

Pruning and Training Apple Trees

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Introduction

Pruning and tree training are two of the more powerful horticultural techniques available to the tree fruit producer. Properly applied they can help to prevent or overcome many of the problems in the mature orchard. However, they can also be the cause of problems. A good understanding of the training system, just what pruning can do and what limitations are imposed by the nature of the tree is therefore important if one is to obtain the desired production and fruit quality from the orchard.

There are many styles and methods of pruning. This can bewilder even the experienced orchardist. However, there is no confusion if you remember that there is no one best way to prune. In each case, the choice will depend upon what the starting conditions are and on what the objectives are.

Training refers to the development of the structural framework of the trees. While some training may be necessary after the tree comes into production, this activity is largely confined to the nonbearing years. The objective of the training program is to develop a framework that effectively displays a large surface area of the tree canopy to full sunlight and support heavy crop loads. Pruning is part of the training program.

Through practice, good observation and careful consideration of objectives it is possible to make pruning easier and achieve desired effects. The present guide is intended to serve as a continuing reference as you learn from personal experience and observations.

When to Prune

There are two preferred times to prune. When the tree is dormant and in the summer when terminal shoot buds have been formed. In N.S. and N.B., climatic conditions dictate the dormant pruning period because pruning can contribute to winterkill or freezing damage. The safe period for dormant pruning is usually from early March to the end of April. Late fall or early winter pruning is especially risky because the trees have not fully hardened off and prepared for maximum cold. Pruning can delay this process, especially so if many cuts are made.

Freezing damage and its severity to the cambium layer of the bark can be related to late fall and early winter pruning. Pruning during extreme temperature lows or temperature swings in the dead of winter can contribute to winter injury. Growers that can not wait until early March to begin pruning should at least wait until the end of January and prune during stable weather conditions. The risk factor associated with pruning in late January and February can be reduced

by only pruning blocks that are (i) due for removal in the near future, (ii) those that bore light crops, and (iii) trees which require only light pruning or hardier varieties.

Growers can continue dormant type pruning up until bloom time but once growth has started, the growth response to pruning cuts will be less than desired. In NS and NB, summer pruning may be done the last of July into early August once the terminal bud has been set. Summer pruning prior to this can promote weak shoot growth which is more prone to winter kill.

Some Principles of Pruning

1. Pruning can never make a tree larger, parts of the tree are removed and thus it is a dwarfing process.
2. Pruning encourages shoot growth; there are fewer buds (shoots) to compete with each other, thus each grows somewhat more.
3. Pruning is more dwarfing and less invigorating when done after growth has started versus dormant pruning.
4. Removal of large branches removes more reserves. This is less stimulating and thus more dwarfing than the removal of many small branches having an equivalent number of growing points (buds).
5. Pruning must be combined or integrated with other practices such as fruit thinning, fertilization, irrigation, spraying, etc. according to economic conditions for the best results.
6. Young trees should be trained not pruned; it is better to prevent undesirable shoots from developing than to waste the tree energy in producing twigs, which must be cut off before they have fruited.
7. A single strongly growing dominant terminal shoot will induce wide angles on any basipetal lateral shoots. It will also tend to inhibit the initiation and development of lateral shoots.
8. Correct pruning becomes more critical as the tree becomes crowded; in modern intensive plantings, training and pruning must be carefully planned and executed.
9. Train and prune so that a bearing surface will develop and can be easily maintained where you want it. Ideally, each leaf should receive the equivalent of at least 50 percent full sun skylight every day. This means the canopy should not be over two leaves equivalent in thickness and well spread over the orchard area. While such an arrangement is not fully attainable in practice, it is well to know that this is the goal towards which we are striving.
10. Cuts should be close to the branch or limb (Fig. 1a & b). Do not leave sticks or snags, which may die back, heal slowly and leave a point of entry for disease. Under cut large limbs to prevent stripping of bark from the trunk (Fig. 1a). Wound dressings, such as the asphalt emulsions may be applied to large cuts (5 cm or larger in diameter). This generally is not required if the trees are in good vigor and correct pruning cuts (flush and smooth Fig. 1c) are made. Wound dressing has not been required for trees grown on the dwarfing rootstock.

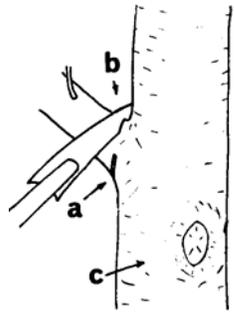


Fig. 1: Correct method for making pruning cuts.

Light Interception and Tree Form

The productivity of an orchard is directly related to the amount of light intercepted by the orchard canopy. Light which influences flower bud formation, productivity and fruit quality is a major limiting factor in fruit production. Therefore one of the main goals of pruning and training apple trees should be to maximize light capture and distribution within the tree canopy. Tree form and size along with tree density will determine the percentage of light captured on a per area bases that can be utilized for fruit production.

In general, the effective light penetration into the tree canopy is approximately one meter. Based upon this fact, the canopy of a large tree can be broken down into three zones with regards to light penetration (Fig. 2). Zone one located in the top portion of the tree receives 100 to 60% full sunlight; zone two receives 59 to 30% full sunlight and zone three receives less than 30% full sunlight.

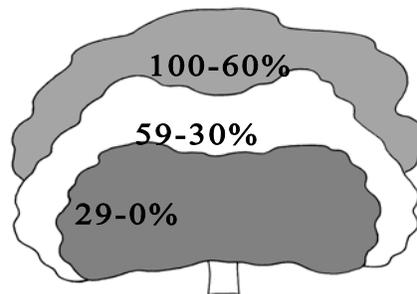


Fig. 2: Light Penetration.

