Chapter 6

Pruning and Training

This chapter discusses the principles of grapevine dormant pruning, reviews reasons for vine training, and describes systems appropriate for use in North Carolina.

Profitable grape production requires that grapevines be managed so that a large area of healthy leaves is exposed to sunlight. Such vines are likely to produce large crops of high-quality fruit each year. Grapevines must be trained and pruned annually to achieve this goal. The training system chosen generally dictates how the vines are pruned. Thus, pruning practices and training systems are discussed together in this chapter.

Dormant pruning is probably the single most important task you will perform routinely in the vineyard. The term *dormant pruning* refers to the annual removal of wood during the vine’s dormant period. Grapevines are pruned primarily to regulate the crop but also to maintain a vine

conformation consistent with the desired training system. As we will see, pruning has both a shortand long-term effect on crop quantity and quality. Training positions the fruit-bearing wood and other vine parts on a trellis or other support. Except for renewal of damaged vine parts or system conversion, vine training is largely complete by the third year. Training should uniformly distribute the fruit-bearing units (nodes) in the vine’s row space to facilitate perennial vine management, including pruning, and to promote high fruit yield and quality.

Definitions

Knowledge of the terms used to describe a grapevine is necessary to understand pruning and training concepts. The current season’s crop is borne as one to several clusters on *shoots* that develop from dormant *buds* (Figures 6.1 and 6.2). Most buds are located at *nodes*, the conspicuous joints of shoots and canes (Figures 6.1, 6.2, and 6.3)

The drawings in **Figures 6.1 and 6.2 show the dormant bud and node of one-year-old cane. Figure 6.1 shows the parts of the compound bud has been cut cross-sectionally to reveal the arrangement of the bud’s inner structures: primary bud, secondary bud, tertiary bud, bud scales, node, leaf scar, and summer lateral scale. Figure 6.2 shows the recently emerged primary shoot at node of one-year-old cane. Figure 6.3 is a drawing of a dormant, grafted grapevine. Vine has been spur-pruned. In an in-spur close up, the base bud and count node are shown.**

Buds are also present at the bases of shoots and canes. Also, buds can remain latent at the less conspicuous nodes of trunks and other perennial parts of the vine. Buds not borne at clearly defined nodes of canes are referred to as *base buds* (Figure 6.3), and their shoots, which are often unfruitful, are termed *base shoots*. Shoots stop growing in late summer and become brown and woody during the *acclimation*, or hardening, process. Shoots are termed *canes* after leaf-fall. Lateral shoots often develop at the nodes of primary shoots. They, too, can become woody and persist after fall frosts. Buds borne at nodes are *compound*. Compound buds consist of several growing points, or *primordia*. The primary bud is the largest primordium, the first to break bud (emerge) in the spring, and it usually bears more flower clusters than do shoots developing from secondary or tertiary buds.

Additional terms describe grapevine parts in the context of a particular training system's integration with a trellis or other support. The *vine trunk* is the vertical support structure that connects the root system and the fruit-bearing wood of the vine. Trunks can have horizontal extensions of two-year-old or older wood. These extensions might be short *arms*, as in the umbrella kniffin system or long *cordons*, as in the bilateral cordon system. Arms and cordons, in turn, usually bear *spurs* (canes that have been pruned to 1 to 4 nodes) or canes (8 to 15 nodes). Trunks, arms, and cordons are generally retained for years. The shoots of a vine and their leaves represent the *canopy* of the vine. The *renewal region* is that region of the canopy where buds for the next season's crop develop. The renewal region is often, but not always, the fruiting region of the canopy.

Dormant Pruning

Reasons for Pruning

Dormant pruning is the primary means of regulating crop. If other factors do not limit productivity, vines pruned correctly are likely to produce large crops of high-quality fruit. Pruned incorrectly, vines and crop will ultimately suffer. It is important to understand how many nodes to retain as well as which nodes are associated with good cold hardiness and fruitfulness.

