoot, branch or limb, back to the point where it originated while leaving the branch collar intact. Thinning cuts open up light channels throughout the tree without increasing vigour.

Heading cuts remove part of a shoot, branch or limb, typically up to 30%–50% of its length. These cuts should be used conservatively as they stimulate the growth of side branches at the location of the cut and result in increased vigour and crowding. Heading cuts are used to establish branches or scaffolds in young trees and manage tree height and shape.

Stub cut is a heading cut that leaves a portion of the branch (stub) (Figure 7) remaining on the tree. Generally stub cuts are avoided as they take longer to heal and may be more susceptible to disease. Stub cuts are used to remove old unproductive wood and stimulate the development of new productive fruiting wood closer to the trunk of the tree. Stub cuts are also used to limit the spread of diseases — such as fire blight and bacterial

canker — from infected branches to the trunk of the tree. Refer to Chapter 6, *Training and Pruning Cherry Trees* for additional information.

Tipping cut is a heading cut that removes only a small amount from the terminal end of the branch. These cuts are used to remove the inhibitory affect of apical dominance, the process where the main shoot is suppressed by the growth of other shoots. It promotes the elongation of 1–3 lateral buds near the location of the cut and induces lateral branch development.

Topping cut is a heading cut that removes the canopy beyond the point of its desired maximum height.

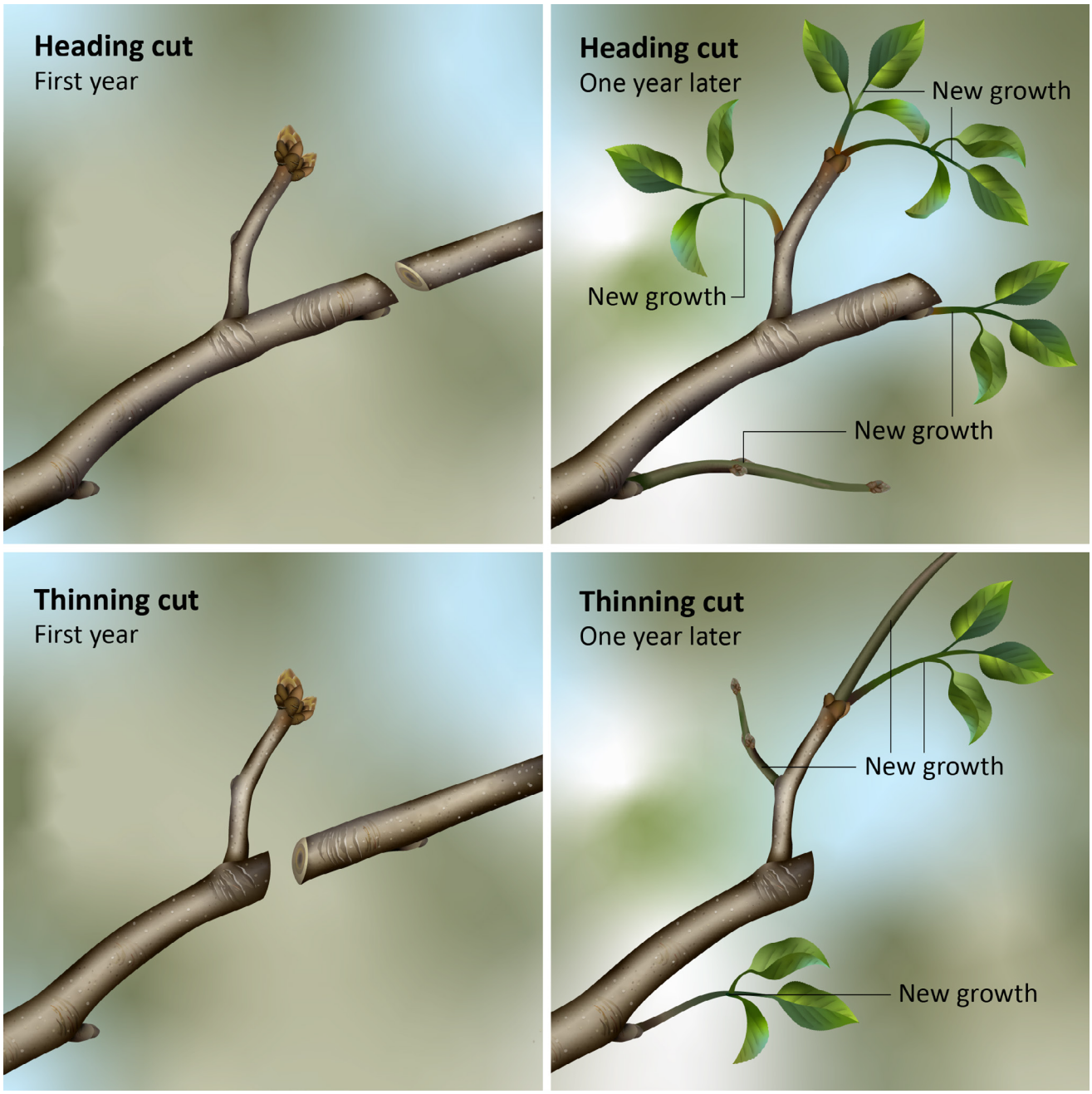


Figure 6. Comparison of thinning and heading cuts.

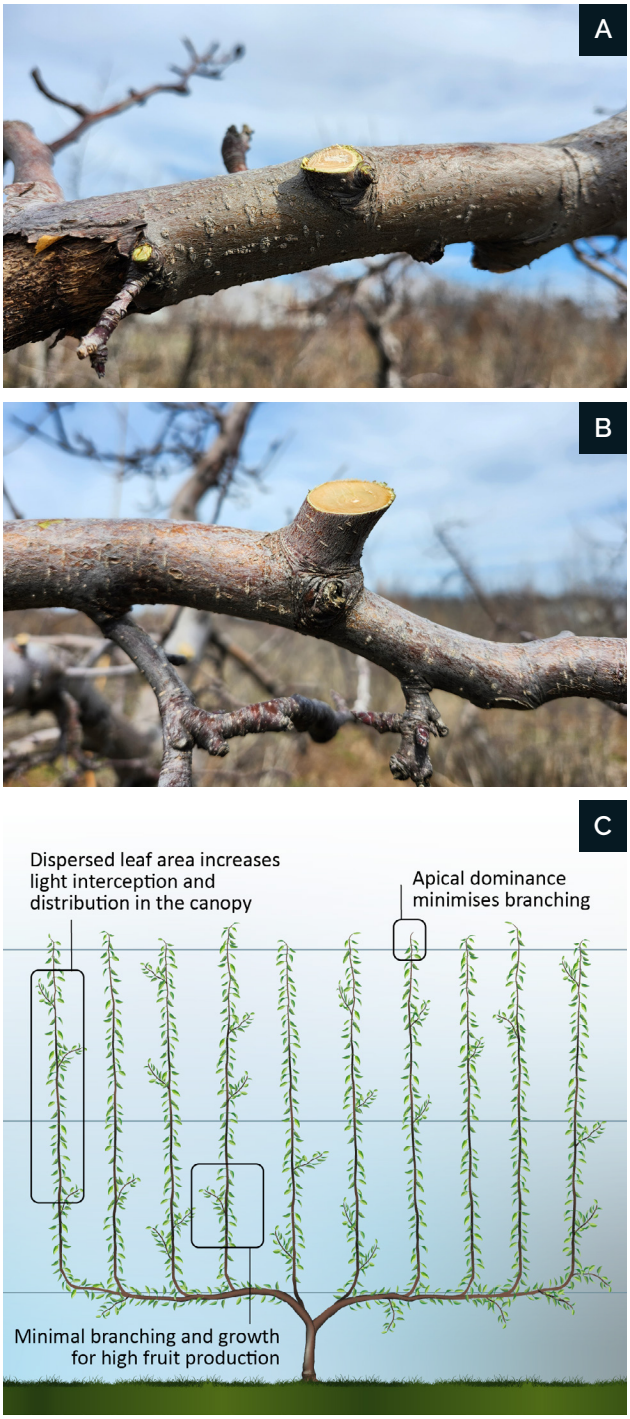


Figure 7. Generally clean cuts (A) are used for pruning as they encourage proper healing, while stub cuts can encourage decay and canker. However, stub cuts (B) can be effective in renewing fruiting wood or limiting the spread of bacterial canker. (C) Trees pruned to a multi-leader fruiting wall have improved light distribution and high fruit production.

Pruning Guidelines

Consider these general guidelines when deciding how to prune a tree:

- ✓ Prune annually to maintain the tree's shape, structure and minimize the need to remove large branches.
- ✓ Manage tree height to reduce shading. Optimal tree height will vary depending on the crop and training system.
- ✓ Time pruning to minimize the risk of cold injury and disease infections.
- ✓ Prune during dry weather conditions to reduce the risk of spreading pathogens.
- ✓ Plan before you prune. Consider the long-term impacts of pruning cuts on the tree's productivity and growth.
- ✓ Pruning encourages shoot growth in the vicinity of the cut due to reduced competition for resources.
- ✓ Excess pruning can cause excess vigour and potentially delay fruit production on young trees.
- ✓ Remove undesirable shoots early to prevent the tree from wasting energy on them. Early removal reduces the need for large diameter cuts that may be prone to canker disease.
- ✓ Prune/train young trees at planting to develop a healthy root system and encourage tree growth and development. Delays in training and pruning can reduce shoot growth and have a negative impact on tree development.
- ✓ Excessive or poorly-timed pruning on young trees can lead to reduced root growth and delays in tree growth and fruit production.
- ✓ Keep branches with wide-angled crotches (45°–60°). Remove branches with narrow angled crotches as they won't support heavy crop loads and may break.
- ✓ Remove broken, dead, infested or diseased branches that can be susceptible to infections. Burn diseased wood to remove inoculum.

- ✓ Remove undesirable shoots based on the training system. Generally shoots that have upright growth (water sprout), are drooping, unproductive, crowded or large vigorous branches are not desirable. However, upright shoots may be preferred in some training systems (Upright Fruiting Offshoot or UFO). For additional information on the UFO system, refer to *Chapter 6, Training and Pruning Cherry Trees*.
- ✓ Remove branches ‹60 cm (23 in.) above the ground to allow for orchard management (herbicide sprays).
- ✓ When removing branches use close, clean cuts that heal quickly and avoid leaving stubs that encourage decay and canker.
- ✓ Use renewal cuts on single leader systems to remove old unproductive wood and stimulate new productive fruiting wood. Stub cuts are used to generate new fruiting wood or to slow the spread of disease (i.e., bacterial canker in sweet cherries and fire blight in pear production).
- ✓ Remove root suckers as they take nutrients and energy from the tree. Suckers may also uptake herbicides which can be translocated into the trunk, potentially stunting its growth and delaying fruit production.
- ✓ The removal of large branches has a greater impact on tree reserves than removing many small branches with an equal number of growing points (buds).

Selecting a Training System

Consider the following factors when selecting an orchard training system.

Growth and Fruiting Habits

Choose a training system that compliments the natural tree growth and fruiting habits (upright, drooping, etc.). The system must develop adequate fruiting wood each year to ensure high yields of good quality fruit throughout the orchard's lifespan. For information on growth habits of tender fruit trees, refer to the individual commodity chapters.

Tree Vigour

When selecting a training system, consider the vigour of the trees. Balancing vigour with fruit production is essential to achieve high yields of top-quality fruit. Tree vigour determines how easily the tree can be manipulated to form the desired shape and density of the training system. It is affected by the training system, cultivar, rootstock, soil conditions (nutrient and water), climatic conditions (temperature and light) and pruning practices. Some high density training systems such as the Tall Spindle Axe — referred to in Chapter 2, *Training Systems Used in Tender Fruit Production* — require low vigour trees to optimize yields and fruit quality. Planting vigorous trees too close together can result in overcrowding and poor light distribution.

Size-restricting rootstocks can be used to help manage tree vigour and allow for high density plantings. Note that vigorous cultivars grown on size-restricting rootstocks may still be too vigorous for high density plantings.

Training systems such as the Bi-Axis, multi-leader system also help manage tree vigour. Adopting closer tree spacing (medium to high density orchards) can also help reduce tree size.

Economics and Labour

Orchards are long-term investments and it is important to consider the costs and returns of using a training system prior to planting an orchard. Table 1 compares some of the factors to consider.

Table 1. Cost Comparison Associated with Training Systems

Factor	Low Density	High Density
Costs of Establishing Orchard	Lower costs, as they require: • fewer trees/acre • no supports/trellis • less labour in the early years of the tree as less training is required • less water as there is less competition between trees so irrigation may not be as critical • minimal equipment requirements	Higher costs, as they require: • higher number of trees/acre • extra costs for trellis • increased labour in the early years due to need for additional training • irrigation is more critical due to increased competition between trees • additional equipment costs (platforms etc.)
Labour Costs (pruning, thinning, harvest)	Higher costs, as a result of: • large tree size that require ladders for harvest	Lower costs, as a result: • smaller trees (that do not require ladders to maintain) or are compatible with mechanization (platforms)
Costs for Agricultural Inputs (fertilizers, pesticide sprays)	Higher costs as a result of: • larger trees that require greater amount of agricultural inputs • more land requirements (to accomodate larger sized trees	Lower costs as a result of: • smaller trees that require less agricultural inputs • efficient land use
Return on Investment	• Lower yields per acre, but more fruit per tree • Less impacted by frost due to the size of the tree • Fruit quality is lower as there is less light distribution in the dense canopy • Delayed fruit production	• Lower yields per tree, but greater fruit per acre • More impacted by frost due to small size of the tree (cold air close to ground) and trellis systems which can impede airflow • Open and uniform canopy means greater light distribution, higher fruit quality, more uniform fruit maturation and fewer picks at harvest • Potential higher returns from markets, larger fruit size and higher packouts • Early fruit production
Knowledge	• Less knowledge required	• Higher costs, as they require more intensive management in the early life of the orchard • Lack of management can result in orchards that are not profitable • Requires re-educating orchard managers and workers on new training and pruning techniques • Trees are closer together so there is more potential for spread of disease between trees

CHAPTER 2

Training Systems Used in Tender Fruit Production

Orchards are long-term investments and choosing the right training system is essential to ensuring a profitable orchard that has maximum sunlight interception, high yields and good fruit quality.

There are many different training systems used in fruit production and the crop (growth and fruiting habit), soil type, irrigation, tree spacing, rootstock, grower experience, management practices and climatic conditions all contribute to the success of the training system. More detailed information on the various training systems used for each crop can be found in each commodity chapter in this guide. The information in this chapter will provide general guidelines on pruning fruit trees to the various training systems.

Pruning Terminology

The following terminology is used in pruning fruit trees. Refer to Figure 8 for the key parts of a fruit tree.

Feathered trees: Trees have a dominant straight leader, 3–10 feathers (branches produced the same year as the leader) with good crotch angles (45˚–60˚), that are well distributed on the leader.

Whips: Trees with poor quality branches can be whipped by removing all the side branches to stimulate the production of new shoots. Some training systems may have specific requirements for shoots and angles which are not commercially available and may require whipping trees to stimulate the production of appropriate shoots.

Narrow crotch angles: Narrow crotch angles less than 40˚ are weak, prone to splitting and susceptible to winter injury, canker and borers. Optimal crotch angles for fruit trees are 45˚–60˚ as they will support strong limbs.

Planting good quality trees results in earlier cropping and early returns.

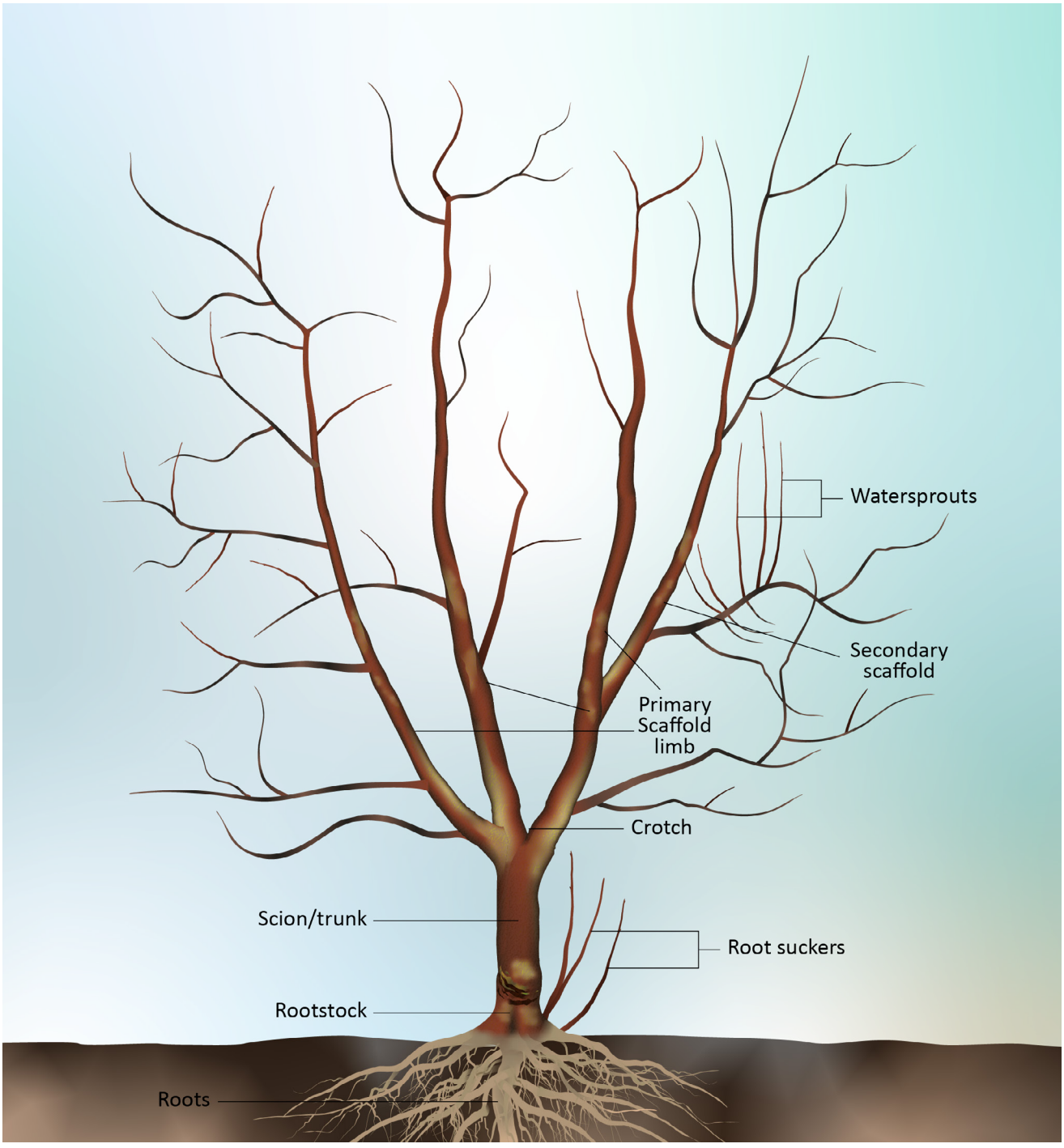


Figure 8. Key parts of an Open Centre training system on fruit tree.

Training Systems Used in Tender Fruit Orchards

Open Centre/Open Vase System

The Open Centre training system (Figure 9), has traditionally been used in peach production and develops a tree with low spreading canopy that allows more light exposure in the top of the tree. This system produces a large vase-shaped tree with 3–5 primary scaffolds spaced evenly around the tree, extending outward and upward at a 45˚–60˚ angle from the main trunk.

These primary scaffolds develop secondary and tertiary scaffolds. Tree spacing is low density. This system is often used in peach, nectarine, plum and cherry orchards.