Once light levels drop below 30% of full sunlight, flower-bud formation is reduced, spur vigor is lost and fruit that is produced in this zone is small and of poor quality. With time, fruit production will decline in this area as a result of fruit spur death. Zone three is a non-productive zone and the size of this zone is influenced by tree size, form and pruning.

Tree size has a significant influence on the area of zone three within the tree canopy. This area of inadequate light can vary as much as 25% in a large central leader tree to as little as 1.6% in a dwarf central leader tree (Fig. 3). The smaller area of a nonproductive zone is one of the reasons why smaller trees can be more productive than large trees. Consideration also needs to be given to shading of adjacent trees. With increasing tree height there is a greater tendency for the top of the tree to shade the bottom of the tree, the bottom of adjacent trees or the bottoms of adjacent rows. In freestanding trees, the height should not exceed the spread of the branches. In tree walls and trellis systems, the height should not be greater than the distance between rows.

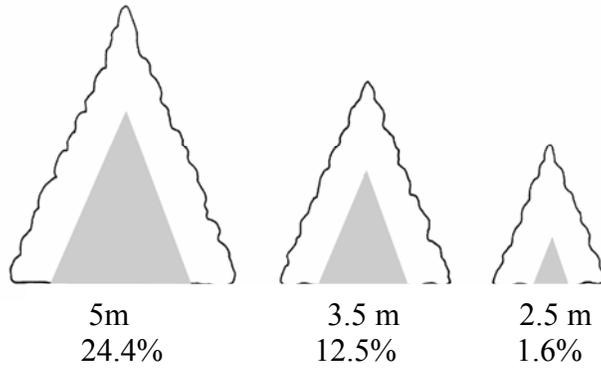


Fig. 3: Effect of tree size on light penetration and the non productive zone

Tree shape also affects light distribution within the tree canopy and the areas of the three zones. A conic or pyramidal shape such as a central leader tree, produces a much more favorable light distribution than that of the globular form which was typical of standard trees (Fig.4).

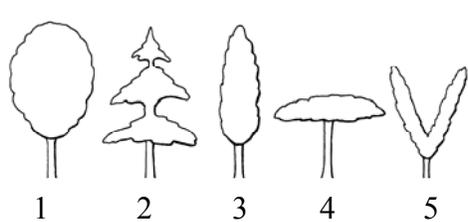


Fig. 4: Common tree shapes.

The most common tree forms that apple trees are trained are as follow: 1) Globular - is characteristic of large open centered trees where the most productive portion of the tree is top third, where the fruit is less accessible. 2) Conical or pyramidal - this would be characteristic of a Christmas tree shape with an open framework. The top of the tree does not shade the bottom branches and a major part of the bearing surface is close to the ground. The open framework will allow light to penetrate well into the canopy. Central leader and spindle this form. 4) Horizontal canopy - where the thickness of the canopy is limited to about 1 m, which allows for effective light penetration to the full canopy. The Lincoln canopy is a good example of this tree form. 5) Y or V form - allows for maximum light penetration while providing growth control and influencing productivity. The Tatura V trellis and the New York Y trellis are examples of this form. The conic, vertical tree wall and Y or V trellis shapes lend themselves best to fruit production in the Atlantic Region.

The natural growing habit of apples varies from variety to variety. The work of Lespinasse in classing apple trees into four categories as to their natural growth and fruit habit is recognized widely in the tree fruit industry. The four classifications are based upon shoot gradient and the relative vigor of the branches within the branch hierarchy and fruiting habit. Understanding the natural growth habit of apple varieties will greatly assist producers in selecting a training system and developing the tree to a prescribed form.

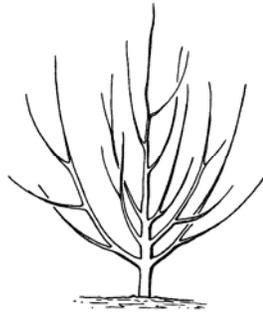


Fig. 5: Type I

Type I: The scaffold branches are conical and have a strong tendency to develop sub-branches on their lower side (basitony). The leader is not particularly strong varying among cultivars. The majority of the fruit spurs are located on branches 2 years and older. Spurs continue to be produced on old wood. Since the fruit remains close to the main branches the fruit zone follows the main structure of the tree. Spur type cultivars and Gravenstein would fit this type.

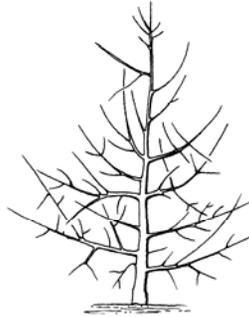


Fig. 6: Type II

Type II: The main branches have strong wide angles. The central leader shows greater dominance than the spur type varieties. There is still a tendency for sub-branches to develop on the lower surface of scaffold limbs particularly when grown on vigorous rootstocks. The majority of spurs are located on branches that are 2 to 4 years of age. As a result, the fruiting zone has little influence on the tree form. McIntosh and Spartan are examples of this type.

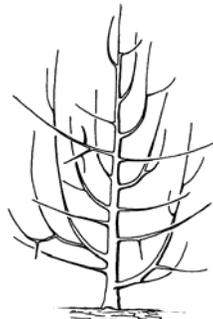


Fig. 7: Type III

Type III: The leader dominates the tree's branches. Fruit branches are at wide angles (60 to 90) to the trunk. There are short shoots. As the tree matures the fruit zone moves rapidly away from the main structure of the tree.

the centre of the tree. In the natural state this causes a bending of the main branches. Fruit is no longer born on these branches but on younger lateral wood. Golden Delicious is an example of this group.