A mature, unpruned grapevine can have more than 400 buds. Overcropping would occur if all of these buds were allowed to grow and bear fruit. There are both immediate and long-term effects of overcropping grapevines. Immediate effects are observed in the current year. Symptoms can include reduced sugar accumulation in fruit and reduced pigmentation in berry skin. Rather than maturing into woody canes, the shoots of overcropped vines typically die back completely to older wood, or they may mature only one or two basal nodes (toward the base of the shoot). Poor wood maturation occurs because the maturing fruit competes for the necessary carbohydrates.

The long-term effect of overcropping is reduction of vine vigor (rate of shoot growth) and vine size (pruning weight). Vine size reduction due to overcropping can occur without a noticeable degree of cane dieback. Although wood might appear to be mature, stored starch reserves in vines stressed by overcropping can be so low that the next year's vegetative growth and crop will be severely reduced.

Although dormant pruning is the primary means of controlling the crop, it will not provide adequate control in all situations. Additional control through thinning of flower or fruit clusters is generally required with young vines (two years old or younger), with very fruitful varieties such as some of the interspecific hybrids, and in any case where the vine vigor and vine size are insufficient to fill the available trellis space.

Number of Nodes to Retain

Eighty to 90 percent of the one-year-old wood is removed from vines at dormant pruning. Before pruning mature grapevines, the vineyardist must decide how many nodes to retain. Overcropping and excessive canopy density will occur if too many nodes are retained. On the other hand, the crop will be needlessly reduced if too few remain. Furthermore, severely pruned vines are apt to produce excessively vigorous shoots because all of the stored energy in the trunks and roots is available to relatively few growing points. Excessive shoot vigor can reduce fruit set and delay shoot maturation in the fall.

Balanced pruning was developed to help vineyardists determine the appropriate number of nodes to retain. This method is based on the concept that a vine's capacity for vegetative growth and fruit production is a function of the vine's size. The size of a vine is determined by the

extent of growth of roots, shoots, and perennial wood. Because the growth of roots and other perennial wood cannot be conveniently measured, vine size is measured by weighing the one-year old wood (canes) removed at pruning. Essentially, we balance the number of nodes retained against the weight of pruned canes: more nodes should be retained on a large vine than a on small vine because the large vine has a greater capacity for both vegetative growth and crop production. Pruning formulas for many varieties have been developed to calculate the number of nodes to be retained for a given pruning weight (Table 6.1). A pruning formula of 20 + 20, for example, would require leaving 20 nodes for the first pound of canes removed, plus an additional 20 nodes for each additional pound above the first. A 3.2-pound vine would therefore retain 64 nodes if the 20 + 20 schedule were used at pruning. Weighing is done to the nearest tenth of a pound. With all pruning formulas, these are minimum and maximum numbers of nodes that must be retained. For example, a minimum of 15 nodes should be retained on vines that are two years old or older. Given 15 or more shoots, small vines will require some degree of cluster thinning to prevent overcropping, but the shoots and leaf area are needed to increase vine size. The maximum number of nodes to be retained on mature vines should be on the order of 4 to 6 nodes per linear foot of row space (for example, 32 to 48 nodes for vines spaced 8 feet apart in the row). The lower number would be more appropriate for large-clustered varieties; the higher number would be acceptable for varieties with small- to medium-sized clusters.

Table 6.1. Suggested Pruning Formulas for the Balanced Pruning of Selected Grapevine Varieties Variety Pruning Formula*

*The first number in the pruning formula indicates the number of nodes to retain for the first pound of cane prunings; the second number indicates the number of nodes to retain for each additional pound of cane prunings after the first. See text.

Cabernet Sauvignon 20 + 20

Cabernet franc 20 + 20

Chardonnay 20 + 20

Seyval 5 + 10

Vidal blanc 15 + 10

Other hybrids 20 + 10

Delaware 20 + 10

Niagara 40 + 10

(end of Table 6.1)

Nodes, specifically *count nodes*, are the units counted in the pruning formulas. Count nodes have clearly defined internodes in both directions on the cane. Once the appropriate pruning formula has been determined, the vine size is visually estimated and the number of nodes that should be retained on the pruned vine is calculated on the basis of that estimate. This requires some experience, but 5- to 6-foot canes average about 0.1 pound. The vine is then pruned, leaving 10 to 15 extra nodes as a margin of estimation error. The cane prunings are weighed with a hand-held scale and their weight is entered into the pruning formula to determine accurately the number of nodes to be retained. Nodes in excess of that number are then removed. Commercially, it is neither necessary nor practical to weigh cane prunings from every vine. In practice, most pruners acquire an ability to estimate the pruning weights and node retention closely. Thereafter, only an occasional vine is weighed to check estimates.