Planting

After planting, head the leader back to 20 cm (8 in.) above the first side shoot. Remove all shoots below 50 cm (20 in.) and branches with narrow crotch angles (less than 45˚ from the trunk). Head back the remaining shoots to 2 buds. If needed, use clothespins to increase crotch angles.

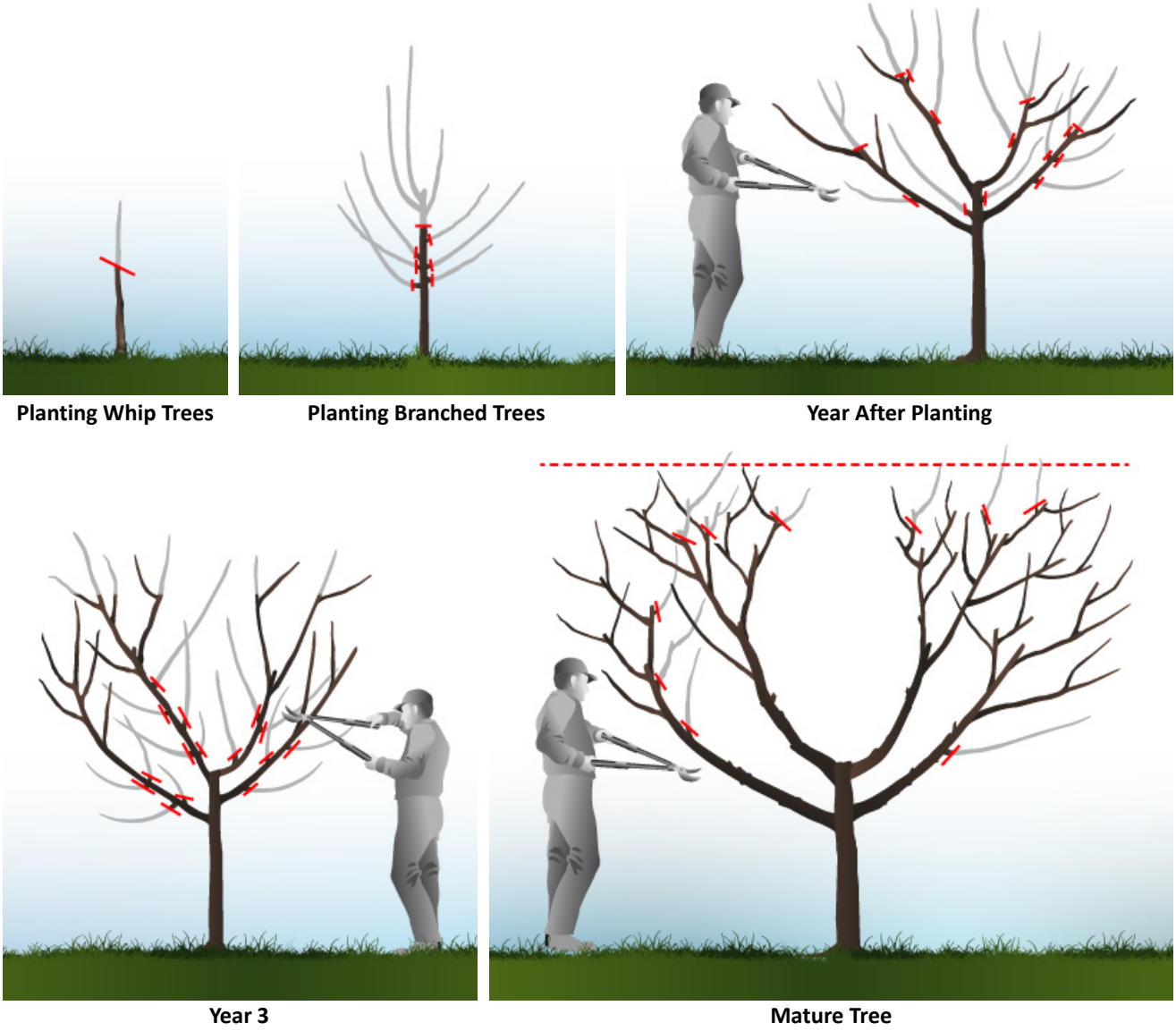


Figure 9. Pruning an Open Centre training system produces a tree with 3–5 scaffolds.

Summer prune to remove branches that grow below 50 cm (20 in.) or have narrow crotch angles. Remove shoots that grow within 10 cm (4 in.) from the trunk on each branch — to lessen the chance of canker infection close to the trunk.

Year After Planting (Year 2)

In spring, select 3–5 limbs on the main trunk with wide crotch angles to become scaffolds and remove any additional shoots. Selected branches should have wide crotch angles, be evenly spaced around the tree and have similar vigour. For trees with 3 scaffolds, limbs should originate at approximately the same height, but be staggered up the trunk by 3 cm (1 in.). If more than 3 scaffolds are selected, the shoots should be separated by at least 40 cm (16 in.) to prevent them from growing together. Limbs that grow together are more susceptible to canker. Avoid selecting branches that face directly into the prevailing wind (usually southwest) as they are more susceptible to wind injury.

Head scaffold limbs by ⅓ to ½ to an outward growing lateral to encourage the development of strong spreading limbs. Remove all other branches and head the trunk to 76 cm (30 in.) to create an open centre. Thin out shoots growing on the scaffolds that are less than pencil sized. Summer pruning in July can be used to improve light penetration into the tree centre.

Year 3 and 4

Remove crowded limbs or low hanging, shaded branches and branches that grow into the interior of the tree. Remove any shoot growth below the scaffolds and from the crotch area of the scaffolds to reduce the risk of limb breakage and minimize the risk of canker infections. Head back main scaffold limbs to laterals if they are too high. Fruit will be produced on 1-year-old branches that should be spread uniformly throughout the tree. Thin fruiting shoots to a spacing of 10–15 cm (4–6 in.) apart on the limbs to reduce overcrowding. Retain fruiting shoots that are pencil thick, 5 mm (0.2 in.) in diameter, grow horizontally and are 30–46 cm (12–18 in.) long, as they produce the best fruit size and quality.

Prune to maintain the vase shape and prevent limb breakage. Remove: shoots growing into the interior canopy, crowded shoots and vigorous upright branches. Head back limbs to encourage the development of new fruiting wood. Thin out and shorten limbs to avoid shading in the interior canopy.

Mature Tree

Manage tree height to 2.1–2.7 m (7–9 ft) by cutting back limbs at the top of the tree to an outward growing lateral branch. Maintain the open centre to improve air circulation and light penetration into the interior canopy. Remove vigorous and upright branches on the trunk and scaffolds. Prune to manage the crop load.

Other Crops

Prune plums and tart cherries lightly for the first 5 years to avoid removing branches that would bear fruit. Tart cherries require longer trunks for mechanical harvest, so trees should be headed at 91 cm (36 in.) from the ground at planting and selected scaffolds should be 71–91 cm (28–36 in.) above the ground to facilitate mechanical harvest. Use renewal cuts and leave a 10–15 cm (4–6 in.) stub to renew fruiting wood in tart cherry trees.

The Quad-V System

The Quad-V system (Figure 10) produces a vase-shaped, pedestrian tree with four evenly spaced primary scaffold limbs that are approximately 90˚ apart (two on each side of the alleyway). Fruiting shoots develop off the primary scaffolds. Tree spacing is medium density. The Quad-V system has been used successfully on peaches and nectarines. The addition of a trellis to this system helps improve fruit uniformity, yields and makes the system more compatible with the use of string thinners improving labour efficiency.

Planting

Heading height depends on the tree caliper, (i.e., diameter). The heading height is generally 45–60 cm (18–24 in.) above the ground. Remove branches below

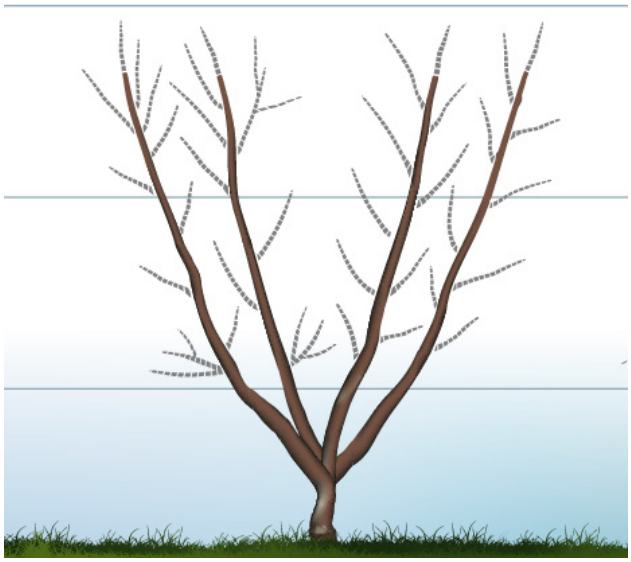


Figure 10. Quad-V training system on peaches. Trees have four permanent scaffolds, with 2 scaffolds on either side of the alleyway.

38 cm (15 in.), weak feathers and branches with narrow crotch angles. Select 4 shoots, on each side of the tree facing the alleyway (8 shoots total). Shoots should have wide (45˚) crotch angles on each side of the tree (8 shoots total), facing into the alleyway and head them back to 2–4 viable buds. Remove additional shoots. Allow the selected shoots to grow 25–30 cm (10–12 in.), then head the shoots in half. Continue to remove upright branches and branches below 38 cm (15 in.) during summer pruning.

Year After Planting (Second Leaf)

During the spring, select 2 permanent scaffolds per side (4 total), from shoots that are 45–60 cm (1.5 to 2 ft) above the ground and that are evenly distributed around the tree at different compass points, with 25˚–30˚ angles between the two limbs on each side. Remove all other shoots. Side branches on the selected scaffolds should be thinned to create a single axis. Remove water sprouts, broken, branched and/or diseased shoots. Remove shoots growing into the interior canopy to maintain an open center. Early in the season, install 2.1 m (7 ft) bamboo poles to train scaffolds to 24˚–30˚ angles from vertical. Secure bamboo to scaffolds with duct tape at 2–3 locations. Use twist ties to secure the bamboo to new limb growth.

Continue to remove water sprouts that grow into the interior of the canopy and any shoots where the terminal bud formed at the end of the first leaf. Thin out fruiting laterals on the scaffolds to manage the crop load and create a single axis. Remove shoots that are vigorous, poor quality or overcrowded. These laterals will produce fruit in the third season. Do not allow the trees to fruit until the third season so the canopy can grow and fill its space.

Year 3 (First Year of Fruit)

During dormant pruning, manage the crop load on trees by removing fruiting shoots. Select 10 fruiting laterals per scaffold and remove the other branches. Assuming there are 2 fruit laterals and fruit diameter is 7–8 cm (2.75–3 in.), there should be 5.7–6.8 metric ton/acre (250–300 bu/acre) of peaches.

Year 4 and Mature Trees

After trees have filled their space, manage tree height by cutting back limbs at the top of the tree to an outward growing shoot. Leave 15 fruiting laterals per scaffold with 2 fruit laterals during pruning. This should result in 9.5–10 metric ton/acre (400–425 bu of fruit acre). Adjust the number of laterals based on markets, tree vigour and cultivars — early cultivars should have fewer fruit to help with fruit sizing. Trees without irrigation may require fewer fruit to attain marketable fruit size.

Summer pruning in July involves removing upright shoots and side branches that are older than 1 year. Retain shoots that are 25–45 cm (10–18 in.) long with a diameter of 6 cm (0.25 in.) and shorten secondary branches back to the first fruiting lateral. Maintain tree height to 3 m (10 ft).

Notes

Quad-V training systems produce pedestrian trees. Research suggests that allowing the trees to grow taller, and using a trellis for support, can reduce frost injury and increase yields per acre.

The Hex-V System

The Hex-V system (Figure 11) creates vase-shaped trees with 6 primary scaffolds, 3 scaffolds on either side of the alleyway. Fruiting shoots develop off the primary scaffold branches. Tree spacing is medium density. This system has been used successfully on peaches and nectarines. This system can produce pedestrian orchards or larger trees with the support of a trellis.

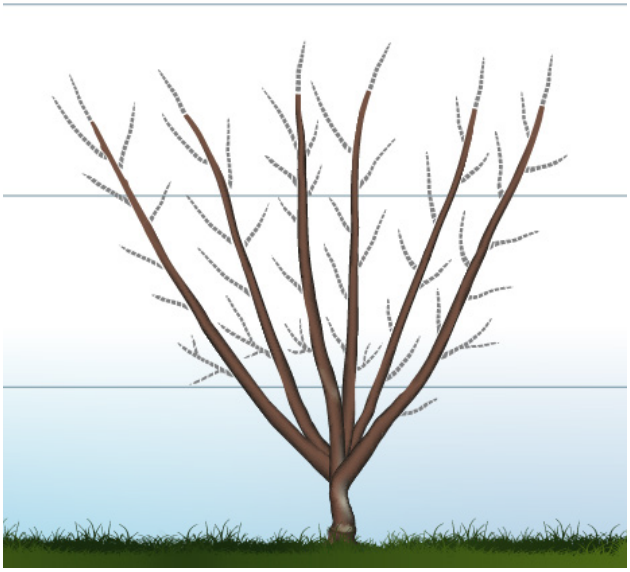


Figure 11. Hex-V training system on Peaches. Trees have 6 permanent scaffolds, with 3 scaffolds on either side of the alleyway.

Training and pruning trees to the Hex-V system is similar to the Quad-V, however, 3 scaffolds (6 scaffolds total) are selected on either side of the alleyway instead of 2 scaffolds. Hex-V is a medium density system and requires a trellis to support the scaffolds. The use of a trellis improves fruit uniformity, yields and makes the system more compatible with the use of string thinners improving labour efficiency. This system works well with trees with an upright growth habit such as peaches and European plums.

Central Leader System

The Central Leader system (Figure 12) creates a main trunk (central leader) with scaffold limbs spaced evenly around the trunk creating a Christmas tree (pyramid) shape. Tree row spacing varies depending on the commodity. This system is used for pears, sweet cherries and European plums.

Figure 12. Central Leader pear tree.

Planting

Remove shoots below 45 cm (18 in.). Head the central leader of poorly feathered trees at 66 cm (26 in.) to stimulate branch development. If the tree is well feathered, head the leader 30 cm (12 in.) above the top branch. If feathers are of poor quality, remove the feathers and stimulate better quality branches. Stake trees shortly after planting.

After a few weeks, shoots will emerge below the cut. Select a vigorous shoot to be the central leader (tree trunk). Pinch off 2–3 competing buds below it. Remove any flowers that form.

After 5–10 cm (2–4 in.) of new growth select 3–4 branches to become lower scaffolds. Selected branches should be 20–30 cm (8–12 in.) apart, well distributed around the central leader. Branches should not be directly above or across from each other.

The lowest branch should be 60–66 cm (24–26 in.) above the ground. Remove all other branches that are below 60 cm (24 in.), which compete with the leader, crowd scaffolds and those with narrow angles.

Cut the selected branches back to ⅓ or ½ their length, keeping their lengths equal. Branches should be spaced several inches apart on the trunk and not be directly above or next to each other. Limb spreaders and clothespins can be used on developing shoots when the branches are 10–15 cm (4–6 in.) long to develop wide branch angles to spread the scaffolds to near horizontal.

In mid-July, remove vigorous shoots that compete with the central leader. Tie the developing leader to the stake. Remove clothespins.

In the fall, tie the trunk of the tree above the first layer of scaffolds.

Year After Planting and Year 3

If there are less than 3 acceptable scaffold limbs, remove all the limbs and head the tree at 91 cm (36 in.) and repeat the training conducted in the first year. Create a second tier of scaffold limbs with wide crotch angles by selecting 3–4 branches that are at least 60 cm (24 in.) above the top branch of the lower tier, allowing sunlight to reach the lower part of the canopy. Upper branches must be kept shorter than lower branches to prevent shading, creating a Christmas tree like shape. Remove side shoots that are more than ⅓ to ½ of the diameter of the trunk where they meet. Dwarf trees will need only 2 tiers of branches, while semi dwarf will need 3. Repeat the process where necessary to create a third tier.

Subsequent Years

The central leader needs to remain the tallest part of the tree, so remove any side branches that get too tall or compete with the central leader. Once the central leader reaches the desired height, maintain the tree height by cutting the leader back to a weak side branch. Remove weak, upright and drooping shoots. For more information refer to Figure 12.

Modified Central Leader System

The Modified Central Leader training system (Figure 13) is a combination between the Central Leader system and Open Centre system. The tree is initially trained as a central leader tree producing a tree with 2–3 tiers of scaffold limbs attached to a central trunk. However, the central leader is removed in the third or fourth year, once the scaffolds have been established. Removing the leader helps round the top of the tree and manage tree heights to 2-3 m (7–10 ft). This system is used for cherry and pear trees.

Notes

For sweet cherry, use only use 1-year-old whips with a trunk diameter of 15–22 mm (½–¾ in.). Promote branching on limbs of young sweet cherry trees that grow over 1.8 m (6 ft) by heading them back. During the first growing season use clothespins on lateral shoots that are 7–10 cm (3–4 in.) in length to widen angles to 60˚. Tart cherry pruning is similar to sweet cherry, however do not head tart cherry trees in year 1. In year 2, when selecting the 4 first tier scaffold limbs, the lowest scaffold should be 60–76 cm (24–30 in.) above ground to allow for machine harvest.

Figure 13. Modified Central Leader peach tree.

Tall Spindle Axe System

The Tall Spindle Axe (Figure 14) creates a pyramidal tree shape that promotes good light distribution, early fruit bearing and high yields of premium quality fruit. The system produces a single leader tree, freestanding tree with a spiraled whorl of moderately vigorous lateral branches. This system requires a dwarfing rootstock to help maintain the tree height as semi-pedestrian orchard. Tree spacing depends on vigour. This system has been used successfully on sweet cherries and pear trees, with slight differences in pruning practices between the crops. The following information outlines training for sweet cherry.

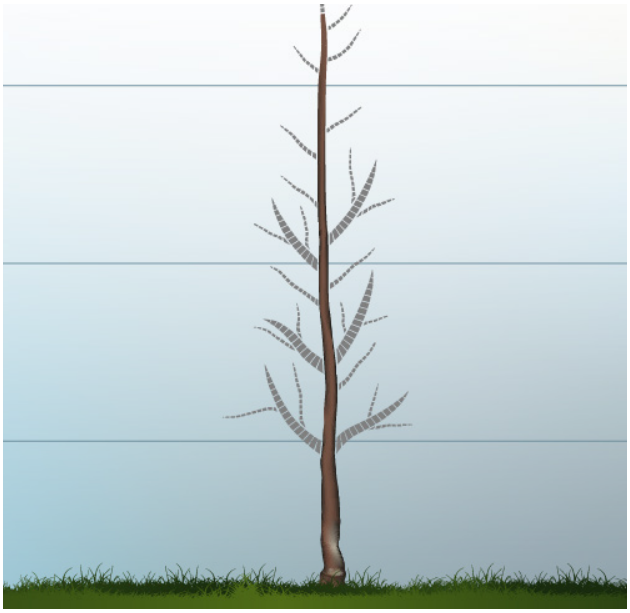


Figure 14. Tall Spindle Axe System.