Fig.8: Type IV

Type IV: These cultivars rarely develop lateral shoots on the lower portion of the limb. Branching is more prominent on the upper third of the leader and limbs. Main limbs become elongated through successive arching. The fruit zone moves towards the outside of the tree and more rapidly than type III trees. The majority of fruit spurs are located on young 1 and 2-year-old wood, either in a terminal position or in a lateral position after arching of the branch. The early development of tree branches generally has an upright habit. Cortland is a good example of this group.

Training Systems

Tree training systems have been with us since the early cultivation of apple trees. In the 16 and 17th century historians wrote about actual planting systems and intensive training systems that were used in small gardens established near monasteries and castles. Orchard planting systems evolved with time and continue to be developed on a regular basis to fit a particular cultivar or growing trend. This publication only concentrates on five systems which should lend themselves to the present production trends in the Atlantic Region.

System 1: 155 System

In today's production trends this system would be classed as a low-density system, which does not require tree support. Trees planted to the 155 system are spaced at a distance of 4.3 m in the row and 6.1 m between rows for a tree density of 383 per hectare or 155 trees per acre. This system makes use of semi-standard or semi-dwarf rootstock depending upon soil conditions and the cultivar being planted. The tree is trained as a central leader tree making use of scaffold renewal pruning systems once the tree has become mature. The mature tree is maintained at a height and spread of 4.3 m.

It is essential that the trees be trained to a pyramidal or Christmas tree shape in order to maintain a large productive fruiting zone. Limbs located in the upper portion of the tree must never be allowed to spread outward and dominate over limbs located in the bottom portion.

The basic frame is a 5-way tree. There should be a central leader above four well-spaced laterals (permanent scaffold limbs). Preferably, these laterals should form an X along the row rather than a +. This limb ordination allows for better spray penetration and ease of harvesting.

Fruiting spurs should be developed within the canopy for most cultivars so that fruit is carried throughout the tree. If the trees are pruned regularly there will be good light penetration thus, maintaining a healthy bearing surface within the canopy. When the proper tree frame is established from the beginning, and prescribed pruning procedures are followed annually, this system should produce a good crop of quality fruit.

The Young Tree: The first two to three growing seasons following planting is the important time for establishing a balanced tree frame. Keep the leader dominant and in balance with the four laterals. Head back one year whips to 1-1.2 m at time of planting to induce strong leader growth and lateral breaks (limbs) at the desired distance from the ground. Generally, the first permanent scaffold limb should be at least 60 cm above the soil line to allow for cultural operations under the tree canopy. In the case of type four varieties, this limb should begin even higher from the soil line. When branched trees are planted, head the leader back by one third to one half depending upon leader vigor. The weaker the leader the more you will need to head it back to promote strong growth. If there are less than four limbs on the tree remove or stub back all limbs to avoid the development of strong laterals that compete with the leader.

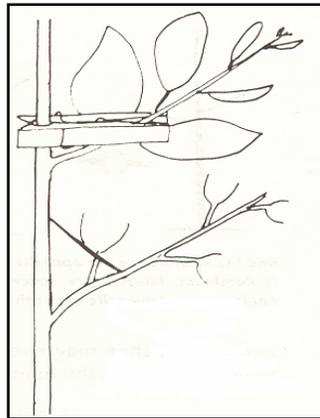


Fig. 9: Limb spreading

Keep the leader dominant and in balance with the four laterals. Avoid allowing limb diameter to become greater than half of the diameter of the leader directly above the limb. Spurs and sub-laterals should not be removed, merely kept in bounds and not too competitive with the four main lateral limbs. Use cloth pins, twine or other spreaders where necessary to correct crotch angles and control vegetative growth. Lower scaffold limbs should be spread to form crotch angles of 60° to 45° from the vertical. Prevent unwanted growth through frequent pinching in spring and summer rather than making corrective pruning cuts in the dormant season.

The Developing Tree: After the basic tree structure is established it should not be necessary to do much pruning until the tree has borne several crops of apples.

The Mature Tree: It is of primary importance that cropping commence when the trees are nearing one-half of their mature spread (that is when the tree is 2 meters across). Cropping is a component of the training system because it influences tree vigour and structure. The influence of cropping on training can not be substituted for by pruning.

When the trees have been cropping and are beginning to fill their allotted space, it is time to begin the mature pruning phase. Pruning of the mature central leader tree should primarily take the form of containment pruning. This pruning is designed to control the size of the full mature tree

by about one-third. Thus, the trees have only about one-half of the canopy volume that they would develop if they were not contained. This pruning has been called “Scaffold Renewal”, the 2-step method or the 4-step method. This style of pruning is very similar to the “Slender Spindle” method. The central leader above the four main laterals should essentially be handled as a slender spindle as well as each of the main laterals. In essence, pruning is the removal of 1 to 3 of the largest limbs in the thickest upper parts of the tree with follow-up in details as required by the variety. If a renewal limb is desired in the same location as the limb being removed then use a 45° cut or stub cut (Fig. 10).

To facilitate the management of pruning labor the “Scaffold Renewal” method should be done in two distinctly separate operations; large cuts first and detail cuts second. The detail cut may be subdivided into 3 operations: (i) removal of strong upright new shoots arising near or on the lower trunk, (ii) removal of down-hanging low branches, and (iii) detailed handwork along the remaining branches as necessary to grow the size of fruit required in the market place.