Pruning formulas (Table 6.1) allow for additional shoots to develop from noncount node locations (base buds). Generally, the native American and vinifera varieties do not produce many base shoots unless the vines have been pruned too severely. Many of the interspecific hybrid varieties, however, produce numerous, fruitful base shoots, even with moderate pruning. Balanced pruning of hybrid varieties has limited utility. Crop control with some hybrid varieties, notably Seyval, must be achieved through a combination of fairly severe pruning and shoot or fruit cluster thinning. (See chapter 7.)

There are other, more arbitrary means of determining the number of nodes to retain at pruning. Node retention figures are sometimes based on the linear row space or the square area a vine occupies. For example, mature vines trained to conventional, nondivided canopy training systems should generally retain four to six nodes per linear foot of row. Expressing node retention on the basis of the linear measure of row or the square area of vineyard is convenient; however, it ignores individual variation in vine capacity and can lead to overcropping of small vines or undercropping of large vines. It is not as precise as balanced pruning and is therefore not a recommended procedure where variation in vine size is great.

When to Prune

Vines can be pruned any time between leaf fall and bud break the following spring. However, there is evidence that fall-pruned vines are more susceptible to winter injury than vines pruned in late winter or early spring. Delaying pruning until late winter makes it possible to evaluate bud injury and compensate by increasing the number of nodes retained. Spring pruning does not harm vines, even when sap bleeding is observed; however, swollen buds and young shoots are extremely susceptible to breakage. Therefore, the removal of unwanted wood from the trellis should be completed before bud swell. Experienced pruners require 30 to 40 hours to caneprune an acre of vines. Somewhat less time is required for spur-pruned vines. Cane pruning and spur pruning are described in the section on grapevine training.

Double-pruning of vines is sometimes practiced in areas where spring frosts are common. At the initial pruning in late winter or early spring, canes or spurs are retained with two to three times the desired number of nodes. Buds nearest the pruning cut develop shoots as much as seven days earlier than the basal buds of the same cane or spur. To correct shoot density, a second pruning cut is made after the threat of frost before appreciable shoot growth has occurred.

What to Retain

The selection and retention of suitable fruiting canes and spurs is extremely important. Select only canes or nodes that show good wood maturation. This criterion is far more important than selecting wood strictly on the basis of its location in relation to a desired training system. Generally, dark brown canes with short internodes (4 to 6 inches long) are superior to lighter colored canes that have internodes longer than 6 inches. Canes that have internode diameters of ¼ to ½ inch are superior to canes outside that range. The diameter of a person’s small finger is an appropriate guide for a desirable cane diameter. Well-matured lateral canes or spurs can be retained as fruiting wood if needed; however, medium diameter canes lacking persistent laterals are superior to large canes bearing many persistent laterals. Canes associated with good bud fruitfulness and cold hardiness are located toward the exterior of the canopy where they received more sunlight than those canes that developed within the canopy.

Complications Due to Cold Injury

In many years, assessing and compensating for cold injury is an important aspect of pruning grapevines in this region. The retention of nodes is based on the assumption that buds of retained nodes are viable. If buds have been killed by freezing or other causes, the number of retained nodes must be increased to compensate for the injury.

Bud injury is assessed before pruning by evaluating the viability of a representative sample of buds from a given variety. Dead buds are identified by a browning of their primordia, which occurs after the frozen buds are allowed to warm for a few days. To determine if a bud is dead, make several consecutively deeper cross-sectional cuts through the bud to expose the individual primordia (primary, secondary, and tertiary buds of Figure 6.1). A sharp, single-edged razor is the best tool for this purpose. The primary bud, located between the secondary and tertiary buds, is most susceptible to cold injury. Dead buds will appear brown, whereas live buds will be a light green color. If buds are sectioned too deeply, the primordia may be missed, exposing the green tissue beneath the bud. The novice should gain some experience by cutting live buds (such as those of a cold-hardy variety) to learn to recognize the individual primordia of a bud and to become familiar with the green appearance of live primordia.