Planting

Do not head nursery trees at planting. Remove all lateral branches (feathers) by cutting them back to the most basal (bottom) vegetative bud. Remove all buds <0.5 m (1.5 ft) off the ground. Keep the most terminal healthy bud on the central leader. Remove 5 buds below the terminal bud, leave a bud and continue this process by selecting a bud every 10–11 cm (4–4.5 in.) apart on the trunk of the tree, removing the buds in between. Selected buds should be activated to stimulate shoot formation. Buds can be activated by using cytokinin gibberellin based plant growth regulator (Promalin) on the buds — or by scoring/cutting the bark above the selected buds from bud swell through bud break — or removing intervening buds. Activated buds will develop shoots and the resulting tree will have a continuous whorl of shoots around the leader. During the first growing season when new laterals are 8–10 cm (3–4 in.) long, use a clothespin to adjust crotch angles to nearly 90˚. Remove clothespins after 2–3 weeks. Aim for 8–12 well distributed lateral shoots on the trunk with moderate vigour by the end of the season. Develop at least 65% of the final leader height.

First Dormant Season

If 6 or more branches did not develop in the first year, cut back the branches to stimulate branching. If 6 or more lateral branches were produced last year, the branches should be headed (past the two side orientated buds at the shoot terminal) to remove 15%–25% of their length. This will fill out the canopy and start balancing crop load for third year and beyond. Remove less wood on weaker shoots and more on stronger shoots.

If terminal leader growth was 1.2 m (4 ft) or more, it should be headed back to about 0.9–1.2 m (3–4 ft). Treat the new section of the leader (that grew in last year) the same as the nursery leader at planting with respect to bud removal, selection and activating buds.

Year After Planting

Use clothespins to develop good crotch angles of new lateral shoots off the leader in year 2. Some precocious rootstocks might have a small amount of fruit this year. Develop 8–12 additional well distributed primary branches. Develop 15–20 well distributed secondary branches that are moderately vigorous and uniform in size. Aim to develop 90% of the final tree height and fill 65% of the trees allotted space.

Second Dormant Season

Focus on stimulating secondary and tertiary lateral shoot formation and managing future cropping capacity. Maintain good canopy light by thinning laterals.

Continue bud selection and activation on the leader until the tree has reached its mature height (usually by year 3 at the latest). Head most lateral shoots again, to remove 15%–25% of the previous season's shoot length growth. Remove overlapping shoots, weak shoots, downward growing shoots and upright shoots to maintain good light distribution. Maintain the Christmas tree conical shape by leaving branches in the lower portion of the canopy longer than in the middle or upper portions.

Year 3 and Subsequent Seasons

After the leader has reached its final height (year 3), head it back to a weak lateral shoot just below the preferred tree height. This can be done at 4–6 weeks after budbreak or post-harvest (mid-summer) to minimize regrowth. First commercial harvest begins in year 3.

When fruiting branches are 5–6 years old, cut back the largest 2–3 branches to a 20 cm (8 in.) stub to renew fruiting wood. Maintain tree height at 3–3.6 m (10–12 ft) for easy harvest.

Note

This system works best with dwarfing rootstocks. Plant feathered trees with a trunk caliper of 1.5 cm (5/8 in.). Tree height should be limited to 2.7–3 m (9–10 ft) tall.

Slender Spindle System (or Super Slender Axe)

The Slender Spindle system (Figure 15) produces a small, cone-shaped tree with a permanent central vertical leader and a series of semi-permanent branches spaced along its trunk. The system can be used in higher density plantings and requires a post for support. Alternatively smaller stakes or bamboo can be used if supported by a trellis system. This system has been used for pear and sweet cherry.

Figure 15. Slender Spindle system used in apple production.

Planting

Large feather trees with 3–7 weak, short branches (feathers) about 76 cm (30 in.) up the trunk work best with this system. After planting, remove all feathers that are less than 60 cm (24 in.) above the ground or too vigorous. Retain branches with wide crotch angles (nearly 90˚). Cut back any feathers longer than 40 cm (16 in.) by ¼ to ⅓ of their length. If less than 4 well-spaced feathers remain, remove all the feathers using an angled cut that is wide on the bottom to encourage latent buds to grow a limb. The tree can then be treated as though it were a whip.

Head the leader 20–25 cm (8–10 in.) above the highest retained feather. When the shoots that emerge below the heading cut are 7–10 cm (3–4 in.) long, select one to become the leader and remove any competing shoots. Use a stake or a trellis to support the tree. Tie down the feathers and secure the tree to the trellis. Remove fruit to allow trees to establish and grow. When planting whips, head the trunk of the tree at 80–90 cm (31–35 in.) from the ground to induce branching at 76 cm (30 in.) from the ground.

Winter After Planting

Trees planted as whips can be pruned as a feathered tree (see above). If feathered trees were planted, retain 4–5 limbs with wide

crotch angles to develop a permanent layer of fruiting branches in the lower part of the tree, approximately 66–101 cm (26–40 in.) above ground. Branches should be arranged around the tree so none are directly above one another. Use clothespins, ties or weights to improve crotch angles to 30˚–45˚ above horizontal as necessary.

Several vigorous shoots should have developed from buds on the leader below the heading cut. Choose the new leader by making a thinning cut into 2-year-old wood, just above one of the weaker growing lateral branches that will become the future leader. The thinning cut will remove several of the highest lateral shoots. Bend the new leader (highest remaining lateral shoot) into a loop by fastening the tip to the support stake leader. Buds, along the top surface of the horizontally-oriented section of the shoot (the section at the bend), will develop into upright shoots during the next growing season. This process is repeated into 2-year-old wood each year and results in zigzagging of the central leader that slightly restricts growth in the top of the tree and allows the bottom of the tree to develop first.

Years 2–4

Proceed with tying and pruning as in previous years. Vigour control is largely dependent on positioning limbs horizontally and early cropping.

In the summer, tie limbs as needed to keep them above horizontal. Remove shoots that are too upright or too vigorous in July or August or use spreaders and weights to reposition them. Summer pruning will not suppress tree vigour but may improve light penetration into the tree.

Each winter, select a new leader by cutting into a weak lateral on 2-year-old wood and zigzag by looping (see section *Winter After Planting*). Remove upright vigorous shoots and excessive branches.

Mature Trees

By the fifth or sixth year, trees should be at the top of the support stake and 2.4 m (8 ft) tall, have filled in the space between the trees and form a conical shape. Maintain the maximum tree height at 2.4–3 m (8–10 ft) by replacing the leader with a side limb each winter. Cut the leader at a weaker side limb, tying the limb into position on the support post as a replacement. Do not head the replacement leader shoot.

All limbs above the bottom layer of branches are temporary limbs and should be removed using a dutch cut once the branch diameter is half the diameter of the trunk at the point of attachment.

The dutch cut is an angled cut that leaves a larger stub at the base of the cut than the top, which stimulates buds on the underside of the stub to develop into limbs with wide crotches and replace the vigorous limb that was removed.

Removing the largest branches in the tree top each year ensures this area remains narrow to allow good light distribution throughout the tree. After a few years of fruiting, the lower branches will droop with the weight of a crop. Shorten these branches with thinning cuts to a slightly upright side branch. Tie up branches as needed during the summer to keep fruit off the ground.

Bi-Axis System

Bi-Axis training (Figure 16) creates a tree with two parallel leaders (axes) with renewable branches coming off these leaders. This system helps manage tree vigour and produces a narrow planar fruiting wall with fruiting wood developing close to the leader. Bi-Axis systems can also be used to increase the total number of leaders per acre, allowing high density production with fewer trees.

The Bi-Axis system helps increase light exposure resulting in improvements in fruit size, quality and uniform fruit maturity. This system increases labour efficiency by managing tree height and promoting the development of a thin canopy that is compatible with mechanization and/or robotics to reduce labour costs.

The Bi-Axis system requires a trellis for support. Tree spacing is high density. This training system has been used effectively on pear and peach trees.

Planting

Head back trees to 50 cm (20 in.) above ground, then raise two side shoots which will become leaders (axes). Equalize the vigour between the two leaders (axes) by taking the most vigorous leader and make two scores, deep enough to cut into the xylem and phloem, one on each side of the leader 7.5–10 cm (3 to 4 in.) apart and 20–30 cm (8–12 in.) away from the trunk. Leaders should be at least 30 cm (12 in.) apart and optimally 46 cm (18 in.) apart with a crotch angle of 30˚–40˚ at planting.

It is important that the two leaders are equally strong, to prevent one from taking over and becoming a central leader. Vigour can be evened out while the orchard is being established by cropping the more vigorous leaders to reduce the height. When vegetative growth starts, the two axes will be in the direction of the row, resulting in a flat and narrow canopy with a depth of 70 cm (28 in.).

The Bi-Axis system requires a trellis for support and the leaders are tied to trellis wires, spaced 70 cm (28 in.) apart. Use plastic wires in the trellis to reduce rubbing and decrease the risk of bacterial canker infections. Short, uniform and renewable fruiting branches emerge from the two leaders. Tree height is kept at 3 m (10 ft) by heading the leaders.

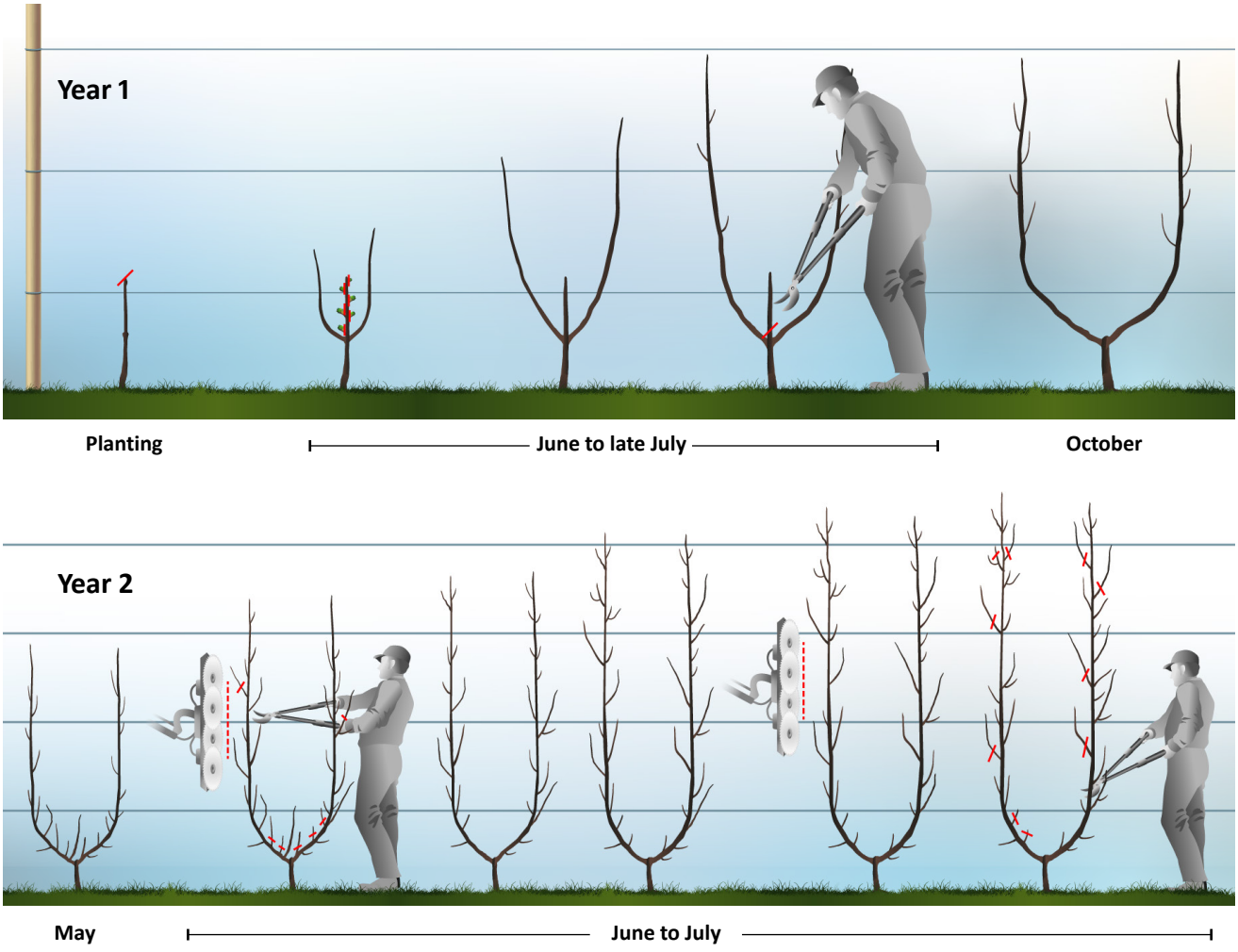


Figure 16. Bi-Axis System. Adapted from Iglesias et al, 2023. *Peach Tree Architecture: Training Systems and Pruning*.

Notes for Pear Bi-Axis system:
This system works well for managing tree vigour in pear orchards. When training for a Bi-Axis system in pears, plant trees as whips and head back at 50 cm (20 in.). Head back a second time above the selected axis 20–30 cm (0.6–1 ft.). Click pruning can help maintain the cropping zone close to the trunk. Pruning is used to remove shoots that are too vigorous and branches oriented to the inside. At the end of the year there should be at least 2 m (7 ft) of new growth.

Upright Fruiting Offshoots

The Upright Fruiting Offshoots (UFO) system (Figure 17) produces a tree with a permanent single horizontal trunk (cordon) and multiple renewable fruiting leaders that are grown vertically which complement the natural growth habit of the tree.

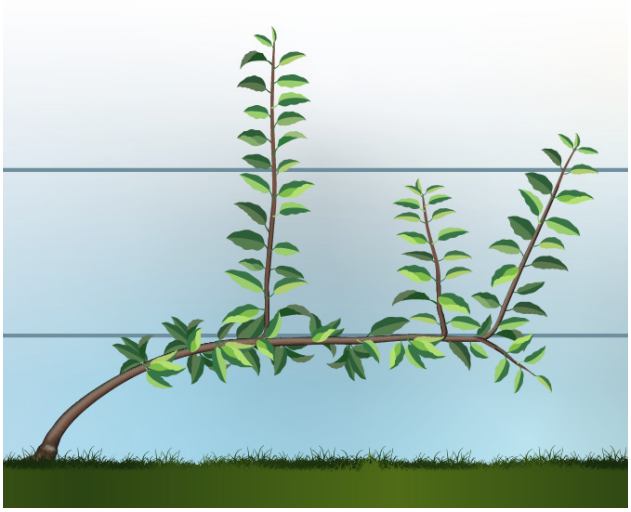


Figure 17. Upright Fruiting Offshoots (UFO) system on sweet cherry.

This system creates a narrow fruiting wall that is early bearing, productive and simple to maintain and manage crops. The UFO system can be used to establish a pedestrian orchard, but higher yields can be achieved by maintaining the tree height about 20% taller than the between row spacing. Tree row spacing for the UFO system depends on the rootstock and the number of upright shoots desired. This system produces a high density orchard and requires a trellis to support trees. This training system is used for sweet cherry trees.

Planting

Use un-headed whips for this system, which may require extra communication with the nursery. Don't plant trees vertically, plant trees at a 45˚ angle pointing the terminal (tip of the tree) to the south to minimize sunburn on the trunk during establishment.

Clip or tie the trunk where it intersects the lowest wire 51 cm (20 in.) above ground to maintain the proper angle. Use thinning cuts to remove any feathers. Rub off all buds below the first trellis wire. Use bud activation techniques (see *Tall Spindle Axe System*) on upper buds about every 20 cm (8 in.) (UFO) to stimulate vertical shoot formation.

First Growing Season

Remove any shoots that form below the first trellis wire. In the spring evaluate growth uniformity on vertical shoots, keep shoots that are relatively uniform and have moderate vigour. Head any excessively strong shoots to a stub of 5 cm (2 in.) with several leaves to promote regrowth as dual shoots that are less vigorous.

When new shoots at the terminal end of the leader are 31 cm (12 in.) or longer, remove the initial clip, bend the leader to the lowest wire and place the clip further along the trunk so the leader orientation is slightly above horizontal. Do not bend the trunk below the lowest wire.

If the trained tree exceeds its allotted tree spacing, train the terminal end as a vertical shoot. In mid-summer, use a thinning cut to completely remove any bull shoots (excessively vigorous growth).

First Dormant Season

If there are more than 1 shoot/20 cm (8 in.) along the leader, thin the weakest or most vigorous shoots. Remove any shoots growing below horizontal from the leader. Clip or tie shoots vertically to the second wire (UFO).

Second Growing Season

If there are fewer than 1 shoot/20 cm (8 in.) along the leader, use bud activation techniques on upper-facing buds to promote the development of shoots to fill in the gaps. Continue to tie or clip, upright shoots to trellis wires as the shoots grow. Use thinning cuts to remove shoots growing below the first trellis wire.

In late spring, evaluate growth uniformity of new vertical shoots — head any excessively vigorous shoots to a 5 cm (2 in.) stub to promote the production of new dual shoots that will be more balanced in vigour. In mid-summer, thin to remove excessively vigorous upright shoots. Aim for balanced upright growth of 61–76 cm (24–30 in.) for each vertical shoot by the end of the season. Fruit will be produced along the horizontal scaffold and the base of previous seasons vertical shoots. Flowering spurs begin to form in year two with cropping in year three, which will help manage vigour as the trees fill their space in years 3–5.

Second Dormant Season

If there is more than 1 shoot/20 cm (8 in.) along the leader, thin out the weakest or most vigorous shoots to increase light in the canopy. On highly productive cultivars, remove all lateral shoots on upright leaders with thinning cuts to manage fruit production. With moderately productive cultivars, remove all lateral shoots on upright leaders with stub cuts, leaving 3–7 buds at the base of the lateral shoots for fruiting. This removal of shoots can also be done at summer hedging at 4–6 weeks after harvest. Continue to tie or clip upright shoots to wires.

Third and Subsequent Growing Seasons

As the upright shoots grow, tie or clip them to vertical trellis wires. Maintain 1 shoot/ 20 cm (8 in.), by removing excess shoots or excessively vigorous shoots using thinning cuts after harvest. Promote balanced upright growth of 60–76 cm (24–30 in) per leader.

Trees should be topped manually or mechanically (hedged) at a height ratio of about 1.1–1.2 times the row spacing. In an orchard with 3 m (10 ft) tree spacing, trees should be maintained at 3.3–3.5 m (11–12 ft). Topping trees 4–6 weeks after harvest will reduce vigour in the top of the tree, resulting in minimal regrowth and reducing the amount of dormant pruning required to maintain the fruiting wall height.

Select one or two of the largest upright branches for renewal each year. None of the vertical branches on the tree should be more than 6–7 years old. Remove the selected branches with a stub cut during or just prior to bloom, leaving 1–2 nodes for regrowth. As new uprights are generated from renewal cuts, manage them using the same rules when establishing the system. On highly productive varieties, remove all lateral shoots on upright leaders with thinning cuts. With moderately productive varieties, remove all lateral shoots on upright leaders with stub cuts (i.e., leaving 3–7 buds at the base of the lateral shoots). The short stubs that are retained will bear fruit and should be removed after harvest.

Note

The removal of lateral shoots growing into the alley can also be done by summer pruning or mechanical hedging approximately 4–6 weeks after harvest. Follow-up removal of lateral shoots growing between trees in the row can be done when trees are dormant.

CHAPTER 3

Training and Pruning Peach Trees

Peaches and nectarines belong to the same species and pruning is essentially the same. Similar to other fruit crops, the objective for training and pruning peaches is to develop and maintain a tree architecture that will enable efficient production of high yields of premium quality fruit. Some unique characteristics of peach trees such as growth and bearing habit, susceptibility to cold injury and peach canker diseases and labour requirements all have a significant impact on training and pruning practices.