System 2: Spindle Bush

Basically this training system is similar to the 155 system in that a central leader training method is used to develop a cone shaped tree supported by a post or wire support system. The training form is suitable for medium-to-medium high density planting with tree height varying from 2 to 3 meters in height and spread. This tree size necessitates the development of a permanent set of scaffold limbs in the bottom third of the tree canopy. Early cropping is desirable where good growth is being obtained in order to control tree vigor and retain the mature tree to its allotted tree spacing.

The Young Tree: The first two to three seasons following planting are the important time for establishing a balanced framework. Keep the leader dominant and in balance with the four laterals. Head back one year whips (1-1.2 m) at time of planting to induce strong leader growth and to induce lateral breaks at the desired distance from the ground. Generally, the first permanent scaffold limb should be at least 45 cm above the soil line to allow for cultural operations under the tree canopy. In the case of type four varieties this limb should begin even higher, 60 cm, from the soil line. In cases where branched (feathered) trees are planted, remove limbs that are closer than 45 cm to the soil line as well as any broken limbs or those with narrow crotch angles. The desired crotch angle should be 60° to 45° from the vertical depending upon the growth habit of the variety. If there are less than four remaining laterals left following the removal of undesirable limbs then these should be either removed or stubbed back in order to prevent strong and uneven lateral growth in the bottom portion of the tree. The objective should be to develop four laterals evenly spaced in the bottom third of the tree canopy with diameters that are not more than 50% of the diameter of the leader directly above it. When possible, avoid selecting permanent limbs that stick out directly into the alleyways. Strive for an “x” configuration for the permanent scaffold limbs. Prevent limbs from developing opposite each other on the trunk or too close together on the trunk as they will weaken leader growth. In the Atlantic Region, branched trees can fail to get off to a good start growth wise. The root growth in the year of planting may not be rapid or extensive enough to keep up with the demand of the growing points on a branched tree. It is therefore suggested that laterals be headed back by one third to one half the year of planting to promote stronger scaffold growth. The leader should also be headed back to approximately 30 to 40 cm above the highest retained lateral. To promote strong leader growth, pinch out competing shoots which develop just below the heading cut. In most cases two to three shoots will require removal. The growing point should be pinched out of shoots that are too strong compared to surrounding shoot growth. Use clothespins or wooden toothpicks to improve crotch angles for those varieties such as spur-type Red Delicious and Northern Spy, which tend to produce shoots with a strong upright growth habit.

Pruning cuts in the second and third years should be restricted as much as possible in order to induce early cropping where tree canopy permits it. Maintain leader dominance by eliminating competing shoots and only head the leader where the past seasons growth was less than 45 cm. If leader growth is excessive it can be cut back to the next suitable weaker lateral (this is tied up and trained to take the place of the removed leader). Remove laterals with poor crotch angles that cannot be corrected by tying or spreading. Head back selected scaffold branches only if; 1) extension growth has been poor or excessive, 2) the plane of the limb is bent beyond 45% (tip of the limb is bent towards the ground) and 3) if the cultivar normally develops few side branches i.e. Cortland. Spread or tie down laterals of cultivars that have a strong upright growth habit and/or are slow to come into production.

The Developing Tree: The objective in developing the tree to its mature status should be one of obtaining a balance between vegetative growth and fruit production. Leader dominance is important and if allowed to become too weak from over cropping or lateral limb competition, it may be lost. Loss of the leader in many cases results in a reduced tree canopy which translates into reduced productivity. On the other hand, if it is allowed to become too strong, lateral growth and development will be reduced impacting negatively on production. A good leader is maintained by spacing branches well apart and not allowing several branches to develop at the same height. Not allowing laterals to be more than 50% of the diameter of the trunk directly above the lateral will also assist with leader development. Light fruit cropping is permitted in the third year provided that good tree growth is being obtained. Avoid cropping on the upper third of the leader, as it will weaken the leader.

The Mature Tree: Use the method outlined for the pruning of mature trees in the 155 system.

System 3: Slender Spindles

Apple trees trained to the slender spindle system have more of a conical shape than the pyramidal shape of a central leader or spindle bush tree. This shape is achieved by limiting lateral limb growth through partial or total removal. A 45° cut (Fig. 10) is used when removing limbs in order to promote a new lateral from the same location on the trunk. Limbs are trained to or below the horizontal position in order to control tree vigor and induce early fruit production. The slender spindle system lends itself to high density plantings on dwarf rootstocks with a tree height of 2 m or less. Tree density can vary from 2000 to 5000 trees per hectare depending upon the use of single row or multi-row bed plantings.



Fig.10: Limb renewal with a 45° Dutch cut

The Young Tree: One year old, well branched (feathered) nursery trees are preferred for this system. Obtaining this quality of nursery trees can be difficult and growers in the Atlantic Region will often only have the choice of planting one-year-old whips. One-year whips should be headed back at the time of planting. The heading height will depend upon the variety and

strength of the whip. Varieties that branch well such as Jonagold and Gala can be headed back to 80 to 85 cm. In the case of weak whips or varieties that do not tend to branch freely head back to 75 cm. This will help to ensure for lateral branch development 50 to 70 cm above the soil line. These vigorous limbs at the base give the tree its proper shape. As the tree matures the base framework prevents overgrowth in the upper portion of the tree and allows for the regular renewal of fruiting branches in the lower portion of the canopy. In situations where the spacing between trees is 90 cm or less, it is recommended that the leader not be headed. Where well branched (feathered) nursery trees are planted head back the leader to no more than 90 cm above the ground line or 20 to 30 cm above the highest retained lateral limb. Remove all limbs that are closer than 50 cm above the soil line. Head back the lowest remaining laterals to 25 to 30 cm to avoid blind wood and weak basal branches. This will help to encourage spur development back to the trunk. As you go up the tree, head back the laterals more aggressively to create the desired pyramidal shape and to promote vegetative growth in the year of planting. The first, second and perhaps the third laterals from the top should be bench cut to prevent them from becoming dominant and reducing growth of the lower limbs. Limbs that have a diameter that is 50% or greater than the diameter of the trunk directly above it should be removed to prevent weakening of the leader. In the case of poorly feathered trees, those with fewer than 4 branches should have all laterals closer than 50 to 60 cm from the soil removed and then bench cut the remaining limbs and head back the leader the same as that described for a whip.