Buds can be examined for viability on the vine, but it is generally more comfortable to collect 10 to 20 canes at random through a varietal block and examine the buds indoors. Collect only canes and nodes that might otherwise be retained at pruning. If there are large differences in elevation (30 to 40 feet) within a vineyard block, sample the regions separately because injury will probably be greater at the lower elevation. Examine 100 to 200 buds of each variety and record the percentage of dead primary buds.

If your bud assessment reveals 40 percent bud injury on a vinifera variety, then a 20 + 20 pruning schedule should be increased 40 percent to 28 + 28 or, for convenience, 30 + 30. Pruning adjustment is roughly proportional to primary bud injury with vinifera and native American varieties. Because many of the interspecific hybrid varieties have fairly fruitful secondary and base shoots, death of primary buds alone might not significantly reduce yields. The compensation for primary bud injury is therefore not as generous as with native American and vinifera varieties. Low temperature can also kill canes and trunks. Figure 6.4 shows in cross-section a portion of a three-year-old grapevine trunk. Trunk tissues include (from exterior to interior): a corky *periderm* or *bark*; the *phloem*, or food-conducting tissue; the *vascular cambium*; the *xylem*, or water-conducting tissue; and a central *pith*. The vascular cambium is a region of cell differentiation and division that produces new xylem and phloem cells annually. Canes have the same tissues as trunks but lack the annual rings of xylem. Cambium and phloem tissues are generally the most susceptible to cold injury. These tissues, like buds, will brown after being killed and subsequently rewarmed. Injury to the vascular cambium reduces or prevents the development of new xylem and phloem tissues. The old xylem tissue might sustain the initial water-conducting needs of the developing shoots in early spring. However, cold-injured vines often wilt and die in midsummer because the transpirational loss of water from leaves exceeds the ability of the impaired vascular system to transport water.

Figure 6.4 is a drawing showing a cross-sectional view of a portion of a three-year-old grapevine trunk. The annual rings, cambium, phloem, and periderm (bark) are labeled. (Redrawn from Esau, K. 1948. Phloem structure in the grapevine and its seasonal changes. Hilgardia 18:217-296.)

Cane and trunk cold injury is diagnosed by making shallow, longitudinal cuts into the wood and examining the phloem and cambial regions for browning. These tissues form a thin cylinder immediately beneath the bark. Browning or darkening of these tissues indicates injury. If wood injury is observed, retain extra canes at pruning. Injury will not be uniform and some canes will be unaffected. Some of these extra canes can be removed or shortened after bud break if too many shoots are present. Trunk injury is also diagnosed by making shallow, longitudinal cuts into the wood. Injury is usually most severe near the ground.

Cold-injured trunks frequently split or are affected by crown gall one to two years after the cold injury occurred. Vines will ultimately die if they must depend on a single, cold-injured trunk. Multiple trunking is therefore highly recommended to assure the long-term survival of vines (see the section on grapevine training). Split, heavily crown-galled, or otherwise defective trunks should be sawn off and replaced with a cane that arises near ground level but above the graft union (Figure 6.3). This strategy will ensure a continuous supply of shoots and canes to replace injured trunks.

Grapevine Training

Like dormant pruning, grapevine training is essential for high-quality grape production. There are numerous training systems used worldwide, and no single system is appropriate for all situations. The training system used will depend upon the variety, the frequency of cold injury, the degree of vineyard mechanization, and the availability of skilled labor. An acceptable training system will

1. promote maximum exposure of leaf area to sunlight

2. create a desirable environment within the canopy (microclimate), particularly in the renewal region

3. promote uniform bud break, especially with those varieties that exhibit pronounced apical dominance (described in the section on initial

training of grapevines)

4. promote efficient vineyard operation with respect to equipment traffic, fruit harvesting, pesticide application, and dormant pruning, and

5. be economical.