Profitable peach orchards produce high yields of large, premium-quality fruit to meet market demands. To maximize an orchard's productivity, it is critical to:

- ensure tree survival (cold injury, pest and disease)
- balance vigour and fruit production
- optimize light distribution to improve fruit size and quality
- achieve early yields
- sustain high yields through the life of the orchard
- minimize labour costs

Traditionally peach orchards are grown on low density training systems that produce large trees with dense canopies which are labour intensive to manage, slow to produce

fruit and have considerable variation in yields and fruit quality throughout the tree canopy if not managed properly.

Research suggests that new training systems can allow for more efficient use of land, improved fruit quality, higher labour efficiency and increased yields per acre. While North American growers have slowly started to use new training systems for peaches, there has been greater adoption of these systems in South Africa and Italy.

Growth and Fruiting Habits of Peach Trees

Understanding the growth habit of the tree — and where the flowers and fruit develop — are important when selecting a training and pruning system.

Peach trees are vigorous and have upright spreading canopies that work well with the Open Centre training system commonly used in peach orchards. The Modified Central Leader system produces an upright tree that works well with the growth habit of select peach and nectarine cultivars and has been used successfully in some Ontario orchards.

Training systems that alter the tree architecture to manage tree vigour and produce smaller trees (Quad-V, Bi-Axis), provide the opportunity to plant medium to high density peach orchards. These systems provide early and increased yields, reduced labour costs (mechanization and pedestrian orchards), better light and spray distribution, and improved fruit quality.

Size restricting rootstocks (Figure 18) that show promise in managing tree vigour and facilitating higher density peach plantings are

Vigorous 110–120%	Standard Vigour 90–110%	Semi-Dwarf 60–90%	Semi-Dwarf ‹60%
Bailey	Lovell*	Controller™8*	Controller™5*
Nemaguard*	Krymsk ®86	Controller™7*	Krymsk®1*
Guardian*	—	Controller™6*	Rootpac®20*
Rootpac®70*	—	Rootpac® 40*	MP-29*
—	—	*Empyrean® 2* (Penta)*	—
—	—	*Empryean® 3* (Tetra)*	—

* Indicates rootstocks which are not currently available commercially in Ontario.
"—" = Not Applicable
Note: Sizes are based on comparison of the Lovell rootstock that is commonly used in the United States. Vigorous trees are 100–120% the size of Lovell. Semi-dwarf trees are 60–90% of Lovell trees and Dwarf rootstocks produce trees that are ‹60% the size of Lovell.

Figure 18. Peach rootstocks and their vigour classification. Adapted from Anthony and Minas, 2021.[1]

being evaluated in the United States, but are not yet commercially available in Canada. Training systems also play an important role in managing tree vigour. For more information on the impact of training systems, refer to Chapter 1, *Training and Pruning Tender Fruit Trees*. Tree spacing has a significant impact on tree vigour and managing tree size. The higher the tree density the greater the competition between trees, resulting in smaller sized trees. Cool summers and cold winters can reduce tree vigour and have a negative impact on yields. Fruit size and yield per tree can also decline with increasing density in peach orchards — but yield per acre increases due to the high number of trees. As a result, peach orchards should have trees no closer than 1.2–1.5 m (4–5 ft) apart within a row and 3.7 m (12 ft) between rows to minimize the negative impact on fruit size.

It takes 3-4 years for peaches to start bearing fruit with full production in the fifth year, which results in a delayed return on investment.

Peach trees have two types of buds — vegetative (leaf) and fruit (flower). Vegetative buds are small and pointed. Flower buds are larger, rounder and hairy (Figure 19).

Peach flower buds are simple and produce 1 fruit per bud. Buds develop during the summer at the base of leaves (nodes) on the current seasons growth. A single leaf bud along with 1–3 fruit buds develop at each node. The terminal bud at the end of a shoot is always vegetative and produces a leafy shoot. Fruit buds at the base of a shoot often open slightly later than fruit buds elsewhere on the shoot.

Figure 19. Buds on 1-year-old peach shoot. *Note:* The narrow pointed bud in the middle will produce leaves and large round buds on either side will produce fruit.

Peach trees begin producing fruit in their third year and only bear fruit on 1-year-old-wood or wood that was produced in the last season. Training and pruning systems that develop 1-year-old wood and minimize older unproductive wood are optimal for peach production.

Annual shoot growth of 30–60 cm (1–2 ft.) per year is needed to produce the appropriate number of fruit buds for next year's crop. However, annual shoot growth of more than 0.6 m (2 ft), will shade the lower and interior canopy. This reduces fruit production in the lower part of the tree and shifts fruit production to the top of the tree, resulting in increased labour costs at harvest. Additionally, excess growth can make trees more susceptible to canker infections and winter injury.

The number and distribution of flower buds on a shoot varies with the size of the shoot, cultivar, crop load and the light conditions during shoot development. Shoots that are <20 cm (8 in.) generally have the most fruit buds per inch of growth but produce small fruit as there are too few leaves to support the growth of fruit.

The ideal fruiting shoot is 30–60 cm (12–24 in.) long, pencil thick (5–6 mm in diameter) and has no secondary shoots (Figure 20). These shoots are the most productive and produce the largest sized fruit. Long shoots that are branched produce fewer fruit buds. Heavy crop loads reduce the number of fruit buds produced on the basal (bottom) third of the current season's shoot. Shoots in low light conditions develop fewer flower buds. Cold injury or frost can kill flower buds reducing yields.

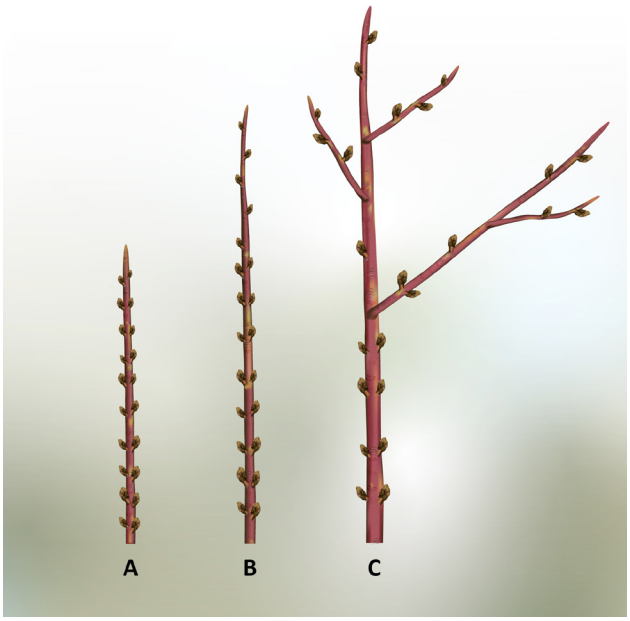


Figure 20. Length of shoot and density of fruit buds on peaches. (A) Short shoots less than 20 cm (8 in.) long have a high density of fruit buds, but produce small fruit. (B) Shoots 30–61 cm (12–24 in.) produce the largest sized fruit.
(C) Long-branched shoots that are >61 cm (24 in.) in length produce fewer flower buds. Adapted from *Pruning Peach Trees*, Virginia Tech.[7]

Light and Peach Production

Adequate light penetration into the interior canopy of the tree is crucial for obtaining consistently high yields and uniform fruit maturation throughout the tree. Shading results in more picks at harvest, poor fruit size and quality. The timing of the light exposure has a significant impact on the peach tree's response:

- Shoots must be exposed to light during June and early July for maximum flower bud development for next year's crop. Pruning after this time will not improve flower bud initiation or development.
- Shading in the orchard canopy in the last six weeks before harvest has a negative impact on fruit size (Table 2), red colour development, sugar levels and firmness. Shading at this time also increases preharvest fruit drop. Maintaining an open canopy throughout the season, is important in producing large, high quality fruit.

Training and pruning systems impact light interception and distribution within the tree. For more information on the impact of training systems on light distribution in the canopy refer to Chapter 1, *Training and Pruning Tender Fruit Trees*.

Pruning to Manage Crop Load

Similar to other fruit crops, managing the crop load (number of fruit per tree) is important in peach production to ensure good fruit size and quality. Crop load management is also important to prevent limb breakage on peach trees. Peach trees typically only need to set 10% of the flowers that develop each year.

Pruning helps manage crop loads by removing excess shoots and reducing the number of flowers (fruit) per tree. Removing

Table 2. Effect of Shade During Final Swell on Average Peach Fruit — by Weight (g/fruit)

	Time of Shade (Days Before Harvest)		
Percentage of Sun	**44–20 Days**	**20–0 Days**	**44–0 Days**
100	148 g	153 g	160 g
45	150 g	140 g	130 g
23	142 g	138 g	135 g
9	145 g	159 g	143 g

Note: A fruit weighing 130g is about 6 cm (2.5 in). in diameter.
Adapted from Marini, 1991.[8]

fruit buds early in the season (bud swell to fruit set) reduces the amount of resources allocated to unwanted fruit, resulting in improved fruit sizing earlier and more uniform fruit maturity. Thinning fruit earlier in the season (pre-bloom) has more benefit on fruit size. Pruning reduces fruit set and the amount of time required to hand thin fruit.

When pruning to manage crop load on mature peach trees, start by determining the optimum yields per acre based on the market and cultivar. Markets determine the optimal fruit size, which in turn impacts optimal yields.

Note
Early-season cultivars produce smaller fruit and typically require lower crop loads (retain fewer fruiting buds per acre) to help improve fruit size. Orchards without access to irrigation may need to leave fewer shoots per acre (fewer fruits per acre) to ensure adequate fruit size.

Pruning can be used to manage crop loads in any training system, however it is more accurate to obtain preferred yields on systems that are simple and uniform (i.e., Hex-V, Quad-V or Bi-Axis) as compared to systems with dense canopies (Open Centre system). The following is an example of how to estimate pruning requirements to obtain a set yield on a Quad-V training system.

Calculating Crop Load Management

Early Cultivars — Small-Sized Fruit
If the goal is to produce 6 ton/acre (12,000 lb/acre) or 36,000 fruit/acre:

- 242 trees/acre that would mean leaving 149 peaches/tree.
- On a Quad-V system with 4 scaffolds/tree = 37 fruit/scaffold.
- Shoots are generally hand thinned to retain 2 peaches/fruiting lateral. As a result 19 laterals should be retained on each scaffold on the tree.

Medium to Large Sized Cultivars — 8cm (3 in.) Sized Fruit
If the goal is to produce 10 ton/acre (20,000 lb/acre) or 60,000 fruit/acre:

- 242 trees/acre that would mean leaving 247 fruit/tree.
- On a Quad-V system with 4 scaffolds/tree = 61 fruit/scaffold.
- Shoots are generally hand thinned to retain 4 fruit/shoot. As a result 16 fruiting laterals should be retained on each scaffold on the tree.

When pruning to manage crop load, remove excess or poor-quality fruiting wood first. Maintain shoots that are 30–60 cm (12–24 in.) and pencil thick in diameter.

As a general rule remove branches that have poor light, inadequate foliage or fruiting shoots that are <20 cm (8 in.) long as they will produce small sized fruit.

Pruning and Cold Injury

Peaches are susceptible to cold injury and Ontario's climate has a significant impact on pruning decisions. Cold injury can result in reduced yields, death of shoots/limbs and tree mortality. Factors such as cultivar, tree health, tree age, phenology and intensity and length of cold event all impact the temperatures trees can withstand (cold hardiness). Winter injury to fruit buds occurs when temperatures drop below -22˚C killing fruit buds and reducing yields. Temperatures below -26˚C can damage vascular tissues in twigs or branches of peach trees and can kill the entire tree. Cold-injured peach trees are also more susceptible to perennial canker, a destructive disease that can kill branches or trees. Spring frosts at bud swell and beyond can kill fruit buds or blossoms, reducing or eliminating the crop resulting in increased vegetative growth (vigour).

Peach trees are relatively short-lived, with a lifespan of 15–18 years, significantly less compared to other fruit crops. The reduced lifespan is primarily due to cold injury and perennial canker disease. Pruning practices can make peach trees more susceptible to cold injury. Pruning strategies affect how quickly the trees recover from cold injury.

Pruning tips to reduce the risk of cold injury in peaches:

- ✓ Avoid excessive pruning — or pruning from August through November as it will delay cold acclimation in trees until mid-winter (February).
- ✓ Pruning temporarily reduces cold tolerance. Delay pruning if cold temperatures are predicted in the next 48 hours, even at the pink stage of development.
- ✓ Prune peach trees from bud swell through fruit set to reduce the risk of cold injury and canker.
- ✓ Excessive and relatively low vigour are associated with reduced cold hardiness. Prune trees moderately to manage vigour and reduce the risk of cold injury.

Tips on pruning peach trees after cold injury:

- ✓ Always prune cold injured trees in the spring. Delaying pruning until after fruit set or pruning trees early can cause increased stress on already weakened trees.
- ✓ Trees with reduced yields (due to frost or winter injury) often produce excess vegetative growth, leading to dense canopies and increased shading in the lower canopy. If trees are left unpruned the fruit production will shift to the top of the tree, resulting in higher labour costs.
- ✓ Prune cold injured trees moderately – remove no more than a quarter of the tree's branches and avoid making big cuts on the lower part of the scaffolds. Do not excessively prune cold injured trees to reduce the tree height, as this can cause additional stress to the trees. Reducing, but not eliminating, nitrogen applications in orchards with cold injuries can help manage vigour and moderate the need for pruning.
- ✓ Cold injured buds or wood can be a point of entry for peach canker and insects, so it is important to remove damaged wood.

Pruning to Prevent Cankers

Perennial canker (also known as *Cytospora* canker or *Leucostoma* canker) (Figure 21) is one of the most destructive diseases of peach, nectarine, sweet cherry, apricot and plum trees. Canker is most damaging to young orchards where it can cause tree death. In older orchards, trees gradually lose productivity and slowly decline as individual scaffold limbs are girdled by the canker and eventually killed.

Figure 21. Perennial canker on the trunk of a peach tree. Note gumming and cracking of bark. Cankers must be removed from tree, resulting in reduced productivity.
Photo: Dr. Wendy McFadden-Smith

The causal fungus (*Leucostoma* species) overwinters in cankers and dead twigs, exuding spores throughout the year that infect the woody tissue of stone fruit through weak, dying or dead tissue or unhealed wounds.

The most common infection sites are pruning cuts, leaf scars, shade-weakened twigs in tree centres and winter-injured wood. Infection sites exude gum initially and then the canker forms a small necrotic centre that slowly enlarges with the collapse of the inner bark tissue. Once established, the fungus continues to grow and expand into adjacent healthy tissue that are encircled by annual callus rings.

Canker formation on scaffold branches inhibits movement of nutrients and water, resulting in symptoms of nutrient deficiencies, wilting and dieback of twigs on that branch. Canker development on the trunk can cause rapid death of the entire tree.

Remove canker infections by cutting the branch at least 15 cm (6 in.) below the canker whenever possible. Cankers on trunks and large limbs can be surgically removed in June or July when trees heal most rapidly. For more information on stone fruit cankers, refer to the ministry's Crop IPM site.

Pruning Peaches

The guidelines for pruning fruit trees apply to all fruit crops, see Chapter 1, *Training and Pruning Tender Fruit Trees* for more information.

Peaches have some specific pruning requirements as follows:

- ✓ Prune from bud break to fruit set to reduce the risk of winter injury and susceptibility to canker infections. Pruning after shuck split can reduce tree vigour and increase winter injury.
- ✓ Prune during warm, dry weather to reduce the risk of canker infections.
- ✓ Peach limbs are prone to breakage. Train young trees early to develop scaffolds with good crotch angles (40˚–60˚ from horizontal) that can withstand heavy crop load without breaking.
- ✓ Annual training and pruning can minimize the need for large cuts that are more susceptible to canker infections.
- ✓ Thin shoots to open the tree canopy by removing problematic shoots that are upright, drooping, crowded or unproductive.
- ✓ Use thinning cuts to remove older branches and stimulate the production of 1-year-old fruiting wood to ensure future fruit production.
- ✓ Remove all weak, diseased, infested and dead wood to minimize the risk of canker infections. Burn diseased wood to remove inoculum. Remove and destroy fruit mummies (dried up fruit hanging on the tree) to reduce inoculum.
- ✓ Remove small branches ‹20 cm (8 in.) and long shoots ›45 cm (18 in.). Retain shoots that are pencil thick ‹6 mm (0.25 in.) and 25-45 cm (10-18 in.) long.
- ✓ Make collar cuts that will seal off pruning wounds and reduce susceptibility to infections. Avoid making flush cuts (that are as close as possible to the trunk or main branch) that create a large wound.
- ✓ Maintain an optimal tree height to reduce shading. Optimal height will vary with training system (refer to Chapter 2, *Training Systems Used in Tender Fruit Production*).
- ✓ Aim for 0.50 m (2 ft) of growth on trees per year to ensure adequate fruit bud production.

Summer Pruning

Summer pruning involves the removal of water sprouts and shoots from the canopy in June or July. Summer pruning helps open the interior canopy to increase light penetration and improve fruit size and quality. Pruning at

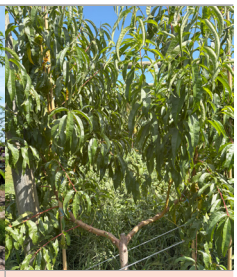
this time also helps air circulation and spray coverage resulting in improved cold hardiness and reduced disease pressure (canker, brown rot and powdery mildew).

Summer prune young trees to maintain the desired shape of the tree and reduce the number and size of pruning cuts needed the following year. Pinch or rub off vigorous or upright water sprouts while still succulent (within 6 weeks of bud break). Early shoot removal can be done easily by hand before the base of the shoot has hardened (lignified). After the base of the shoots have lignified use hand pruners to remove shoots. Summer pruning completed before late July increases the development of fruit buds. Avoid late season summer pruning (after mid-August) as it can delay the onset of dormancy and cold acclimation.

Training Systems Used in Peach Orchards

There isn't a perfect production system for peaches. Each grower must identify the training system that best suits their orchard. Table 3 provides a comparison of selected training systems used in peach production.