In the spring following planting remove blossoms to promote shoot growth. Once new shoot growth is 5 to 10 cm long remove laterals that are closer than 50 cm from the ground. Do not tear out shoots that are competing with the leader. They should be removed with a bench cut which will induce the tree to produce new, flat-angled limbs from the less vigorous lateral bud. In late July or early August tie down only the stronger shoots to reduce their growth and stimulate more growth on the weaker laterals. These limbs should be tied down so that terminal tip is facing the ground. This will provide for a more balanced growth within the tree. The summer tying down will also induce stronger fruit bud compared to limbs tied down in late fall or early winter. Tying down of weak shoots is not necessary.

Dormant pruning following the year of planting is determined by tree development and the amount of training conducted during the year of planting. If tree training was carried out then the need to dormant prune should be limited. Branches which grew less than 20 cm, should be lightly headed back to prevent flowering and to increase shoot growth. Stub cut any broken limbs to 2.5 cm. Laterals that are too strong and are competing with the leader should be removed using a stub cut. Head upright shoots longer than 20 cm to a stub of about 6 cm. If tree development was poor the year of planting it is best to start the tree over. A poorly developed tree would be one with weak terminal growth and/or less than four lateral shoots. Bench or stub cut all the laterals and head back the leader. Tip any dards to remove the potential for bloom in the spring. If there are sufficient laterals but they are weak the first option is to leave the leader and head back the laterals. The other option would be to bench cut the laterals and head the leader which delays the development of the leader by one year and allows the laterals to catch up. Score buds where laterals are desired. Scoring should take place when tree development is at green tip. In some apple growing areas fruiting is allowed in the second year. In the Atlantic growing region this is not advisable as tree growth does not generally permit this and planting densities are not high enough where cropping is needed to control vigor.

Leader control is a very important component of this training system. The objective is to avoid strong leaders and lateral growth in the top of the tree, which will negatively affect cropping and growth in the lower scaffolds. There are several methods which can be used to control leader vigor. One is to remove the central leader by heading into 2-year old wood to a competing lateral

and tying the lateral up to form the new leader. An alternative to this is bending the leader over the previous summer, then return the leader to the other side of the post the following spring. The leader is not headed. These two methods develop a zigzag trunk which has an influence nutrient flow to the upper portion of the tree and reduces tree vigor. An alternative method for leader control is to use a May or June cut (Knip). This is recommended where the in row spacing is greater than a meter. A late May or early June cut to the leader will force flat-angled side branches from flower buds. A May or June cut is used instead of a dormant cut because the dormant cut may be too invigorating. Dormant pruning also results in sharp angled limbs in the top of the tree. The greatest response to this cut is immediately below the cut whereas side-branching is needed throughout the top. A May or June-Knip is made by cutting back the leader to the upper most flower cluster unless the leader is too long and the last cluster will be very high. Do not cut higher than 60 to 70 cm above last year's heading cut. It is preferable to cut to a flower bud as there is less of a growth response than cutting to a vegetative bud. A cut to a leaf bud will stimulate growth immediately below the cut, while side-branching is needed throughout the top. Varieties such as McIntosh and Spartan which do not throw many side laterals can be cut lower to avoid too much blind wood between the base framework and the next layer of limbs.

In August, tie down shoots with sharp crotch angles or remove them with stub cuts. Tie down strong shoots that have grown from bench cuts bending them below the horizontal. These can be used for scaffold limbs in the lower portion of the canopy. While selecting and training laterals, follow the 50% rule. The limb diameter should be less than 50% of the diameter of the trunk immediately above it. This will prevent the growth of vigorous lateral limbs while providing balanced growth throughout the tree and a healthy leader.

Pruning and Training the Bearing Tree: Continue to train the upper portion of the tree as described above until the tree has reached the desired height. Once the desired height has been reached, maintain the leader by replacing it with a slide limb as needed to control tree height. Avoid heading cuts in the top of the tree so as to prevent excessive vigor in this portion of the canopy. If excessive vigor is a problem then delay the leader replacement until June, which will help reduce re-growth. Lateral limbs that have become too strong should be removed. The number of scaffolds in the bottom section of the canopy should gradually be reduced to 4 or 5 which are evenly spaced in the 60 to 90 cm range from the soil line. Using renewal type cuts remove one to two laterals per season in order to avoid excessive re-growth.

Where required, tie limbs down to control growth and inducing cropping. When tying down limbs in the lower portion of a tree position them near the horizontal. If bent beyond the horizontal it will weaken the limb too much for this position within the tree canopy. Limbs that are above the first set of scaffolds should be tied so the growing point is facing the ground. Do not prune tied shoots in the year which they are tied down. If they become too long shorten them after 1 to 2 years by cutting to a flower bud or a weak downward to the horizontal lateral. Training is completed when the tree has filled its space. A well trained tree should have a tapered appearance with weak fruiting laterals in the top of the canopy with limbs getting progressively larger as limbs descend down the leader.