Initial Training

The growth potential of grapevines and the conditions under which vines are grown is never uniform. Other factors being equal, however, vines grafted to vigorous, pest-resistant rootstocks generally develop faster and usually grow larger than nongrafted vines. Variation in moisture and nutrient availability within a vineyard can cause differences in the extent of growth for a given variety. Training grapevines, therefore, requires evaluating the growth of individual vines during their establishment. Regardless of the intended training system, the initial training of grapevines has the following goals:

YEAR 1: To develop large, healthy root systems;

YEAR 2: To establish the initial components of the intended training system, including at least one semipermanent trunk; and to harvest a very light crop on vines that grew extensively in the first year.

YEAR 3: To develop or complete the training system, harvest a partial crop, and establish a second trunk.

These goals can be achieved by several methods. The following text and illustrations describe one means of establishing a low, bilateral cordon trained vine using two semipermanent trunks. The training method described here is but one of several possible approaches.

YEAR 1: Erect the trellis posts and at least the lowest of the training wires before or during the first growing season. This wire, and a slender stake set next to individual vines, will provide a support for shoot growth. Allow two to three shoots to develop on vines during the first year (Figures 6.5a and 6.5b). Train these shoots vertically to the support stake. They may eventually be tied loosely to the training wire if their growth warrants it. Lateral shoots on these primary shoots can be pruned off to promote elongation of the primary shoots. Lateral shoot growth will be minimized if shoots are positioned upright and fastened to the support stake. Leaving several shoots on the first-year vine provides an abundant leaf area. Root growth is dependent on food produced in the leaves. Thus, the greater the leaf area, the greater the root growth that will occur in late summer. Eliminating all but one shoot can also lead to an excessive rate and duration of shoot growth, especially if the vines have large root systems when planted. Rapid and continued growth late into the fall can result in incomplete wood maturation, increasing the susceptibility to cold injury. In addition, retaining several shoots, rather than one, provides some measure of compensation for possible wind damage, deer browsing, and other factors that can retard the development of young vines.

Figure 6.5a (top). Development of bilateral cordontrained grapevines. Year 1: spring, at planting. This drawing shows a first-year vine at planting beside a trellis post. Figure 6.5b (bottom). Year 1: fall, at end of growing season. Vine on left has demonstrated weak growth. Vine on right grew vigorously and attained a greater size. This drawing shows two vines at the end of the growing season. Both have training stakes. The one on the left hasn't reached the bottom trellis wire. The one on the right has reached the bottom trellis wire, which is 36 to 44 inches above the ground.

It is essential that young vines be protected from fungal diseases by applying the appropriate fungicide. Powdery and downy mildews in particular can severely reduce the photosynthetic (food manufacturing) capabilities of leaves and retard the establishment of the training system. Deer, Japanese beetles, weeds, and other pests — as well as drought — also have greater impacts on young vines than on older vines and must be diligently controlled. Young vines do not have the food storage reserves afforded by the large root systems and trunks of older vines.

YEAR 2: Complete the trellis before bud break of the second growing season. Training in the second year starts by evaluating the extent of growth achieved during the first year (Figure 6.5c). If no canes reach the first wire, remove all but one cane. Prune this cane to three or four buds and secure it to the training stake. Treat such a vine as a one-year-old vine.

Figure 6.5c. Development of bilateral cordon-trained grapevines. Year 2: spring, after pruning. Vine on left has demonstrated weak growth. Vine on right grew vigorously and attained a greater size. This drawing is similar to the figure in 6.5b but the vines have been pruned as described in the following paragraph.

Vines that grew extensively in their first year will likely have one or more canes suitable for retention as a trunk. If a cane is long enough to reach the lowest trellis wire and is of adequate diameter at the wire, retain the cane as a trunk. The distal portion (the end towards the tip) of such canes can be trained horizontally along the training wire to serve as the basis for establishing the cordon (Figure 6.5c). If you elect to use a high training system, tie the cane vertically to the top wire of the trellis to form a trunk. In addition to the first trunk, retain a renewal spur of one or two buds that originates near the soil line but above the graft union (Figure 6.5c). If a second cane is large enough to serve as the second trunk, it can also be retained.