Table 3. Comparison of Selected Training Systems Used in Peach Orchards

					
System Attributes	**Open Centre or Open Vase (OC)**	**Central Axis (Fusetto, Tall Spindle Axe, Super Spindle Axe)**	**Hex-V (HV)**	**Quad-V (QV)**	**Fruiting Wall Dual Leader (e.g. Bi-Axis)**
Tree Structure	3 or 4 primary scaffolds, secondary and tertiary scaffolds	1 central trunk with 2–4 permanent scaffolds in the lower part of the tree and numerous renewable branches on the upper part.	6 evenly spaced primary scaffolds, 3 on each side, fruiting wood forms directly off scaffolds	4 primary scaffolds, 2 on each side, fruiting wood forms directly off these scaffolds	2 main axis (leaders) that are parallel along the row, fruiting wood forms directly off these leaders
Canopy Information	Large tree (2.2–2.5 m tall), free standing tree with dense canopy	Large tree (2.5–3.5 m tall), free standing, medium density canopy, narrow cone shaped trees	Pedestrian tree, (2–2.5 m or taller) with trellis, uniform open canopy, manages tree vigour	Medium sized (2.5–3 m tall), free standing, however trellis may help support the tree, uniform, open canopy, manage tree vigour	Fruiting wall, uniform open canopy, multiple leaders help manage tree vigour.
Rootstock	Vigorous	Semi-vigorous work best, however vigorous rootstocks can be used to help control vigour of the tree	Vigorous to semi-vigorous	Vigorous to semi-vigorous	Semi-dwarfing to dwarfing are optimal, standard rootstocks can be used.
Mechanization Suitability	Minimal, limited to top hedging	Partial (top and side hedging, some blossom/fruit thinning	Partial (top and side hedging, some blossom /fruit thinning)	Partial (top and side hedging, some blossom /fruit thinning	Extensive (top and side hedging, blossom/ fruit thinning)

Adapted from Manganaris et al, 2023[6]
Source: (Photo: Open Centre) Jim Schupp, (Photo: Bi-Axis) Leslie Huffman.

continued ››

Table 3. Comparison of Training Systems Used in Peach Orchards *(continued)*

System Attributes	Open Centre or Open Vase (OC)	Central Axis (Fusetto, Tall Spindle Axe, Super Spindle Axe)	Hex-V (HV)	Quad-V (QV)	Fruiting Wall Dual Leader (e.g. Bi-Axis)
Light Exposure	Poor light distribution in the interior canopy and lower part of the tree, if not managed properly	Good	Good	Good	Good
Fruit Quality Fruit Size/Yield	Less uniform fruit colouring and maturation Large fruit even in dry seasons, wide distribution of fruit sizes If not managed properly yields may be reduced due to shading	Higher yields than OC and QV Higher crop load may result in smaller fruit size than OC and QV Fruit size is smaller than OC and QV	High fruit colouring and quality, large fruit size High yield, good fruit quality	Smaller fruit size Similar yields to OC, good fruit quality	Closer tree spacing can result in reduced yields per tree, but also increase yields per acre, fruit quality is excellent
Tree Density	Low to medium, 220–550 trees/ha	Medium to high, 1250–2000 tree/ha Fusetto 1500–2445 tree/ha Super Spindle Axe	Medium 750 trees/ha	Medium 900–1000 trees/ha	High 900–2000 trees/ha Increasing the # of leaders per tree can be used to increase the total number of leaders per hectare with less trees, reducing establishment costs
Pruning Decisions	More complex so require more time to train workers	Increased labour costs for pruning to maintain tree shape and fruiting wood Majority of fruit can be harvested without ladders	Simple pruning, reducing time required to train workers Summer pruning is beneficial but not required	Simple pruning, reducing time required to train workers Summer pruning is beneficial but not required	Majority of fruit can be harvested without ladders, reducing labour costs
Early Production/ Yields	No Trees take longer to fill their space Tree mortality has a greater impact on yields/acre	Yes Minimal impact to yields if branch is infected with canker (large # of branches) Greater risk of tree mortality if trunk is infected with canker	Yes High yield efficiency	Yes High yields per acre High yield efficiency	Yes High yields per acre High yield efficiency
Comment	Less impacted by frost due to large tree size Lower establishment costs	Fruit is produced closer to ground so more vulnerable to frost	Fruit is produced closer to ground so more vulnerable to frost	Fruit is produced closer to ground so more vulnerable to frost	Fruit is produced closer to ground so more vulnerable to frost Use plastic wire when using a trellis to reduce the risk of cankers from metal wires damaging wood

Adapted from Manganaris et al, 2023[6]

« previous

CHAPTER 4

Training and Pruning Pear Trees

Pear trees take up to 7 years to get into full production, resulting in a delayed return on investment. Pear trees are vigorous and early training and pruning are critical to establish tree structure, regulate vegetative growth, promote early fruit production and consistent yields throughout the life of the orchard.

Pruning mature trees helps minimize over-crowding and shading, resulting in better fruit quality and higher yields. Pruning and removing old unproductive wood stimulates the production of new fruiting wood and helps to maintain orchard productivity throughout its lifespan. Pruning is also a valuable tool in managing fire blight — a devastating bacterial disease that can damage tree limbs, kill trees or destroy an entire orchard in a season.

Traditionally, Ontario pear orchards were planted in low densities, using an Open Centre system that produced tall trees that were labour intensive to maintain. Over the past decade, pear growers have been shifting towards planting high density pear orchards that work well with the upright growth habit of pear trees, produce fruit earlier and have high yields of premium quality fruit. The adoption of high density pear orchards requires a change in training and pruning strategies to help keep trees in their allotted space, reduce crowding, increase light interception and renew fruiting wood to ensure an orchard is productive throughout its life.

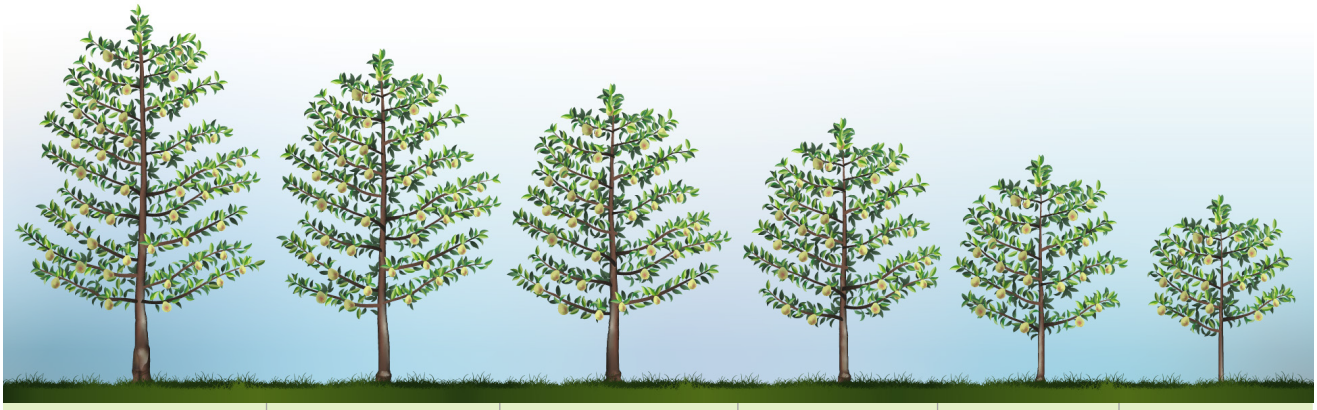
Growth Habit and Fruiting

Understanding the growth and fruiting habit of a pear tree is critical when deciding how to prune for optimal harvest and selecting the best training system for your orchard.

Pear trees are vigorous and have strong apical dominance resulting in branches that tend to grow straight up with fewer lateral branches. Managing apical dominance and tree vigour in young trees is critical for early fruit production and obtaining high yields of fruit.

Some pear cultivars are prone to producing more blind wood — an area of the branch without buds, usually located near the base of the branch — that reduces the tree's overall productivity. Training and pruning pear trees to maintain optimal branch angles is critical in reducing blind wood and ensuring high quality fruiting wood in pear trees.

High density pear orchards require training systems that work with the upright growth habit of the trees and manage tree vigour to keep it in its allotted space and minimize shading (Bi-Axis, Spindle). Additionally, size restricting rootstocks (Figure 22) are used in European pear orchards to help manage vigour and provide the opportunity to manage orchards from the ground (pedestrian orchard). Many of these rootstocks are incompatible with the cultivars grown in North America (Bartlett and Bosc) and often lack the cold hardiness required for Ontario's climate. While researchers continue to evaluate new size controlling



Seedling >100%	Vigorous 91–100%	Semi-Vigorous 71–90%	Semi-Dwarf 61-70%	Dwarf 40–60%	Very Dwarfing <40%
P. betulifolia seedling*	Bartlett seedling*	OHxF 97	OHxF 87	Quince EMC*	Amelanchier*
—	—	—	Pyrodwarf*	Quince EMA*	—
—	—	—	Pyro 2–33*	Quince C132*	—
—	—	—	OHxF 69*	—	—

* Indicates rootstocks that are not commercially available in Ontario.
"—" = Not Applicable.
Notes: Sizes are based on comparison the Bartlett seedling rootstock. Semi-standard vigours trees are 71-90% the size of Barlett seedlings, semi-dwarf rootstocks are 61–70% of Bartlett seedling and dwarfing rootstocks are <60% the size of Bartlett. In North America the most common rootstock is OHxF 97 (Old Home Farmingdale).

Figure 22. Impact of rootstocks on tree height and vigour.
Source: Adapted from *Rootstocks for Pear*, Washington State University.

pear rootstocks (Amelanchier, Pyrodwarf)[3] for use in North America, growers in Ontario manage tree vigour by using training, pruning, fertilization and tree competition (high density plantings). In Europe, root pruning is used to manage tree vigour by cutting roots to reduce the uptake of water and nutrients. For additional information, refer to the *Root Pruning* section in this chapter.

Pear trees produce two types of buds:

Terminal buds — located at the tip (end) of long shoots, 10 cm (>4 inches) or on short <10 cm (4 in.) stubby shoots — called spurs that develop on branches that are 2 year's or older (Figure 23). Terminal and spur buds both produce clusters of 5–8 flowers and a similar number of leaves. Pears flower and fruit primarily on spurs. Bourse shoots are vegetative shoots that emerge from spurs and do not bear fruit, but impact fruit production as they initially compete with developing fruit for resources, but later can aid fruit growth by providing carbohydrates.

Lateral buds — buds that form on the base of the leaf blades on 1-year-old wood and may produce new shoots or flower buds. Flower buds that develop often form smaller, poor-quality fruit. Usually lateral buds thicken and developing into a spur in subsequent years.

Figure 23. Fruit spur on pear.

Pear cultivars can be divided into three groups depending on where the fruit bud is produced:

- Spur bearing trees (Bartlett, Bosc, Sundown) are trees that produce fruit buds on spurs that develop along 2-year-old wood. Most cultivars are spur bearing.
- Tip bearing trees produce fruit buds at the tip (end) of long shoots (terminal buds) produced the previous year. They are not common in pear trees.
- Partial tip bearers produce fruit on the tips of the previous year's shoots and on some spurs.

When pruning trees, it is important to consider where the fruit is produced. For example, over pruning the tips (ends) of branches could remove most of the fruiting wood (and yields) on tip bearing varieties.

Pears produce the best quality fruit on 2-year-old fruit spurs. As fruiting spurs age (>3 years old), they become less productive and produce small and poor quality fruit. Flower buds that are produced closer to the trunk produce larger pears. Pear trees require adequate vigour to produce quality fruit. Renewal pruning is used to remove old unproductive wood and stimulate the production of new shoots that will become fruiting spurs in the future.

Pear trees take up to 7 years to get into full production. Training systems that manage tree vigour (Bi-Axis) and encourage fruit production early in life of the tree can increase grower returns over the lifetime of the orchard.

Pear Production and Light

Pear trees are very vigorous and will form dense orchard canopies that have poor light penetration if not managed properly. Training and pruning play an important role in managing the orchard canopy to increase

light distribution improving fruit production and quality. Refer to section *Influence on Light Levels in the Tree Canopy* in Chapter 1 for more information.

Pruning and Fire Blight

Fire blight is a contagious disease affecting apples and pears. Under optimal conditions for infection (hot, humid weather), fire blight can destroy an entire orchard in a single growing season resulting in considerable damage and economic losses in apple and pear orchards. The disease is caused by a bacterium, *Erwinia amylovora* (Burrill), that infects different parts of the tree including blossom, shoot, fruit, limb, trunk and collar (rootstock).

When infection occurs, the disease moves quickly through the vascular tissue into spurs and other succulent tissues (1- to 2-year-old wood), especially if accompanied by warm temperatures. Leaves and infected shoots wilt and turn brown or black and the infected shoots bend downward forming a shepherd's crook. Leaves do not fall off. As the growing season progresses, the spread of infection slows and cankers develop in the bark (Figure 24). The most severe injury from fire blight occurs when the disease progresses into the tree's older wood and can kill the tree. For more information, visit *Fire Blight in Pears* on CropIPM.

Fire blight moves from infected spurs or shoots into the main limbs and trunk of the tree when warm temperatures and high humidity combine to form ideal conditions for infections. The cankers that form in the older wood girdle the branch, killing healthy wood from that point outward by cutting off the transport of nutrients and water. Pruning is used to remove fire blight cankers (dormant) and remove infected shoots (during the season), reducing the spread of the pathogen. Improper pruning practices can cause the disease to spread through the orchard.

Figure 24. (A) Fire blight symptoms in shoots. (B) Canker on tree trunk.

Use the following guidelines when pruning for fire blight:[2]

- ✓ Prune as soon as fire blight symptoms are observed to reduce the spread of the disease and minimize the amount of damage and tree loss. A two-week delay in removing diseased tissue can result in a six-fold increase in the amount of infected branches/shoots that need to be removed.

- ✓ Make cuts 30–45 cm (12–18 in.) below visual symptoms to reduce the risk of canker re-formation and the spread of bacteria through the tree.
- ✓ Prioritize timely pruning over sanitizing pruning shears. Sanitizing pruning shears by dipping them in a bleach solution between pruning cuts has been considered an important practice to prevent the spread of fire blight infections. However, new studies show no benefit to sanitizing shears, provided pruning cuts are made at the recommended distance below canker margins.
- ✓ Fire blight infections in structural wood (central leaders and main scaffolds) create a challenge as removing these cankers will reduce tree productivity, but leaving cankers will provide a source of inoculum for new infections. 'Ugly stub cuts' that leave a 13 cm (5 in.) stub can be used to minimize the spread of cankers into structural wood. Small cankers will form on many of these cuts and must be removed during winter pruning.
- ✓ Prune fire blight infections on current season's growth instead of breaking them off by hand. Breaking diseased branches can increase the number of cankers in the orchard at the end of the season, increasing the risk of cankers developing on structural wood.

Dormant Pruning

Pruning is used for all fruit crops to maintain the tree structure to increase yields and tree longevity. The guidelines for pruning fruit trees apply to all fruit crops, see Chapter 1, *Training and Pruning Tender Fruit Trees* for more information.

Pears have some specific requirements as follows:

- ✓ Prune pear trees annually before growth begins and after the coldest weather has passed (February to March) to minimize cold injury. Prune during dry weather to reduce the risk of spreading disease.
- ✓ Consider tree vigour when pruning. Vigorous cultivars can be pruned more heavily than less vigorous cultivars. Prune vigorous trees — or those requiring large cuts last to reduce the risk of cold injury. Prune low vigour trees moderately to avoid reducing vigour and productivity.
- ✓ Excess pruning increases tree vigour and can make trees more susceptible to fire blight infections.
- ✓ In young trees (with Central Leader training systems) remove large branches that compete with the leader to ensure trees reach their full height and fill out their canopy. In the top of the tree remove large branches with a base diameter that is more than 30% of the trunk.
- ✓ Remove or stub large branches that create excess shading. Remove only 1–2 large branches/tree each year. Removing too many large branches at once will result in excess vigour the following year.
- ✓ Don't allow the leader or branches to weep downward as this prevents the tree from filling its space and reduces fruit production.
- ✓ Don't prune the leaders of pear trees until they have reached their maximum permissible height, based on the selected training system. Manage tree height to reduce shading by cutting back the leader to a lateral branch.
- ✓ Minimize blind wood by maintaining optimum branch angles (45° above horizontal for Bartlett). Branch angles can be adjusted by using clothespins, ties or weights when branches are 7.5–15 cm (3–6 in.) long. Remove branches that point downward and horizontal branches (90˚ from tree) as they are less productive.

- ✓ Click pruning can also be used to manage vigour and reduce blind wood.
- ✓ On mature trees, try to renew 10% of the branches each year so new fruiting wood is constantly being produced on the tree. Refer to *Renewal Pruning vs Click Pruning* in this chapter for more information.
- ✓ Promalin is a plant growth regulator that can be used to stimulate lateral bud break and develop new branches on young trees with optimal branch angles to improve tree structure. Refer to Plant Growth Regulators at ontario.ca for additional information.

Summer Pruning

Training and pruning young pear trees in the summer can help maintain the desired tree architecture and help trees quickly fill their space in the orchard. Summer pruning can also be used to manage fire blight, but must be done during dry, sunny weather to avoid spreading the disease. For more information refer to *Pruning and Fire Blight* earlier in this chapter and *Summer Pruning* in Chapter 1.

Renewal Pruning vs Click Pruning

Renewal pruning and click pruning are two methods used to maintain a large amount of high-quality fruiting wood for the life of the tree.

Renewal pruning is a technique used to maintain tree vigour and productivity. It involves selectively removing or heading back older unproductive wood (3-year-old) that will produce small, poor-quality fruit, stimulating the production of new productive shoots for future fruit production. Remove at least 1–2 large branches per year to help increase light levels in the canopy. Avoid removing too many large branches as it will result in excess vigour the following year.

Prune 2-year-old shoots based on tree vigour and the number of fruit buds. In vigorous trees, shoots can be pruned back to the ring dividing 1- and 2-year-old wood to increase fruit set. In low vigour trees with weak wood, avoid cutting into 2-year-old wood as it will reduce the number of fruit buds. Maintain 1-year old shoots that are 30–40 cm (12–16 in.) long, thick as a pencil 5 mm (0.2 in.) and are well spaced with wide crotch angles. Approximately ⅓ of the renewal wood should be 1-year-old, 2-year-old and 3-year-old. Renewal pruning helps to keep trees calm and maintain productive fruiting wood, and reduces biennial bearing. The renewal process is gradual, typically taking three years to rejuvenate trees.

Click pruning is a pruning technique used to manage tree vigour (high density plantings), reduce blind wood and promote fruiting spurs closer to the tree trunk. It involves making a heading cut (click) into 1-year-old wood, just above 2–3 regenerative buds on the branch. This cut removes the apical dominance of the shoot and increases sap flow to the buds, resulting in new growth close to the trunk resulting in improved fruit size and quality.

This type of pruning can be used to manage and enhance tree vigour of weak wood, such as the weak axis of multi-leader trees.

Additionally, click pruning can be used to manage blind wood and promote the production of spurs close to the trunk of the tree resulting in increased fruit production and improved fruit quality in cultivars such as Bartlett pear. Bosc pears produce most of their fruit on older wood and click pruning helps to encourage basal bud growth and reduce blind wood, which can be caused by standard pruning.

Root Pruning

There has been limited use of root pruning (Figure 25) in North American orchards, but the practice has been widely used in European pear orchards to restrict root growth and canopy size in ultra high density pear orchards. Root pruning has also been shown to promote return bloom and fruit set in the subsequent year.

Figure 25. Root pruning a pear orchard.
Source: Matt Peters, Provide Agro.

Root pruning involves cutting the roots of fruit trees by dragging a cutting blade (50 cm or 20 in. long) though the soil. The blade is mounted at an angle to sever tap roots, leaving feeding hair roots that are closer to the surface less affected. Root pruning is done when the trees are dormant (prior to 6 weeks before budburst) and must be done on both sides of the tree. Reducing the amount of tree roots decreases the water and nutrient uptake by the tree, reducing shoot growth and tree vigour. The damaged roots regenerate over time, so root pruning is a short-term solution to issues with vigour.

The following outlines the risks and management involved with root pruning:

- ✓ Removing too many roots can harm or kill the tree.
- ✓ Wounds from root pruning can be points of infection for fungi and bacteria (i.e., fire blight).
- ✓ Pruning too close to bloom can cause poor fruit set.
- ✓ Can cause tree stress — supplemental irrigation or fertilizer applications may be required to ensure adequate fruit sizing. Monitor trees closely to assess the need for amending irrigation and nutrition programs accordingly.
- ✓ Perform testing on small section of an orchard over a few seasons to understand its effect on tree growth and fruit production.
- ✓ Use root pruning in conjunction with other tools (training and pruning) to manage vigour. It's most effective if the block of trees is uniform in growth, crop load and tree vigour.

Training System Used in Pear Orchards

There are a variety of training systems for pears. Table 4 provides a comparison of selected systems used in pear production.