The Mature Tree: Once the tree has filled its spacing, pruning should be maintenance to provide good light penetration throughout the canopy so that the desired fruit quality and production can be obtained. Pruning should be conducted in such a manner so that fruiting and vegetative growth is in balance. Remove all upright shoots that are not needed for replacement limbs. Limbs that are not removed need to be bent to a position that is appropriate for the variety and the position of the limb within the canopy. Thin out fruiting branches with renewal cuts when shading starts to affect quality and production. Renew fruiting wood above the lower set of

scaffolds by replacing weak laterals with renewal cuts. This renewal pruning should be conducted over a period of time to avoid excessive vegetative growth.

The six main points to follow in pruning and training slender spindle trees are:

1. **50% rule for the central leader.** Leave no branches larger than 50% of the leader's diameter. It is preferable to leave the leader un-headed.
2. **Remove excessive and older wood.** This will enhance light penetration and renew wood even if it is less than 50% of the trunk diameter.
3. **50% rule on co-dominant branches.** Leave no side wood greater than 50% of the branch diameter.
4. **Thin.** Remove spurs underneath and cut back hard into weak, hanging wood.
5. **Head back branches.** Stiffen up and keep tree compact with healthy wood close to trunk.
6. **Limit tree height only when tree is in full cropping state.** Ensure a low-vigor response at the top, but with lower parts of the tree open and vigor enough to promote young, healthy flower buds.

System 3: French Axe (Central Axis)

The French Axe training system was developed in France by J. M. Lespinasse and is a modified central leader training style with a narrow pyramid shape. This system takes advantage of the natural growth habits of the variety to develop a proper balance between vegetative growth and fruiting. This system also allows for early cropping, reduced pruning and training time, improved light distribution within the canopy thus, increasing fruit size and color. The natural growth habit and balance between fruiting and growth is used to control fruit size instead of pruning. Therefore, minimal pruning is a key element of this system. Trees trained to the French Axe are generally planted in single rows to form a fruiting wall at maturity. A support system is generally used with this system as it allows for a more rapid development of the leader to the desired height. A trellis system consisting of 1 to 3 wires and ranging in height of up to 4.3 m, depending upon the rootstock variety combinations, is used to support and train the leader. Where a one-wire trellis is used, the leader is often supported by bamboo or conduit piping attached to the single wire at the top of the trellis by a clip. Tree planting densities used for this training method vary from 650 to 2700 per hectare with row spacing of 1.2 to 3 m and between row spacing of 3.6 to 4.6 m.

The Young Tree: With all high density planting and training systems, the planting of large well feathered trees is recommended as these trees will fill their allotted spacing, allow for earlier fruiting and reach full production sooner. In reality, this type of tree is very difficult to obtain in the Atlantic Region and for the most part in North America. In most cases growers will be starting with one year whips and these should be headed to 80 to 85 cm at the time of planting or just after to promote lateral shoot development at the desired height. If a poorly branched tree is planted it would be advisable to start the tree over by removing the laterals with a stub cut and heading the leader back to 80 to 85 cm. Failure to do so will lead to strong limb growth in the bottom portion of the tree, weakened leader growth and result in unbalanced vegetative growth within the tree. Where a well-feathered nursery tree is planted (5 to 8 strong laterals with wide crotch angles) remove laterals closer than 45 cm to soil line, remove laterals from the top third of the tree, and remove laterals with a narrow crotch angle. Leave only 5 to 6 large laterals between 45 and 75 cm evenly distributed around the trunk. Remove one or two when they are directly

over one another, leaving laterals spaced up and down the axis, not all at one height. Under shorter growing conditions it is advisable to head back the leader 25 to 30 cm above the highest retained branch to promote strong growth in the bottom portion of the tree. In areas with a longer growing season or where fall planting is permissible, heading of the leader is not required.

Tree training and vegetation manipulation is the key to the success of this system. In late spring or early summer, select the strongest shoot in the top of the tree as the leader and remove any other shoots at the same level and for 7.5 or 10 cm immediately above the highest retained lateral shoot. Pinch back shoots that appear to be upright and strong enough to compete with the leader. This should be done every 2 to 3 weeks. Pinch out the growing points on laterals that are growing too strong and are out of balance compared to the growth of other laterals. Remove laterals that are closer than 45 cm to the soil line. Spread or tie down is only recommended for those varieties that produce thick, strong laterals low in the tree such as Gravenstein and spur type Delicious. Spread or tie only those limbs that appear to need it.

In the second year, no dormant pruning should be required if proper summer training was carried out. If summer training was not carried out, remove competing laterals, vigorous upright growth, low branches and poorly placed growth. The leader is not headed. Where poor tree growth was obtained, less than four laterals and/or weak shoot growth, it is recommended to start the tree over again. At bloom, head the leader lightly only if the terminal bud is a flower bud. This may happen with the more dwarfing rootstock such as M 9. When new shoot growth is 7.5 to 10 cm long break out or pinch back those that appear to be competing with the leader. During the growing season, monitor shoot growth and if the central leader is not growing ahead of the side laterals, pinch back side limbs to encourage greater growth of the leader. Do not allow vigorous growth to remain on the tree. Remove any fruit that has set. Bending may be required as mentioned for year one.