Cordon Establishment

The process of establishing cordons can begin in the first or second season, depending on the first year's shoot development. In either case, establish cordons over a two-year period. Long canes (8 to 15 nodes) often exhibit poor shoot growth at midcane nodes. Shoots that develop near the terminal, or distal, end of a cane produce growth regulating hormones that retard the development of midcane shoots. This so-called apical dominance of distal shoots is greatest when the cane is oriented vertically up and is minimized when the cane is trained vertically down. To establish 4-foot-long cordons, use a 24-inch-long cane (or trunk extension) in year two (Figure 6.5c) and complete the cordon in year three with another 24-inch-long cane that originates near the distal end of the short cordon (Figure 6.5e). Canes used to establish cordons should be wrapped loosely around the trellis wire and securely tied at their terminal end with wire. The tying process will prevent the cordon from rotating or falling from the wire. If canes are wrapped too tightly around the cordon wire (greater than about two rotations in a 4-foot length), they may grow into the cordon wire within a few years. This does not impair vine performance, but it does prevent the cordon wire from being properly tensioned as it stretches with time.

During the second growing season, thin the shoots of vigorous vines that originate below the lowest trellis wire to one or two near the graft union (Figure 6.5d). Retain shoots that originate on the developing cordon. Retain 10 or more shoots, if possible, in year two. Treat small or weak vines as first-year vines during the second growing season (Figure 6.5d). Remove all flower clusters. Where exceptional growth was achieved in year one, it may be desirable to leave several fruit clusters per vine in the second growing season to slow vegetative growth. This token crop can be removed quickly in early summer if growth is less than expected.

Shoots that develop in year two should be positioned and tied to the trellis wires to maximize sunlight exposure of their leaves. For cordon training, these shoots will form the spurs for shoot development during the following year (Figure 6.5e).

Figure 6.5d. Development of bilateral cordon-trained grapevines. Year 2: fall, at end of growing season. Vine on left has demonstrated weak

growth. Vine on right grew vigorously and attained a greater size. The drawing shows the weaker vine on the left reaching the middle trellis wire while the stronger vine on the right has reached the top of trellis wire, which is 6 to 6 ½ feet from the ground.

Figure 6.5e (left). Development of bilateral cordon-trained vines. Year 3: spring, after pruning. Vine on left has demonstrated weak growth. Vine on right grew vigorously and attained a greater size. Both vines have been pruned back to the bottom trellis wire, but the more vigorous vine on the right stretches further along the trellis wire.

YEAR 3: Complete the basic elements of the training system during the third year. For low cordon-trained vines, prune the canes that arise from the upper side of the cordon to one- or two-node spurs (Figure 6.5e). For high cordon-trained vines (Figure 6.6), retain the spurs on the lower side of the cordon. Spurs should be spaced 4 to 6 inches apart. Develop a second trunk and cordon from a cane that originates near the graft union; follow the procedure outlined for the initial trunk. Retain a small crop (for example, one cluster per two shoots) on vines that had at least 1 pound of cane prunings from second-year growth. Position and tie the shoots to the upper trellis wires, as necessary, during the growing season. Treat weak vines as second-year vines and remove all crop.

Figure 6.6 (above). The drawing shows the high-wire cordon training system. The training wire at 36 to 44 inches is optional, and spurs or short canes are pruned and grown along a wire 6 to 6 ½ feet off the ground.

Multiple Trunking, Trunk Renewal, and Graft Union Protection

Growing cold-tender grapevine varieties introduces problems not experienced in regions with mild or more constant winter temperatures. Some degree of bud injury occurs regularly with cold-tender varieties but can generally be compensated for by retaining additional buds at dormant pruning. It is much more difficult to compensate for cane and trunk injury. In some situations (such as cold-tender varieties planted in poor sites) complete vine loss has been experienced. Even in good to excellent sites, it is wise to anticipate cold injury to better compensate for its occurrence. In addition to winter injury, other forms of injury can occur to vines, such as disease and mechanical damage by vineyard equipment.

The experienced grape grower recognizes that the only permanent part of living vines is the root system.