Table 4. Comparison of Selected Training Systems Used in Pear Orchards

			
System Attributes	**Central Leader**	**Slender Spindle (Super Spindle/Tall Spindle/ Fusetto)**	**Bi-Axis or Multi-Leader**
Tree Structure	1 trunk and 3–4 levels of scaffolds Conical shaped tree	1 central trunk and 2–4 permanent scaffolds in the lower part of the tree and numerous renewable branches on the upper part Conical shaped tree	2 main axis (leaders) that are parallel along the row and are kept free of large or long branches Fruiting wood forms directly off these leaders
Canopy Information	Free standing or with support system	Require stake at each tree or bamboo and trellis wire for support Open and uniform canopy	Creates a narrow fruiting wall Open and uniform canopy Requires a trellis for support
Rootstock	Semi-vigorous to semi-dwarfing, otherwise can be difficult to control vigour at top of canopy	Vigorous to semi-vigorous	Vigorous to semi-vigorous
Mechanization Suitability	Partial (top and side hedging, some blossom /fruit thinning)	Compatible with mechanization	Yes, thinning and pruning Costs for pruning may be greater if you don't have access to platforms
Light Exposure	Risk of shading in lower canopy if shape is not maintained	Light is good initially, but eventually it shades out the bottom of the tree	Good
Fruit Quality Fruit Size/Yield	Good quality, provided shape is maintained	Good	Good/uniform
Tree Density	Medium density 597 trees/ha	High density 1976–2965 trees/ha Tall Spindle	High density 1482–2965 trees/ha
Pruning Decisions	Needs regular pruning to maintain shape and spacing	High pruning costs	Simple Requires platform or ladders due to tree height
Early Production/Yields	Yields lower than high density systems	Yes, high yields	Yes, high yields
Comment	Slower to establish	Plant well feathered trees	Good vigour management

CHAPTER 5

Training and Pruning Plum Trees

The goal of training and pruning plums is to develop healthy trees that are easily harvested, have sufficient light to produce optimal fruit quality and good yields. Pruning is also a method of reducing the crop load when trees form too many flowers. Managing the crop load will reduce the amount of time spent fruit thinning and increase fruit size. Plums begin to produce fruit in year 3 and reach full production around 7 (European plum) to 9 (Japanese plum) years of age. Some varieties of Japanese plums are less winter hardy (Early Golden) and can be more susceptible to fluctuating temperatures in winter and early spring. Winter injury can kill flower buds and negatively impact yields. Tree trunks and branches can also be damaged or killed by cold temperatures.

Most plum varieties are very susceptible to black knot — a fungal disease that can girdle branches, reduce yields and reduce the lifespan of the tree. Pruning (and fungicides) play an important role in managing black knot in plum orchards.

Growth and Fruiting Habits of Plum Trees

Generally, Japanese plum trees are pruned to an Open Centre training system that works well with their vigorous spreading growth habit and prevents trees from growing to unmanageable height or into neighbouring trees.

In contrast, European plum trees are generally pruned and trained to a Modified Central Leader system that works well with their upright growth habit. Additionally, Central Leader systems have been tried with some success.

Researchers are looking at alternative training systems for plum orchards. The Hex-V or Quad-V system may work well for European plums and more upright Japanese plum varieties due to their growth habit. Training systems that produce fruiting walls have not been well researched in plums in North America, but are being used in other areas. Trellis systems can increase the risk of bacterial canker infections as limbs rub with metal wires, which can damage plum trees. If using a trellis system, consider using plastic wire to reduce the risk of canker.

Plum cultivars vary in their vigour and mature tree size, impacting the pruning and training system and tree spacing. Vigorous cultivars that have a spreading growth habit (Early Golden) often require additional spacing between trees. While vigorous cultivars that have an upright growth habit (Vanier) allow for closer tree spacing. In comparison, Shiro has medium vigour and a spreading growth habit.

There are few options available for rootstocks for plum trees and most lack size-controlling capabilities. Plum trees in Ontario are planted on Myrobalan rootstock, which produce large, vigorous trees, that require low planting densities. Research has shown that plum trees grown on Krymsk® 1 (a size-controlling rootstock) have poor survival rates in Ontario.

Plum rootstocks vary in the amount of root suckers they produce. Suckers must be removed for the health and productivity of the tree, resulting in increased pruning costs.

Japanese and European plum trees produce much of their fruit on lateral spurs that are 2 years or older. Spurs typically produce 1-3 flowers per bud. Many Japanese plum varieties set additional fruit on longer 1-year-old shoots. Fruit spurs on European plums are frequently branched and are longer and more slender than Japanese plums.

Buds can be found at both the apical tip of the branch or axillary position (between leaf axils) and may develop into leaves, shoots or flowers. Plums have fruit buds that produce 1–2 flowers and no leaves accompany the flowers. The number and distribution of flower buds varies with tree vigour, cultivar and light exposure when the shoot was developed. Moderately vigorous shoots have a high proportion of good flower buds.

Plums trees tend to be biennial bearing — trees that produce a heavy fruit crop one year will have very little, to almost no crop, the next year. Biennial bearing is regulated by plant hormones but can be reduced by managing the crop load through pruning and thinning.

Pruning for Black Knot

Black knot is caused by the fungus *Dibotryon morbosum*, also known as *Apiosporina morbosa*. It overwinters on infected trees and the hosts most commonly affected are plum, tart cherry and less commonly apricot, peach, nectarine, flowering almond and sand cherry. Disease spread between tart cherry and plum and vice versa, is highly unlikely.

The fungus produces infective spores (ascospores) that are released during rain events after bloom. Ascospores can germinate and infect new tissue during wet periods from April through June. Ascospores infect only the current season's growth. Young galls (green elongated swellings 2.5–30 cm (1–12 in.) long begin to form within 4 months of infection. They are typically located near the leaf axis of shoots in the summer, making them easy to miss the first year. The galls turn black the following year. Ascospores are not produced in knots until 2 years after infection occurs.

Black knot infections (Figure 26) affect the woody parts of the tree, so a severe infestation causes a yield reduction. Once established in an orchard, black knot is difficult to control on susceptible varieties with fungicides due to difficulties in finding and removing all knots.

Figure 26. Black knot infection.

Pruning Tips

- ✓ Prune and destroy knots during dormant pruning in the spring, prior to bloom, before knots are hidden by foliage and before new shoots can be infected.
- ✓ Always prune a minimum of 15 cm (6 in.) below the knot, as the fungus is present in limbs well beyond where the disease is visible.
- ✓ Knots can release ascospores to be spread by wind for up to 4 months after they are pruned off the tree. As a result, all infected branches should be burned to minimize the spread of the disease.
- ✓ Flail mowing cuts knots into small pieces and reduces ascospore release, helping to reduce inoculum. For more information, visit Black Knot in plums on CropIPM.

Canker Diseases

Cankers on plum trees are common and often occur after winter injury. Following winter injury, tissues can easily be invaded by the bacteria *Pseudomonas syringae pv. syringae* (Pss) and *P syringae* pv. *mors-prunorum* (Psm) that cause bacterial canker. These bacteria overwinter in cankers and can spread by rain splash, wind or insects. They also can be spread to healthy branches by contaminated pruning tools. Infections most often occur during cool, wet conditions.

Cankers begin to form in mid-spring and shoots may die back soon after. Brown spots develop on infected leaves, eventually turning into holes as the tissue falls out. Shoots may either fail to emerge or start to grow normally in spring before rapidly dying back.

Branch or trunk infections often occur at pruning sites and lead to the development of cankers (i.e., sunken, dead areas) that produce a gummy, resinous ooze and discoloured wood. Flower, fruit and branch infections can lead to twig dieback, death of larger branches or even death of an entire tree.

Pruning Notes

- ✓ Prune out and destroy infected tissues at bloom when trees are actively growing and are less susceptible to infections.
- ✓ Prune during dry weather when no rain is in the forecast. Make cuts 10 cm (4 in.) below visible cankers and sterilize tools between cuts. Do not leave stubs when pruning as they are prone to infections.
- ✓ Disease removal **should not** be done during regular pruning to prevent movement of the pathogen to healthy areas of the tree.
- ✓ When cankers occur on the trunk, removal becomes difficult without damaging the tree.
- ✓ Cankers that are less than half the diameter of the branch can be surgically removed by cutting an oval shape about 2.5 cm (1 in.) into the edge of the healthy bark surrounding the canker.
- ✓ Burn or flail mow infected wood to reduce inoculum.

Perennial canker (also known as *Cytospora* canker or *Leucostoma* canker) is a fungal canker disease that affects the branches and trunks of plum, peach, nectarine, sweet cherry and apricots. For more information on perennial cankers refer to section, *Pruning to Prevent Cankers* in Chapter 3 or visit *Perennial Canker of Stone Fruit* on CropIPM.

Dormant Pruning

Pruning is used for all fruit crops to maintain tree structure and ensure high yields and tree longevity. The guidelines for pruning fruit trees apply to all fruit crops, see Chapter 1, *Training and Pruning Tender Fruit Trees* for more information.

Plums have some specific requirements as follows:

- ✓ Pruning reduces cold hardiness in the weeks that follow, so prune in the spring (May or June) after the risk of cold temperatures has passed.
- ✓ Avoid pruning during cool wet periods to minimize canker.
- ✓ After cold winters, flower buds and wood can be cut to assess cold injury. Buds with brown centres are dead while those with green inside are alive. This information can be used when pruning to determine potential crop loads.
- ✓ Prune the tree no more than necessary to develop the tree's structure in the first 5 years. Pruning in the first few years removes branches that would bear fruit.
- ✓ Prune to remove branches that compete with the central leader (European plum) or crowd the interior (European and Japanese plum).
- ✓ Thin side branches so they are spaced several inches apart along the leaders.
- ✓ Renew fruiting wood (2-year-old spurs) by leaving some young shoots and removing old wood to help manage crop load and reduce thinning costs.
- ✓ Prune to manage crop load based on the variety. Varieties that set heavy crops require more extensive pruning of spur wood each year to reduce crop load and increase return bloom for the subsequent year.
- ✓ Avoid using heading cuts or tipping cuts as they create additional leafy shoots that require an additional year to bear flowers. Heading cuts can be used to shorten older branches or develop new scaffolds where needed.
- ✓ Manage tree height below 4.2 m (14 ft) for spraying and harvest. Prune back leaders by heading them to a strong upright side branch.
- ✓ Pruning to reduce spurs and shoots helps manage crop load.
- ✓ Generally pruning European plums involves using mostly thinning cuts to remove water sprouts or suckers and very little heading back is required.
- ✓ Avoid frequent or heavy thinning of shoots on young plum trees as it results in excess vigour. Remove suckers which compete with the tree.
- ✓ Remove diseased and cold injured wood to reduce the spread of disease. Remove mummified fruit to reduce the spread of Brown rot. For more information, visit Brown rot and Black Knot on CropIPM.

Summer Pruning

Research in Ontario has shown that summer pruning reduces yield and growth in European plum trees. Summer pruning is not recommended with European or Japanese plums.

Training Systems Used in Plum Orchards

There are a variety of training systems for plums. Table 5 provides a comparison of selected training systems used in plum production.

Table 5. Comparison of Selected Training Systems Used in Plum Orchards

			
System Attributes	**Open Centre or Open Vase**	**Modified Leader System**	**Central Leader**
Tree Structure	3 or 4 primary scaffolds, secondary and tertiary scaffolds	Central leader with 3–6 scaffold limbs Central leader is removed in 3rd or 4th year to encourage the development of several strong lateral branches	A single dominant trunk (central leader) with 3–6 scaffolds growing out from it, creating a Christmas tree like shape. Central leader with 3–6 scaffolds
Canopy Information	Large, free standing tree with dense canopy	Large, free standing tree with non-uniform canopy Tree size can vary depending on how the tree is pruned	Large, free standing tree
Rootstock	Vigorous	Vigorous	Semi-vigorous
Light Exposure	Poor light distribution in the interior canopy and lower part of the tree if not managed properly	Good	Good
Tree Density[1]	Low density 400–500 trees/ha	Low density 500–700 trees/ha	Medium 500–800 trees/ha
Comment	Works well with trees that have a spreading growth habit (Japanese plum)	Works best with trees with an upright growth habit (European plum)	Needs proper pruning to maintain fruiting wood

[1] Tree spacing is based on non vigorous rootstocks.

CHAPTER 6

Training and Pruning Cherry Trees

The acreage and production of sweet and tart cherries in Ontario has been declining over the past few decades. The tart cherry industry has been faced with challenging markets, reduced returns for growers and increased costs of production. The sweet cherry industry has faced challenging markets and inconsistent yields due to cold injury, spring frosts, bird damage and fruit cracking caused by heavy rain prior to harvest which leaves the fruit unmarketable. Sweet cherry production is labour intensive with labour costs accounting for 50%–60% of the total production costs.

Tart cherry production hasn't changed significantly over the past 20 years with the focus on developing orchards of large trees in low density plantings, that are compatible with the use of tree shakers for mechanical harvest (Figure 27). Mechanical harvest is damaging to tree trunks and branches making them more susceptible to pathogens and reducing the lifespan of the tree. Mechanical harvest also requires large tree trunks, so harvest is delayed until the sixth year, resulting in reduced productivity.

Researchers in Michigan are investigating the use of modified over-the-row harvesters (adapted from blueberry and grape production) to harvest tart cherries, as they are less damaging to the trees. Adoption of over-the-row harvesters would require

significant changes to training and pruning systems (high density orchards with smaller trees), as well as the purchase of new equipment for harvest. There are many potential benefits to these systems, such as early production of fruit and longer lifespan of trees. This publication focuses on the current systems used in Ontario orchards.

Figure 27. Mechanical harvest for tart cherry.

Traditionally sweet cherries have been grown on large trees with dense canopies which require the use of ladders for hand harvest. These large trees are slow to produce fruit and often have poor light interception resulting in reduced fruit size and quality.

Over the last 20 years, there's been a global shift in sweet cherry production to planting high density orchards — which have smaller trees that bear fruit earlier and produce high yields of large premium quality fruit. These orchards can be harvested without the use of ladders and are more labour efficient. Depending on the training system selected, many high density orchards are compatible with the use of row covers (Figure 28) which help protect the fruit from rain and hail, leading to increased yields.

Tart cherries are less prone to rain cracking and less profitable than sweet cherries. As a result, they are less apt to be grown under expensive rain shelters.

Figure 28. Row covers are used to protect the cherries from rain and hail, resulting in less fruit cracking.

Training Systems Used in Cherry Production

Variation in production practices and markets between sweet and tart cherries have resulted in the adoption of different training and pruning systems.

Tart cherries are a processing crop. Market challenges and low grower returns, have resulted in training and pruning systems that focus on developing trees that are compatible with mechanical harvest and optimize labour efficiency rather than increasing yields or fruit size.

Training systems used in tart cherry production:

- ✓ Develop trees with large trunks and scaffold branches that are higher than 1–1.2 m (3-4 ft) above the ground to facilitate mechanical harvest.
- ✓ Produce low density orchards that can accommodate the large pieces of equipment needed for mechanical harvest.
- ✓ Develop good tree structure and strong limbs with wide crotch angles that can withstand mechanical harvest in year 6 with minimal injury.
- ✓ Renew fruiting wood on mature trees, by selectively removing ⅕ of old unproductive limbs to stimulate a new supply of limbs that are of optimal fruit-bearing age and placement.
- ✓ Remove any damaged, diseased or non-productive growth.
- ✓ Manage the height of the tree to allow for easier harvest and better spray coverage and reduced bruising during mechanized harvest.
- ✓ Use thinning cuts to improve air circulation to prevent the spread of powdery mildew.
- ✓ Prune during the summer when weather is hot and dry, or before bud break to reduce the risk of bacterial canker infections.

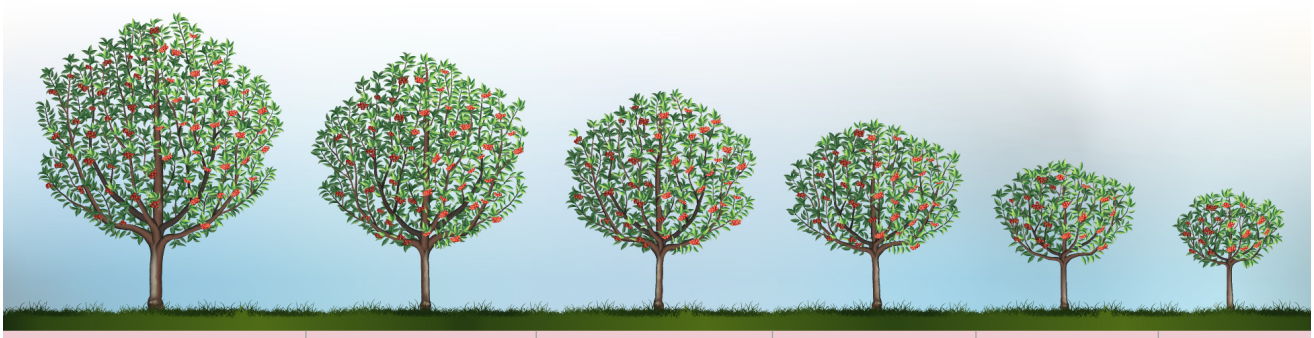
Sweet cherries are a fresh market crop. As a result, training and pruning systems focus on developing trees that produce high yields of large cherries to meet market demands while reducing labour costs for hand harvest and pruning.

Training systems used in sweet cherry production:

- ✓ Manage tree height (pedestrian orchards) and shape to reduce the need for ladders and increase labour efficiency.
- ✓ Allow for the use of row covers, to shield the fruit from rain and reduce the risk of fruit cracking.
- ✓ Increase light interception for improved fruit quality and fruit size.
- ✓ Renew fruiting wood to sustain yields and fruit quality.
- ✓ Provide better leaf cover to the fruit, reducing water on the surface of the fruit and minimizing the risk of fruit cracking – Upright Fruiting Offshoot (UFO).
- ✓ High density orchards that are more precocious, produce high yields and faster returns on investments.

Growth and Fruiting Habit

Tart cherry trees generally have a spreading growth habit and lack a strong central leader. Mature tree height ranges from 4.5–6 m (15–20 ft). Cherry trees have strong apical dominance. They tend to produce branches with narrow crotch angles which are prone to breaking. Tart cherries are grown on vigorous rootstocks such as Mahaleb or Mazzard that form large-sized trees and require training systems that are compatible with low-density plantings. The Modified Central Leader system produces large trees with strong trunks that are compatible with the use of mechanical shakers for harvest.



100%	>90%	80–90%	60–80%	50–60%	40–60%
Mazzard	Gisela 12,13 & 17*	Kyrmsk 6*	WiGi 2*	Gisela 5	Gisela 3
Mahaleb	Krymsk 5*	Gisela 6*	—	—	—

* Indicates rootstocks that are not commercially available in Ontario.
"—" = Not Applicable.
Notes: Mazzard rootstocks are the most common rootstock used for tart cherries in Ontario. Sweet cherries have traditionally been grown on Mazzard rootstocks. Globally there has been an increase in high density sweet cherry plantings and a shift to the use of Gisela rootstocks.

Figure 29. Effects of cherry rootstock on relative tree size. Adapted from L.E. Long, *Sweet Cherries*.

Sweet cherry trees are 9–12 m (30–40 ft) tall and naturally grow as a central leader tree. Size-restricting rootstocks are commercially available for sweet cherries and can reduce the size of the tree by 50%–90% (Figure 29). Rootstocks alter the vigour and productivity of the tree, impacting the production of fruiting wood, flower density, number of spurs, location of fruit buds, fruit quality and time required to bear fruit. High density cherry systems require the use of size restricting rootstocks.

In Canada, the Mazzard rootstock is the standard rootstock for sweet cherry, with some growers moving to Gisela series rootstocks for high density orchards due to their vigour control, early and high fruit productivity. Gisela rootstocks can have increased susceptibility to cold injury, due to their earlier flowering, and their small size which makes them vulnerable to frost. The increased costs of planting high density orchards has also slowed the use of these rootstocks. Some rootstocks are prone to developing branches that don't produce fruit buds (blind wood). Some growers are using these rootstocks to manage tree height and allow for the use of rain covers. Cherry cultivars differ in their response to rootstocks, resulting in differences in tree size, vigour and fruit quality.