In year three and four, carry out similar training techniques. However, limited cropping can begin in year three provided adequate growth has occurred. The ideal French Axe tree will be one that has a lower tier of about six limbs of similar diameter and positioned from 0.6 to 1.1 m above the ground. Above that tier is a gap with only small fruiting arms so that adequate light reaches the lower tier. Above the gap is an informal array of fruiting limbs which are not permanent, but are renewed close to the central leader after they have fruited and bent downward. The bottom portion of the tree must always be wider than the top. The ease of accomplishing this will depend upon the variety and its natural growth habit. In the case of group 1 type trees which have a basitonic growth habit the branches in the bottom portion of the canopy can become dominant resulting in poor leader development. It will be necessary to reduce the number of laterals in the lower portion of the tree to retain strong leader growth. The reverse to this are type four trees with an acrotonic growth habit such as Cortland. The top portion of the tree can become stronger than the lower branches. Selective removal of limbs in the top portion of the tree is required to encourage stronger growth in the lower portion of the tree. Type two and three trees lend themselves more easily to this training system.

Once the tree has come into production, the number of limbs in the bottom tier should be gradually reduced. The least desirable should be removed on an annual basis until there are only four scaffold limbs in the 0.6 to 1.1 m zone above the soil line. Shorten bottom tier scaffolds where needed back to side branches to allow for equipment movement and to maintain fruit quality. Shorten branches that have become pendant (hanging down) back to a horizontal portion of the branch. By year five it may be necessary to start renewing scaffold in the upper portion of the canopy. Remove one vigorous limb each year with a renewal cut (45 degree or stub cut).

The Mature Tree: The main objective of this training system is to maintain a balance between fruiting and vegetative growth. Heavy pruning will favor vegetative growth while lack of vigor will favor cropping and poor quality fruit. In the Atlantic region, lack of vigor with dwarf and semi-dwarf planting seasons is more common than excessive vigor.

Where required, shorten bottom tier scaffold limbs to side branches to allow for machinery movement and to maintain fruit quality. Continue to remove one to two scaffolds in the upper portion of the tree canopy on annual bases using renewal cuts. This will renew fruiting spurs and allow for good light penetration to the lower scaffold limbs. When pruning use thinning types of cuts as much as possible as they are not as invigorating as heading cuts. It is often desirable to thin branches back to laterals so that fruit is produced closer to the trunk. Heading cuts should only be used where stiffening of a limb is desired.

System 4: Formal Trellis Systems

There are a number of formal trellis systems and they all have merit under certain growing and financial conditions. The Tatura, adaptations of the Tatura and the Y trellis system have been the most widely used trellis systems in North America in recent years. These systems develop a “V” shaped canopy with all limbs being in the same fruiting plane. The advantages of this system are that it’s productive, produces high quality fruit and dwarf rootstocks are not required. The drawbacks are that the trellises are elaborate, expensive and meticulous tree training is required.

The heights of these systems depend upon the rootstock and variety combination but generally do not surpass 3.25 m in height with 60-degree trellis frame. A slightly sharper angle can be used where more tree vigor is desired. The distance between the upper tips of the trellis posts in adjacent rows must be at least 1.8 m. The spacing of trees in the row varies between 0.9 to 1.8 m (depending upon scion/rootstock vigor and soil type) and 4.3 to 5.8 m between rows. Tree density per hectare ranges from 944 to 2,562 trees. The Tatura uses up to 15 wires depending on the height of the trellis while the “Y” trellis uses 4 to 10 wires. The wires are attached to the post at intervals of 60 cm with the upper two wires spaced closer at 45 cm.

The Young Tree: The main difference between the “V” and “Y” trellis is the height at which newly planted trees are headed at following planting. In the “V” trellis, the trees are headed at 20 cm while in the “Y” system the heading cut is made at 65 cm. In the “V” trellis, two strong shoots are selected below the heading preferably on the sides close to the trellis wires and trained onto each set of wires. When these two shoots are 45 to 60 cm long they are brought outside of the wire before they become too stiff. To avoid splitting of the crotch these two shoots should be 2.5 to 5 cm apart and not directly opposite each other. The two primary scaffolds form the main framework and the development of sub-leaders or vigorous secondary branches should be avoided. If a branched tree is planted and has two limbs that are suitable for position onto the trellis, install the bottom wire about 30 cm above the origin of the scaffold limbs. The tree is headed just above these limbs and the two scaffold limbs are headed lightly to ensure for good growth. These two limbs are positioned outside the lowest wire. An adaptation to the development of two primary scaffold limbs is to plant two trees, one on each side of the trellis and staggered within the row. These trees can be developed with little pruning and thus will develop a full canopy more rapidly and begin fruit production 1 to 2 years earlier than trees headed low at the time of planting.

Very little pruning is required in the first 3 to 4 years when the canopy is being developed. Avoid making heading cuts. During the non-bearing years fasten secondary laterals to the outside of the wires to fill the gap between leaders. Bring upright shoots which originate from the main scaffolds outside of the wire when they are about 45 to 60 cm long. Do not bend these shoots

under the wire too soon as this can induce branching and reduce shoot growth. Thus, reducing the time it takes for the scaffolds to reach the top wire.

Attach laterals to wires as required. Position them at about 45 degrees from the axis of the scaffold. The angle can be increased towards 90 degrees in order to control tree vigor in the top portion of the canopy. It is advised to summer prune inside the trellis to remove strong upright growth which is not required for lateral canopy development.