One of the best ways to compensate for trunk injury is to use multiple-trunk training systems. This recommendation applies to cold-tender vinifera or more hardy hybrids. All of the training systems illustrated here can be established using two or three trunks, as opposed to one. Cold injury or death of trunks is often not uniform.

Frequently, only one trunk of a two- or three-trunk vine is killed. Similarly, the development of a wood-rotting disease such as eutypa dieback (see chapter 8) may be observed initially on only one cordon or trunk. In either case, removing one of two trunks does not eliminate grape production from the affected vine. Furthermore, it is usually easier to reestablish the lost unit from an existing trunk. A multiple-trunk training system can be developed starting in the first year as described above for a bilateral cordon system. Alternatively, a second or third trunk can be added in any year by training up a shoot originating near the graft union. Old trunks should not be replaced unless they are mechanically damaged, diseased, or cold injured. The continual removal of shoots (suckers or waterspouts) from the base of the trunk will exhaust the latent buds that could be used to develop new trunks, and with such vines it is sometimes difficult to establish new trunks. Therefore, the maintenance of a one- or two-node renewal spur at the base of the vine, while adding labor, does provide a continual supply of shoots and potential new trunks. A new shoot is trained up before a planned trunk removal or at any time after an unpredicted trunk loss. Note that with grafted vines, any suckers that develop from below ground level usually arise from incompletely disbudded rootstock wood. These shoots can be recognized as rootstock variety by their distinctive leaf appearance. They are of no value in reestablishing the training system.

An additional way to compensate for winter injury of grafted vines is to protect the graft union and a portion (several inches) of the trunks with mounded soil in the fall. Hilling up of graft unions, which can be done mechanically with tractor-mounted implements, protects a portion of the trunks from low temperatures. By providing a continuum with the relatively warm soil beneath the vine, the hilled soil insulates up to several inches of the trunk, including latent buds, above the graft union. The insulating layer of soil must be carefully removed (dehilled) in early spring to prevent permanent scion rooting. In the event of very low winter temperatures, injury may occur to all exposed portions of the vine. This is a rare occurrence, but it has — and will — occur, especially in poor vineyard sites. If such damage occurs, the training system can be reestablished by dehilling the vine and bringing up shoots that had been protected as buds by the soil. This tactic is faster and cheaper then replanting the vineyard. Hilling and dehilling is an insurance practice, and its utility says much about the vineyard site. Hilling is definitely recommended if a variety's hardiness or the suitability of a site is in question. Hilling is not recommended, however, if long-term experience (seven or more years) suggests that severe winter injury is unlikely. Hilling and dehilling have resulted in considerable soil erosion in some vineyards. That problem, combined with some inevitable mechanical damage to vines, has made the practice of dubious value in good to excellent vineyard sites. On the other extreme, if a grower finds that vines are often severely injured, the site, the variety, or both are unworthy of further consideration.

Training Systems

Training systems for vertical trellises are categorized as having either divided or nondivided canopies. Training methods can be further divided into head-trained or cordon-trained systems and cane-pruned or spur-pruned systems. The following training systems are acceptable for vineyards in this region. Trellis dimensions and the number of foliage catch wires used are provided as guidelines and might differ slightly from other references. It is wise to visit many existing vineyards and formulate your own dimensions from a synthesis of those observations and discussions.

Nondivided Canopy Systems

Nondivided canopy training systems have a single curtain of foliage and are less expensive than divided canopy systems.

Head-Trained Vines

Umbrella Kniffin

Two- or three-wire trellises are used for umbrella kniffin training (Figure 6.7). A trunk extends to a point 4 to 6 inches below the top wire. Short

arms bear the fruiting cane arched over the top wire and are tied to the lower wire of the trellis. Renewal spurs are retained in the head region to provide canes for the subsequent season. Large vines (for example, those that produce 3.5 pounds of cane prunings from vines spaced 8 feet apart in the row) might retain three or four canes. Smaller vines (for example, those producing 1 pound of cane prunings) might only retain two canes to provide the appropriate node number.

Figure 6.7. The drawing shows the elements of the umbrella kniffin training system as described above.
Canes are secured to a lower wire below the 6 to 6 ½-foot-high top wire.