Training systems can also be used to manage vigour and encourage earlier cropping in the life of the tree. Prohexidione-calcium a plant growth regulator can be used to reduce terminal growth in cherries, reducing the time required to prune. Refer to *Plant Growth Regulators* at ontario.ca for more information.

Both sweet and tart cherries are considered spur bearing and produce most of their fruit on short spurs located on 2 to 3-year old wood. Spur bearing trees have more even distribution of fruit along the branches. Tip-bearing (non-spur type) trees produce fruit at the tips of new growth (1-year old shoots). Non-spur varieties such as Regina, primarily produce fruit at the base of 1-year-old shoots. Partial tip-bearing trees produce fruit on spurs and the tips of shoots. Training systems like the Super Slender and Tall Spindle Axe work well with non-spur type cherries. The UFO training system works better with spur type cherries that bear most of their

fruit in clusters on short spurs located on 2-3 year-old wood that is produced along the branches. Flower buds may contain up to 7 flowers per bud. Limbs that are older than 3 years are less productive and should be replaced with new growth. Maintaining adequate vegetative growth is important to support the fruit (water, nutrients and carbohydrates) in the current season and to develop fruiting spurs. Balancing vegetative growth and fruit production is important in cherry production.

The largest and highest-quality sweet cherries are produced at the base of the previous season's growth and on young spurs. Annual vegetative shoot growth of 100 cm (39 in.) is required to support the production of large, high-quality sweet cherries. Research has shown that the fruit-to-leaf area ratio is a critical factor influencing the quality of cherries. As the number of fruit per unit leaf area increases, there is a corresponding decrease in mean fruit weight, soluble solids content and titratable acidity. The production of large-sized, high-quality sweet cherries requires a leaf-to-fruit area to fruit ratio of at 210-250 cm^2 per fruit (or 5 leaves per fruit) averaged over the entire canopy. To maintain an optimal leaf-to-fruit ratio, it is important to manage the tree canopy and crop load by pruning it properly. As a general rule, the size of fruiting and non-fruiting spur leaves are the best indication of how much of a fruit load the branch can support. The larger the spur leaves the more large-sized fruit can be supported.

Cherry Production and Light

Sunlight is critical in cherry production. Wood throughout the tree, including the inner canopy, must receive at least 25% full sunlight to form adequately-sized, well-coloured fruit and to set flower and vegetative buds for future crops. Wood that receives less than 20% full sunlight is more prone to cold injury and often dies during winter months.[4] For more information, refer to section *Influence on Light Levels in the Tree Canopy* in Chapter 1.

Pruning for Disease

Many of the diseases that affect other stone-fruit crops, such as perennial canker and black knot (tart cherry only), also affect cherries and the pruning techniques mentioned previously apply to cherries.

Cherries are also susceptible to brown rot, cherry leaf spot and powdery mildew. Pruning to open the tree canopy allows for rapid drying of foliage and good spray penetration, which helps manage these diseases. Prune to remove fruit mummies that can increase the spread of brown rot.

Bacterial canker *Pseuddomonas syringae*, which can also affect stone-fruit trees and pear, is a significant disease in sweet cherry orchards. Pruning practices play an important role in managing this disease and can exacerbate the spread of the disease.

In high infection areas, consider planting trees later in the spring to avoid cool, wet conditions. After planting, if heading is required for tree training, it is best to delay pruning until the weather is hot and dry. Avoid pruning before rain is expected, as wet conditions will increase the risk of infections. To minimize the risk of bacterial infections, prune in late summer or early fall after harvest when weather is dry. Remove infected branches at least 5 cm (2 in.) below the canker and burn them. Avoid pruning in spring or fall when conditions are wet and bacteria is active. If dormant pruning is required to promote growth or renew branches, it should be done in dry weather.

Monitor for bacterial canker and use ugly stub cuts — leaving a 15 cm (6 in.) stub, to remove bacterial canker lesions. Stub cuts will delay the progression of the canker and may lower the risk of the infection moving into the

trunk of the tree. Stubs can be removed at a later date For more information on stub cuts, see Chapter 1, *Training and Pruning Tender Fruit Trees*. For more information on cherry diseases, visit the *Sweet Cherries* and *Tart Cherries* sections on CropIPM.

Dormant Pruning

Pruning is used for all fruit crops to maintain tree structure and ensure high yields and tree longevity. The guidelines for pruning fruit trees apply to all fruit crops, see Chapter 1, *Training and Pruning Tender Fruit Trees* for more information.

Cherries have some specific requirements as follows:

Tart Cherries

- ✓ Training and pruning young trees should focus on developing a strong tree architecture and encouraging the trees to fill their space as quickly as possible during tree establishment years. Gibberellic acid is a plant growth regulator that can be used to reduce flowering and stimulate lateral shoot growth. Refer to *Plant Growth Regulators* at ontario.ca for additional information.
- ✓ Prune trees in the late winter to early spring before bud break to minimize the risk of cold injury. Do not prune trees until danger of extreme cold winter temperatures is past (March).
- ✓ Tree trunks must be strong and the lowest scaffold should be at least 91 cm (36 in.) from the ground to facilitate harvest.
- ✓ Maintain wide crotch angles (50˚–90˚) to minimize limb breakage.
- ✓ For trees that are established with good structure, renew 3–5 of the largest side branches each year to maintain a productive tree. Use a stub cut leaving a 10–15 cm (4–6 in.) stub, making sure that the underside of the branch is longer than the upper side to encourage the production of new shoots with wide angles, from the lower side of the branch.
- ✓ Maintain a balance between vegetative and reproductive growth with annual renewal pruning to ensure adequate fruit size.
- ✓ Thin the tree canopy to ensure proper light penetration and spray coverage.
- ✓ Manage the height of the tree to avoid shading and bruising of fruit at harvest.
- ✓ Remove mummified fruit. Prune out cankers and infected wood to reduce the spread of disease.

Sweet Cherries

- ✓ Generally summer pruning is preferred for sweet cherries as it reduces the risk of bacterial canker infections and decreases the amount of regrowth.
- ✓ Where dormant pruning is required prune in the later winter or early spring after the danger of extreme cold temperatures is over but before budbreak (late February through March) .
- ✓ Weaker branches can be strengthened by cutting the tips (heading/tipping).
- ✓ Remove 30%–50% of last year's growth on highly productive rootstocks and cultivars by tipping all the branches (making sure to leave the central leader intact). This will reduce the quantity of the future crop but increases the size of remaining fruit.
- ✓ In addition to tipping, use renewal pruning during the dormant season to selectively stub limbs that are older than three years old to reduce the current seasons crop and promote new fruiting wood. Branches should be stubbed to 7–12 cm (3–5 in.).
- ✓ Renew 20% of all fruiting branches each year to keep trees productive and ensure high fruit quality. Remove a maximum of 3 large limbs per year. Removing too many limbs results in excess vigour.
- ✓ Remove and destroy fruit mummies (dried fruit hanging on the tree) to reduce the

spread of brown rot. Prune out cankers and dead twigs.

- ✓ Consider the leaf-to-fruit ratio when pruning. Aim to have 3–5 leaves-per-fruit to optimize fruit size. More leaves results in greater carbohydrate production and larger cherries.[5]
- ✓ Adjust pruning practices based on tree vigour and rootstocks. Prune trees on dwarfing rootstocks (Gisela) more aggressively than vigorous trees (Mazzard rootstocks) to stimulate enough vigour to obtain optimal leaf-to-fruit ratios for large fruit and to ensure adequate fruiting wood for future crops.
- ✓ Remove small wood that won't support a crop.
- ✓ Thin shoots to improve light penetration and air circulation.
- ✓ Manage the optimal height of the tree to minimize shading based on the training system.
- ✓ Prohexidione-calcium (a plant growth regulator) can be used to reduce terminal growth, and reduce the time required for dormant pruning.
- ✓ Promalin (a plant growth regulator) can be used to stimulate branching and improve tree structure in non-bearing (nursery) trees. Refer to Plant Growth Regulators at ontario.ca for additional information.

Summer Pruning

Tart Cherries

Mechanical hedging uses motorized blades to nonselectively pre-prune the tree and can be used for managing tree height. Mechanical hedgers can be used for non-selectively tipping tart cherries during the period ranging 2-3 days on either side of 45 days after full bloom. Hedging at this time promotes shoot and spur development resulting in high yields of quality fruit. Hedging after this time can produce a thick wall of brush on the outer surface of the tree which inhibits flower bud production.

Hedging should be set to remove 10%–50% of the current season growth. Avoid cutting into 2-year-old wood. Side-hedging should taper in at the top to optimize light penetration. If not done properly, hedging can create excess vigour and damage fruit, resulting in reduced productivity.

Sweet Cherries

Summer pruning provides the opportunity to moderate vigour, maintain the tree shape and increase light distribution in the canopy. Crop loads are managed at this time by removing fruit buds (to reduce yields) or encouraging the development of fruit spurs (to increase yields). Summer pruning should be done after harvest (August through early September) to minimize the amount of regrowth and encourage wide angled limbs. Remove large branches for renewal and prune to manage the tree height.

The warm, dry weather helps pruning wounds heal more quickly and reduces the risk of bacterial infections.

Summer pruning involves using:

- ✓ renewal cuts to remove large branches to renew fruiting wood
- ✓ heading cuts to manage tree height
- ✓ thinning cuts to remove small branches, pendant or upright shoots to improve light levels and air circulation
- ✓ stub cuts to renew fruit spurs and increase light
- ✓ tipping cuts to remove the terminal end of 1-year-old shoots, 15–25 cm (6–10 in.) — to reduce the subsequent seasons crop and encourage branching in young trees
- ✓ ugly pruning stubs if bacterial canker is a problem, refer to section *Pruning for Disease* for more information

Some orchard systems (such as UFO), are compatible with the use of mechanical hedging to trim the sides and top of trees. Mechanical hedging can be used to manage tree height, increase light penetration into the canopy and improve tree shape. If used properly, mechanical hedging can reduce labour costs.

Mechanical hedging conducted in early summer (around June) when the shoots have 12 leaves will encourage flower bud formation the following year. If done at the wrong time, hedging can remove too many leaves, reducing fruit size and stimulating excess lateral branch growth causing shading. Do not hedge young trees that haven't filled their space in late summer. Hedging during late stages of fruit development can negatively impact fruit maturity, fruit quality and wood maturity. Mechanical hedging does not replace the need for hand pruning, used to remove large wood and undesirable branches. Hedging works best in sweet cherry orchards with high density training systems.

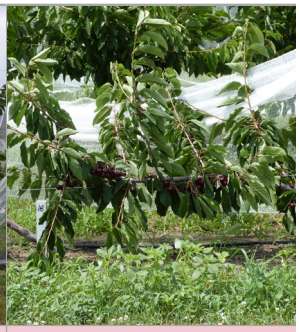
Use late summer pruning minimally to avoid decreasing the trees energy reserves prior to winter. Avoid summer pruning after September as it may impact cold hardiness.

Training Systems Used in Cherry Orchards

There are a variety of training systems for cherries. When selecting a rootstock for cherries it is important to consider factors such as soil adaptability, desired tree vigour, disease resistance, cold hardiness, yield potential and orchard system compatibility. Take into consideration the rootstock and cultivar when selecting a training system. Many dwarfing rootstocks in the Krymsk® and Gisela series require trees to be supported with stakes or a trellis. Cultivars that are more vigorous may not be suitable for high density systems even when propagated on dwarfing rootstocks.

Table 6 provides a comparison of selected training systems used in cherry production.

Table 6. Comparison of Selected Training Systems Used in Cherry Orchards

				
System Attributes	**Open Centre or Open Vase (OC) Tart Cherry**	**Modified Central Leader (Tart Cherry, Sweet Cherry)**	**Tall Spindle Axe (TSA) (Sweet Cherry)**	**Upright Fruiting Offshoots (UFO) and (UFO-Y) (Sweet Cherry)**
Number of Scaffolds	3 or 4 primary scaffolds, secondary and tertiary scaffolds	Central leader with 2 or 3 tiers of well distributed branches around tree	Single vertical leader with whorl of moderately vigorous branches forming a Christmas tree shape Only permanent structure is central leader	Tree has a permanent single horizontal trunk (cordon) where renewable fruiting leaders are grown vertically
Canopy Information	Free standing, non-uniform tree, large canopy volume, large trees	Free standing, medium to large tree, Christmas tree shape	Compact freestanding trees, requires a trellis for support	Trellis system/fruiting wall, uniform trees
Rootstock	Vigorous, semi-dwarfing	Semi-dwarfing or dwarfing	Dwarfing to semi-vigorous rootstocks	Dwarfing or semi-dwarfing rootstock
Mechanization Suitability	Limited to top hedging	Hedging	Semi-pedestrian Pick from ground	Compatible with platforms and hedging Can be pedestrian orchard, but higher yields by increasing tree height in single UFO
Light Exposure	Low	Medium	Good	Good
Fruit Quality Fruit Size/Yield	Large fruit Less uniform fruit colouring and maturation, more picks at harvest	High-quality crops	Good yields of high-quality fruit	Good yields and quality fruit
Tree Density	Low density 598 trees/ha Loss of tree has greater impact on yields	Medium 600–800 trees/ha*	High density 958–1957 trees/ha	High density 1536–2989 trees/ha
Pruning Decisions	More complex	Labour intensive in first few years	Crop load moderation via pruning is possible Training is labour intensive initially	Simple training and pruning Easy to manage crop loads
Early Production	No	Yes	Yes	Yes

** High number of trees per acre is for trees on size controlling rootstocks.*

continued ››

Table 6. Comparison of Training Systems Used in Cherry Orchards *(continued)*

System Attributes	Open Centre or Open Vase (OC) Tart Cherry	Modified Central Leader (Tart Cherry, Sweet Cherry)	Tall Spindle Axe (TSA) (Sweet Cherry)	Upright Fruiting Offshoots (UFO) and (UFO-Y) (Sweet Cherry)
Fruiting Habit	Spur type and non-spur type trees	Spur type and non-spur type Suitable for varieties with lower productivity	Growth is primarily of lateral shoots of moderate vigour	Fruit are produced on spurs but also at the base of 1-year-old shoots Fruiting units are renewable and vertical Must be used on spur type varieties (can't be used on non spur trees varieties) Leaves protect fruit to reduce fruit cracking
Comment	Works well with tart cherry mechanical harvest	Works well with tart cherry mechanical harvest	More productive varieties are better suited to the TSA system which incorporates crop load moderation via pruning Optimizes labour with use of platforms	Small trees may be more vulnerable to frost Optimizes labour

‹‹ previous

Glossary

Activation of buds: The process by which a dormant or suppressed bud moves into an active or growing state.

Apex: The growing tip of the shoot.

Apical dominance: The tendency of the actively growing shoot tip on the main stem/trunk to suppress the growth and development of buds and branches below it.

Ascospore: A sexually produced fungal spore formed within an ascus.

Basal: The part of the shoot closest to its point of origin (base).

Bevel cut (Dutch cut): An angled cut that leaves a larger stub at the base of the cut than the top and preserves a dormant bud on the underside of the shoot. This cut stimulates buds on the underside of the stub to develop a new weaker, fruiting shoot with a wide angled crotch to replace the vigorous limb that was removed.

Bi-axis: A training system that trains the trees to have two leaders (axes) to help divide the vigour over more branches.

Biennial Bearing: The tendency of some fruit trees to produce a heavy crop one year and a light crop the subsequent year.

Blind wood: Branches with no leaf growth or bud development along a portion of their length. Blind wood does not produce fruit and requires renewal through pruning.

Bourse shoot: A vegetative shoot that originates from beneath where a flower bud arises. These shoots can form new flower buds.

Branches (temporary/permanent): Temporary branches remain on the tree for a short period of time, while permanent branches remain on the tree for its entire life. Trees purchased from commercial nurseries will have 5–10 branches.

Breaking branches: Removing branches of the current season's growth by breaking the joint between 1- and 2-year-old wood by hand, rather than cutting. This has been used in some areas to remove fire blight infected shoots.

Brix: A measure of the amount of sugar present in fruit.

Bud: A small, undeveloped shoot that contains the potential for new growth. Buds are typically found on stems where they can be apical (at the tip) or axillary (between leaf axils) and may develop into leaves, shoots or flowers.

Canker: A small area of dead tissue caused by a pathogen, which increases in size over time.

Central leader: The main leader or dominant shoot in the centre of the tree from which side branches grow.

Click pruning (Tira Savia): A technique used on vigorous fruit trees (pear) where a heading cut is used to remove the end of 1-year-old shoot, leaving two to three buds to stimulate lateral bud break and promote fruit bud or spur development.

Cold hardiness: The plant's ability to withstand cold temperatures, generally measured by the lowest temperature a plant can withstand.

Collar cuts: Also known as removal cuts or thinning cuts remove a branch at its origin from a larger branch, leaving the branch collar intact. The branch collar is the swollen area of bark at the base of the limb. Collar cuts help the tree to heal quickly.

Crop load/crop load management: The number of fruit per tree. Balancing the production of fruit with vegetative growth to ensure adequate fruit size, good quality fruit and minimal biennial bearing. Pruning to remove buds, blossom or chemical thinning and hand thinning fruit are used to manage crop loads in tender fruit orchards.

Crotch angle: The angle formed by the spreading of branches or limbs from its trunk. Wider crotch angles of 45–60 degrees are considered to be strong and less prone to breakage.

Cultivar: A variety produced by selective propagation i.e., Bartlett pears or Red haven peaches. Cultivars vary in their growth (vigour), fruiting habits and productivity (amount of fruit produced).

Dormant pruning: Pruning when trees are dormant – usually between leaf drop (late fall) and when the buds begin to swell in early spring (pear). In some crops (peaches, plums, apricots) this pruning is done between bud break and fruit set to reduce the risk of cold injury and minimize the risk of infections.

Early bearing/precocious: Trees bear fruit earlier in their life than usual.

Early cultivars (peaches): Cultivars harvested earlier in the season that have less time for fruit sizing and issues with adequate fruit sizing.

Feathered: A nursery tree that produces side shoots and a central stem during the first growing season after budding.

Free standing: An unsupported tree.

Fruit buds: Buds that produce flowers and fruit. Fruit buds are generally larger and rounder than vegetative buds.

Fruit set: The successful development of fruit from flowers.

Fruiting wood/shoots: Wood that remains on the tree to ensure future fruiting. Some fruit trees only produce fruit on 1-year-old wood (peaches/nectarines), while cherries, plums, apricots bear fruit on 1-year-old wood and older stems.

Fruiting zone: Area on the tree where the fruit is produced. Tall trees have higher fruiting zones and may require the use of ladders to manage and harvest trees, resulting in increased labour costs.

Gibberelic acid: is a plant growth regulator used to regulate fruiting in tart cherry, and to promote or activate buds for lateral branching in sweet cherry.

Heading cut (heading back cut): A pruning cut that removes only a portion of the branch and results in increased growth of side branches at the point of the cut from the part of the branch that remains. It can be used for establishing scaffolds in young trees, but is generally avoided as it can result in overcrowding.

Hex-V: A three-dimensional training system that involves selecting three permanent scaffold limbs per side for a total of six evenly spaced scaffolds. This system can be used to create a pedestrian orchard, but often requires a trellis support.

High/higher density: Describes the number of trees planted per acre compared to traditional orchards. The spacing between trees and between rows impacts the density of trees. Planting trees closer together can result in: smaller tree sizes (increased competition between trees), earlier fruit production and potentially increased yields per acre (yield efficiency). The density of the orchard planting is impacted by the crop, growth habit of the tree, rootstock, variety and soil type.