The Mature Tree: Maintain approximately 1.2 to 1.5 m of open space between the tops of the trees in the row to allow for adequate light penetration down the limbs. Remove shoot growth that develops vertically inside the trellis to prevent shading and loss of fruit quality especially in lower portions of the trellis. The majority of pruning and training is conducted during the summer period. Continue to position shoots outside the wires until the canopy is fully developed. Remove shoots that cannot be easily positioned outside the wires. Depending upon the requirements of the variety, bend shoots towards the horizontal and attach them to the wires.

Where there is excessive growth above the top wire, prune this away in late summer to avoid strong re-growth which would occur from dormant pruning cuts. When laterals have become weak (which will occur more commonly in the lower portion of the trellis) renew these by selecting strong shoots originating near the leader.

Special Techniques

More often than not, limbs do not grow in the desired locations or in sufficient numbers to make tree training easy. Some varieties produce very few laterals the year of planting (Northern Spy) while other varieties (Jonagold) will produce a number of lateral shoots. There are training techniques that can be used to increase branching on the young trees of varieties that do not tend to branch freely. There are chemical treatments that can increase lateral bud breaks but these have not been widely adapted by the industry because of cost, variable results and ease of management. Three cultural practices that can also induce branching are bud notching, bagging and bending.

Notching buds can induce them to grow and develop into laterals. Notching is the removal of a section of bark above a vegetative bud. This can be done quickly with an ordinary hacksaw blade. Japanese saw blades, double hacksaw blades and knives can also be used for notching. The blade is placed approximately 13 mm above the bud and drawn horizontal across the leader or limb. This should remove a strip of bark about one third of the circumference of the leader or branch. Make sure that the bark is removed right down to the wood. This prevents the flow of the growth-inhibiting hormones from the tip of a shoot to the notched bud thus breaking apical dominance and subsequent bud growth. The optimum time of notching appears to be two to four weeks prior to bloom (green tip to ½-inch green). Shoots that develop from notched buds tend to have sharper crotch angles and will need to be corrected with clothes pins or tooth pick spreaders. Not all notch buds will break and therefore two or more buds should be notched in the desired location to achieve the desired results.

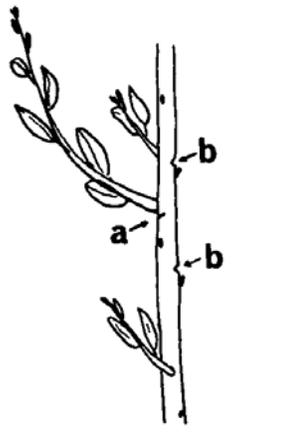


Fig. 11: Notching buds.

Bagging newly planted trees can induce a greater number of buds to break and form laterals. Bagging can be used on headed and non-headed trees and is generally utilized the year of planting. Bagging involves the placement of a plastic bag over the area of the tree where lateral limb growth is desired. Clear or tinted newspaper sleeves or plastic bags that are 35 cm to 50 cm should be used. The bags should be placed on the trees while the buds are still dormant, as bagging has no effect on bud break once growth has begun. Place the bag over the top of the tree and fasten the bag to the leader just below where the first permanent lateral is desired (60 cm from the soil line) with a twist tie. To prevent the bag from working itself off in high winds, fasten the bag to the leader with twist ties at the top and middle. On high or non-headed trees, push the top of the leader through the bottom of the bag and fasten the bag to the leader in the zone where branching is desired. The plastic bag has a greenhouse effect, promoting earlier growth and more lateral bud breaks. The bags are removed when shoot growth within the bag is 12.5 cm long. Results from bagging can be variable and placing bags over trees is time consuming. This technique is not readily used by the industry.



Fig. 12: Bagging newly planted trees.

Bending the tree leader can also induce lateral bud breaks but does not appear to be as effective as notching and bagging. The tip of the leader is tied down in later summer or during the dormant period so that it is facing the ground. This will affect hormonal flow and promote lateral bud breaks on the upper side of the leader. Once buds have broken, the leader is tied up into the vertical position or may be bent in the reverse position to promote lateral bud development on the other side of the leader. Bending the leader will reduce terminal growth which may or may not

be desirable depending upon the planting system. This technique lent itself to the slender spindle system more so than other planting systems.



Fig.13: Bending the tree leader.

Glossary of Pruning Terms

Acrotony(ic) : Branching predominantly at or towards the tip of a stem.

Basitony(ic): Branching predominantly at or towards the base of the stem.

Bench Cut: A heading cut to an outwardly growing lateral, usually of equal or less diameter than the branch being removed and often at an abrupt outward growing angle from the branch being removed.

Feathered maiden: A one year old nursery tree with branches (lateral shoots) on current season growth.

Heading: is also referred to as heading-back; is the removal of part of a shoot or branch.

Thinning or thinning-out: is the removal of an entire shoot or branch at its place of origin.

Spur pruning: is the removal of spurs or part of branched spurs, to eliminate weak spurs and reduce fruiting capacity, or improve fruit size and quality.

Stubbing: a severe heading cut where only a small portion of the branch remains (often 2.5 cm). A renewal pruning cut used to regenerate a fruit branch.

Leader: a shoot, which has been selected to extend the trunk.

Mechanical hedging and topping: the indiscriminate heading-back of shoots and branches.

Pinching: the removal of the tip of young shoots either by pruning or with the fingers.

Renewal Pruning: the removal of a branch at its point of origin on the lateral. A short stub can be left or 45 % cut used to allow for shoot development from this area on the trunk.

Spur-bound: A condition of a weakly growing branch or tree with abundant spurs and with little or no growth.

Summer Pruning: Pruning during the growing season.

Terminal Flowering: Flowering at the end of a shoot.

Whip: One-year-old nursery tree without lateral shoots.

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