Inoculum: Any part of a pathogen that can initiate infection.

Laterals or side branches: Secondary branches that arise as side shoots from scaffold or other branches.

Leader: The uppermost portion of a scaffold limb. In a central leader tree, the leader is the trunk of the tree. Multiple leader trained trees can have two to five leaders per tree.

Light distribution: The amount and quality of light getting to specific zones and surfaces within the tree canopy.

Light interception: The percentage of total sunlight that strikes the tree, it is impacted by canopy size, density and shading.

Low-density orchard: Traditionally, tender fruit orchards were planted at low densities of 100–200 trees/ha, resulting in large trees that are slow to produce fruit.

Mechanical hedging: The use of equipment to non-selectively prune fruit trees to develop or maintain a narrow canopy. This process helps manage tree height and manage the width of the canopy to increase light penetration, improve fruit colour/quality and reduce hand labour pruning costs. It is most suitable for modern tree fruit orchards that are planted to high density and fruiting wall training systems.

Mechanization: Using machines to do activities traditionally done by hand labour, resulting in reduced labour costs. The ability of mechanize operations is impacted by markets (i.e. tart cherries use shakers to mechanically harvest), as well as the production system (i.e. the use of platforms or hedgers requires orchard systems that are highly uniform with an open canopy, which are more typical in two-dimensional training systems). Partial mechanization means equipment is used for some orchard activities (i.e. hedging the tops of trees) but is not compatible with all orchard operations.

Modified Central Leader: Training system that produces a free-standing single leader tree that has renewable fruiting scaffolds spaced vertically and evenly around the tree. The Christmas tree shape of the tree helps promote light distribution in the canopy and fruiting wood is renewed regularly. Removal of the leader helps manage tree height making the trees easier to prune, spray and harvest fruit.

One-year-old wood: Growth that developed during the previous growing season.

Open Centre (Open Vase) system: Training system that produces a large free-standing tree that has three to five scaffolds originating from about the same level vertically on the tree that are evenly spaced around the tree.

Pedestrian orchards: Orchard systems where all activities (pruning, thinning and harvest) can be completed from the ground, eliminating the need for ladders.

Phloem: The vascular tissue in plants that transports sugars, proteins and organic molecules.

Plant growth regulators: Chemicals produced naturally by plants to regulate their growth and development.

Prohexidione-calcium: A plant growth regulator that can be used to reduce terminal growth in tart cherries. Reduction in terminal growth should help reduce the time required to dormant prune, as well as open up the tree canopy leading to improved spray coverage and reduced disease pressure.

Pruning: The process of shoot and limb removal by cutting or sawing. Pruning is used to manage the tree shape and structure, optimize light distribution, manage crop loads and renew growth.

Quad-V: Training system that produces a free-standing tree with two permanent scaffold limbs per side for a total of four evenly spaced scaffolds, ~90˚ apart. This system produces a pedestrian orchard.

Rain covers: Plastic film incorporated into fabric covers used to protect cherries from rain and reduce fruit cracking. These covers also allow harvest to proceed uninterrupted by rain.

Renewal/dynamic pruning: This approach involves removing older, less productive branches by pruning and replacing them with young fruiting wood that is more productive and produces high-quality fruit.

Root pruning: Involves using an offset subsoiler blade or a large coulter along the tree row to cut the roots of fruit trees. Root pruning can be used to help manage tree vigour.

Rootstock: Consists of the roots and lower portion of the trunk on fruit trees. Rootstocks can directly influence productivity, precocity, tree size, tree architecture, fruit size and fruit quality. Rootstocks will also influence many horticultural decisions such as pruning, training, tree support and labour management.

Scaffold: Primary scaffolds are the main limbs that forms a tree's framework or canopy. Secondary scaffolds are branches that develop from the primary scaffold branches and often support fruiting branches

Scion: The fruit bearing or top portion of the tree that determines the cultivar.

Shoot: The above-ground part of the plant that bears the flowering buds, lateral buds and flowering stems. The length of branch growth in one season. Bud scale scars (ring of small ridges) on a branch mark the start of a season's growth.

Shuck split: A stage in peach development when the remnants of the flower (shuck) split and fall off as the young peach fruit develops.

Size controlling rootstocks: Rootstocks that manage the vigour of the tree. Size controlling rootstocks are separated based on their level of vigour control. Dwarfing rootstocks produce trees that are 40%-60% the size of trees on standard rootstocks. Semi-dwarfing rootstocks produce trees that reach of to 75% the size trees on standard rootstocks.

Spur: Short branched shoots on the older wood that produce fruit buds.

Spur bearing cultivars: Cultivars that produce fruit buds on 2-year-old wood and as spurs (short, branched shoots) on older wood.

Spur or fruiting spur: Short shoots, usually less than 3 cm (6 in.) long, with a cluster of fruit buds and some leaf buds. The older the spur is the less likely it is to generate new shoots. Fruit trees that develop spurs include pears, plums and some apricots.

Stub cut: A type of heading cut where a short portion of a branch (stub) is left after pruning. Stub cuts are used to stimulate the regrowth of new lateral branches or to slow the progression of cankers in cherries.

Sucker: Vigorous upright growing shoots that form at the base of a tree. They can reduce flowering and fruiting, alter the form of the tree, harbor pests and diseases and look unsightly.

Summer pruning: The thinning or removal of shoots or branches during the summer with the goal of increasing light penetration into the canopy to maintain fruiting wood in the lower canopy and improve fruit colour. Summer pruning also helps to maintain the tree structure and shape desired for the training system.

Super slender axe: A central leader-based fruiting wall that allows for ultra high density planting, annual renewal of nearly 100% of the fruiting wood and fruiting sites limited primarily to basal flower buds on previous season shoot growth instead of fruiting spurs on older wood.

Terminal: The apex or actively growing end of a shoot.

Thinning (fruit): Removing excess fruit — chemically, using blossom thinners or by hand — to ensure adequate fruit size and quality.

Thinning cut: Pruning cuts made at the origin of a branch to remove an entire shoot branch or limb. Thinning cuts are used often as they open up light into the interior of the tree.

Three-dimensional training system: These systems maintain a larger canopy width with branches that grow perpendicular to the row (into the tractor alley). Examples include the Open Centre, Quad-V, Hex-V systems.

Tip bearing cultivars: Cultivars that flower and fruit predominantly at the shoot tips rather than on spurs.

Tipping: Removal of the terminal point of the shoot which removes the inhibitory effect of apical dominance and promotes the elongation of one to three lateral buds near the tipping cut.

Topping Branches: Removal of the upper part of the canopy beyond the desired maximum height. Topping can be done mechanically using a hedger with a sickle bar or circular saw that indiscriminately cuts the branch or manually using thinning cuts to cut the branch back to a weak side branch or shoot, to manage regrowth.

Training: Managing the tree to direct tree growth to a desired shape and structure. Training incorporates the use of pruning, as well as the use of trellises, clothespins and branch spreaders to manipulate branch angles and direct growth.

Tree shakers and catch frames: Equipment used to harvest tart cherries mechanically.

Trellis: Planting system that uses a post and wire configuration to support the tree for growth.

Two-dimensional training system (planar): Training systems that form a narrow fruiting wall where trees grow flat against a trellis. These systems are open and uniform, facilitating easier maintenance, better light penetration and improved labour efficiency. Examples include the Bi-Axis system, Upright Fruiting Offshoots (UFO) system.

Ugly stub cut: A pruning cut that leaves a 12 cm (5 in.) stub. Ugly cuts have been used as a tool to minimize the spread of cankers such as fire blight.

Upright Fruiting Offshoots (UFO): Training system that produces a tree with a permanent single horizontal trunk (cordon) where renewable fruiting leaders are grown vertically. Fruit are produced predominantly on spurs, but also at the base of 1-year-old shoots all on vertical wood.

Vascular tissue: Conducting tissues in plant made up of different types of cells and elements. The two main components of vascular tissue in plants are the xylem and phloem.

Vegetative buds: Buds that produce leaf and shoot growth without flower and fruit. These buds are slender and pointed and much smaller than fruit buds.

Vertical branch: Branches that grows upright.

Vigour: The trees ability to grow and withstand stress. Adequate vigour is needed to developing fruiting wood that will produce fruit and leaves that will support the developing fruit. Vigorous trees grow more wood than less vigorous trees for the same amount of leaf area.

Water sprout: A vigorous shoot arising from latent buds on the trunk or from older scaffold branches. Similar to suckers, but they arise from the scion in the upper canopy of the tree.

Whip: A nursery tree that has been grown without any evidence of side shoot or feathers and remains unbranched.

Xylem: The vascular tissue in plants that transports water and dissolved nutrients.

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Appendix A. Ministry Resources

OMAFA Tender Fruit Specialists

Kathryn Carter
Fruit Crop Specialist — Tender Fruit and Grape
4890 Victoria Avenue N., Building 3
Vineland Station, ON L0R 2E0
kathryn.carter@ontario.ca
Tel: 905-687-1280

Wendy McFadden-Smith
Horticulture IPM Specialist — Tender Fruit and Grape
4890 Victoria Avenue N., Building 3
Vineland Station, ON L0R 2E0
wendy.mcfadden-smith@ontario.ca
Tel: 905-932-8965

Agricultural Information Contact Centre
Agricultural Information Contact Centre
Provides province-wide, toll-free technical and business information to commercial farms, agri-businesses and rural businesses.

Tel: 1-877-424-1300
Email: ag.info.omafa@ontario.ca
Web: Contact/Feedback Form

Tender Fruit on Ontario.ca

- Tender Fruit
- Cost of Production
- Plant Growth Regulators

Visit ONFruit for what's trending on fruit crop production. Focusing on information for Ontario Fruit Growers, the blog is written by crop specialists from the Ministry of Agriculture, Food and Agribusiness. Subscribe to receive our latest posts and resources!

Highlighs include:

- Fruit crop production
- Insect, disease and weed monitoring/management
- Weather related issues
- Soil and crop nutrition
- Industry events

Ontario Crop Protection Hub

Use this tool on any device to find:

- Proper rates and application protocols for legally registered insecticides, fungicides and herbicides
- Up-to-date information on product efficacy against pests
- Strategies to support environmental stewardship
- Information to help growers manage pesticide resistance

Visit the Ontario Crop Protection Hub at
Ontario.ca/cropprotection

CropIPM

IPM info at your fingertips. The new CropIPM tool includes:

- Up-to-date IPM information for key Ontario pests
- A new 'Identify' feature to help you identify pests and disorders
- An expanded offering of crop specific information
- Scouting calendars
- Comparisons of often-confused-with pests
- Details on soil diagnostics and herbicide injury

Visit the Crop IPM Tool at
Ontario.ca/cropIPM

Appendix B. Other Resources

Agriculture & Agri-Food Canada (AAFC)
Agriculture and Agri-Food Canada supports the Canadian agriculture and agri-food sector through initiatives that promote innovation and competitiveness.
https://agriculture.canada.ca/en

AAFC Research Centres
www.agriculture.canada.ca/en/agricultural-science-and-innovation/agriculture-and-agri-food-research-centres-and-collections

Canadian Food Inspection Agency — Plant Protection
Services and information on plant pests and invasive species, import, export, trade, fertilizers, soil and soil-related matter, grains and field crops, seeds, cannabis, forestry, horticulture. https://inspection.canada.ca/en/plant-health

University of Guelph — Plant Agriculture
Canada's largest and most diverse applied plant biology department. A research intensive department within the Ontario Agricultural College dedicated to teaching, research and service related to horticultural crops, turfgrass, landscape species and field crops. www.plant.uoguelph.ca

Lab Services Division
www.uoguelph.ca/labserv/

Ontario Fruit and Vegetable Convention
The Ontario Fruit and Vegetable Convention (OFVC) is an annual gathering of horticultural crop producers involved in the production of fruit and vegetables. The convention is attended by a cross section of the horticultural sector including government, industry, business, consultants, producers, associations, researchers and educators from across Canada and features a great lineup of horticultural experts, educational sessions, trade show exhibitors and great networking opportunities. If you grow, this is one event you can't afford to miss!
https://www.ofvc.ca/

Appendix C. Metric System and Abbreviations

Metric units

Linear measures (length)

10 millimetres (mm)	=	1 centimetre (cm)
100 centimetres (cm)	=	1 metre (m)
1,000 metres	=	1 kilometre (km)

Square measures (area)

100 m × 100 m = 10,000 m^2	=	1 hectare (ha)
100 ha	=	1 square kilometre (km^2)

Cubic measures (volume)

Dry measure

1,000 cubic millimetres (mm^3)	=	1 cubic centimetre (cm^3)
1,000,000 cm^3	=	1 cubic metre (m^3)

Liquid measure

1,000 millilitres (mL)	=	1 litre (L)
100 L	=	1 hectolitre (hL)

Weight-volume equivalents (for water)

(1.00 kg) 1,000 grams	=	1 litre (1.00 L)
(0.50 kg) 500 g	=	500 mL (0.50 L)
(0.10 kg) 100 g	=	100 mL (0.10 L)
(0.01 kg) 10 g	=	10 mL (0.01 L)
(0.001 kg) 1 g	=	1 mL (0.001 L)

Weight measures

1,000 milligrams (mg)	=	1 gram (g)
1,000 g	=	1 kilogram (kg)
1,000 kg	=	1 tonne (t)
1 mg/kg	=	1 part per million (ppm)

Dry–liquid equivalents

1 cm^3	=	1 mL
1 m^3	=	1,000 L

Metric conversions

5 mL	=	1 tsp
15 mL	=	1 tbsp
28.5 mL	=	1 imp. fl. oz.

Handy metric conversion factor (approximate)

litres per hectare × 0.4	=	litres per acre
kilograms per hectare × 0.4	=	kilograms per acre

Application rate conversions

Metric to imperial or U.S. (approximate)

litres per hectare × 0.09	=	Imp. gallons per acre
litres per hectare × 0.11	=	U.S. gallons per acre
litres per hectare × 0.36	=	Imp. quarts per acre
litres per hectare × 0.43	=	U.S. quarts per acre
litres per hectare × 0.71	=	Imp. pints per acre
litres per hectare × 0.86	=	U.S. pints per acre
millilitres per hectare × 0.014	=	U.S. fluid ounces per acre
grams per hectare × 0.014	=	ounces per acre
kilograms per hectare × 0.89	=	pounds per acre
tonnes per hectare × 0.45	=	tons per acre

Imperial or U.S. to metric (approximate)

Imp. gallons per acre × 11.23	=	litres per hectare (L/ha)
U.S. gallons per acre × 9.35	=	litres per hectare (L/ha)
Imp. quarts per acre × 2.8	=	litres per hectare (L/ha)
U.S. quarts per acre × 2.34	=	litres per hectare (L/ha)
Imp. pints per acre × 1.4	=	litres per hectare (L/ha)
U.S. pints per acre × 1.17	=	litres per hectare (L/ha)
Imp. fluid ounces per acre × 70	=	millilitres per hectare (mL/ha)
U.S. fluid ounces per acre × 73	=	millilitres per hectare (mL/ha)
tons per acre × 2.24	=	tonnes per hectare (t/ha)
pounds per acre × 1.12	=	kilograms per hectare (kg/ha)
pounds per acre × 0.45	=	kilograms per acre (kg/acre)
ounces per acre × 70	=	grams per hectare (g/ha)

Dry weight conversions (approximate)

Metric		Imperial
grams or kilograms/hectare		ounces or pounds/acre
100 g/ha	=	1½ oz/acre
200 g/ha	=	3 oz/acre
300 g/ha	=	4¼ oz/acre
500 g/ha	=	7 oz/acre
700 g/ha	=	10 oz/acre
1.10 kg/ha	=	1 lb/acre
1.50 kg/ha	=	1¼ lb/acre
2.00 kg/ha	=	1¾ lb/acre
2.50 kg/ha	=	2¼ lb/acre
3.25 kg/ha	=	3 lb/acre
4.00 kg/ha	=	3½ lb/acre
5.00 kg/ha	=	4½ lb/acre
6.00 kg/ha	=	5¼ lb/acre
7.50 kg/ha	=	6¾ lb/acre
9.00 kg/ha	=	8 lb/acre
11.00 kg/ha	=	10 lb/acre
13.00 kg/ha	=	11½ lb/acre
15.00 kg/ha	=	13½ lb/acre

Conversion tables – metric to imperial (approximate)

Length

1 millimetre (mm)	=	0.04 inches
1 centimetre (cm)	=	0.40 inches
1 metre (m)	=	39.40 inches
1 metre (m)	=	3.28 feet
1 metre (m)	=	1.09 yards
1 kilometre (km)	=	0.62 miles

Area

1 square centimetre (cm^2)	=	0.16 square inches
1 square metre (m^2)	=	10.77 square feet
1 square metre (m^2)	=	1.20 square yards
1 square kilometre (km^2)	=	0.39 square miles
1 hectare (ha)	=	107,636 square feet
1 hectare (ha)	=	2.5 acres

Volume (dry)		
1 cubic centimetre (cm^3)	=	0.061 cubic inches
1 cubic metre (m^3)	=	1.31 cubic yards
1 cubic metre (m^3)	=	35.31 cubic feet
1,000 cubic metres (m^3)	=	0.81 acre-feet
1 hectolitre (hL)	=	2.8 bushels
Volume (liquid)		
1 millilitre (mL)	=	0.035 fluid ounces (Imp.)
1 litre (L)	=	1.76 pints (Imp.)
1 litre (L)	=	0.88 quarts (Imp.)
1 litre (L)	=	0.22 gallons (Imp.)
1 litre (L)	=	0.26 gallons (U.S.)
Weight		
1 gram (g)	=	0.035 ounces
1 kilogram (kg)	=	2.21 pounds
1 tonne (t)	=	1.10 short tons
1 tonne (t)	=	2,205 pounds
Pressure		
1 kilopascal (kPa)	=	0.15 pounds/$in.^2$
Speed		
1 metre per second	=	3.28 feet per second
1 metre per second	=	2.24 miles per hour
1 kilometre per hour	=	0.62 miles per hour
Temperature		
˚F	=	(˚C × 1.8) + 32

Conversion tables – imperial to metric (approximate)

Length		
1 inch	=	2.54 cm
1 foot	=	0.30 m
1 yard	=	0.91 m
1 mile	=	1.61 km
Area		
1 square foot	=	0.09 m^2
1 square yard	=	0.84 m^2
1 acre	=	0.40 ha
Volume (dry)		
1 cubic yard	=	0.76 m^3
1 bushel	=	36.37 L
Volume (liquid)		
1 fluid ounce (imp.)	=	28.41 mL
1 pint (imp.)	=	0.57 L
1 gallon (imp.)	=	4.55 L
1 gallon (U.S.)	=	3.79 L
Weight		
1 ounce	=	28.35 g
1 pound	=	453.6 g
1 ton	=	0.91 tonne
Pressure		
1 pound per square inch	=	6.90 kPa
Temperature		
˚C	=	(˚F – 32) × .5556

Fruit Conversion Chart		
Peach bushel	=	44–50 lbs
Pear bushel	=	44–50 lbs
Plum bushel	=	50–56 lbs
Cherry quart	=	1.5–1.75 lb
1 (metric) ton	=	2,205 lbs

Abbreviations		
%	=	per cent
°	=	degrees
bu	=	bushel
cm	=	centimetre
cm^2	=	square centimetre
ft	=	feet
g	=	gram
ha	=	hectare
in.	=	inches
kg	=	kilogram
L	=	litre
m	=	metre
m^2	=	square metre
mL	=	millilitre
t	=	tonne

Notes

ontario.ca/crops