ADVANTAGES

1. A relatively simple, low-cost trellis is needed.

2. Pruning decisions are easily learned.

3. Apical dominance is reduced and more buds are positioned in a unit length of row by bending the canes over the top wire.

4. The high renewal region promotes good fruitfulness and good fruit quality with small- to moderate-sized vines.

DISADVANTAGES

1. As with all cane pruning systems, the mandatory tying of canes to trellis wires adds labor costs.

2. Little provision is made for shoot positioning, and shoot crowding can lead to shaded fruit with large, vigorous vines.

Modified Keuka High-Renewal

This training system was developed in northern grape growing regions where frequent winter injury confounds the maintenance of large amounts of perennial wood and standardized training. The system's chief asset is that it permits flexibility in pruning and training. Multiple trunks extend to a midtrellis height (Figure 6.8). The vines are pruned to short canes originating from a dispersed head region. Canes are distributed and tied to trellis wires in a manner that promotes as uniform a shoot density as possible.

Figure 6.8 (top). Modified Keuka high-renewal training system is shown in this drawing. The top wire is 6 ½ feet from the grown. A second wire is 18 to 20 inches below the top wire and a third wire is 18 to 20 inches below the middle wire.

ADVANTAGES

1. This system allows a flexible approach to winter-injury compensation.

2. Short trunks minimize the maintenance of perennial wood.

DISADVANTAGES

1. A considerable amount of time is expended with cane tying.

2. Uniform canopy density is extremely difficult to achieve.

3. The flexibility in training is difficult for inexperienced pruners to grasp.

Cordon-Trained Vines

Low Bilateral Cordon

The distinction between low- and high-trellis cordon systems depends upon the point on the trellis at which the cordon is established. Low cordons are typically 36 to 42 inches above the ground. Although cordons can be established even lower, 36 to 42 inches is a comfortable working height for most persons and is still low enough to permit development of 3 to 4 feet of canopy above the cordon. High cordons are established at the top of the trellis, typically 72 inches above the ground. The establishment of a low, bilateral cordon training system was illustrated earlier. At dormant pruning, one to three node spurs are retained at a uniform spacing along the upper side of the cordon (Figure 6.9). The vertically upright spurs encourage an upright growth habit to developing shoots. Cordons can extend either unilaterally or bilaterally from the trunks; in either case, cordons should ultimately span the distance between two adjacent vines in the row, leaving no gap between cordons of adjacent vines. Multiple sets of paired catch wires can be mounted on the trellis above the cordon to facilitate shoot positioning and to promote the development of a thin, vertical canopy. (See chapter 7.) Three pairs of catch wires are illustrated in Figure 6.9. The first pair of catch wires should be no more than 10 inches above the cordon. This height reduces the likelihood that shoots will fall or be blown down before elongating through the catch wires, and thus the amount of labor required to fasten shoots to wires is greatly reduced. The recommendation to use three sets of paired catch wires, as opposed to a lesser number, is guided by (1) the underlying principles of canopy management (see chapter 7) and (2) the conviction that the installation of wire is cheaper than the alternative labor of fastening shoots to wires to maintain the thin, vertical canopy.

Figure 6.9 (bottom). Low-wire bilateral cordon training system. The drawing shows the semipermanent cordon on the bottom wire 36 to 44 inches above the ground, the top wire 6 ½ feet off the ground and twin catch wires in the middle.

ADVANTAGES

1. Spur pruning minimizes the labor associated with cane tying.

2. Fruit and renewal regions are at a uniform height, facilitating harvest and pruning.

DISADVANTAGES

1. Basal nodes of a cane (those retained as a spur) are often not as fruitful as midcane nodes because of the characteristics of the variety or poor sunlight exposure during bud differentiation and development.

2. Cordons, like trunks, must be renewed in the event of winter injury.

Long-term productivity of cordons can be a problem with varieties that are subject to winter cold injury or in situations where spurs have been pruned improperly. Cold injury or poor bud development can lead to areas of the cordon that lack spurs. Poor pruning can lead to displacement of the one-year-old spurs away from the cordon on older wood. The latter problem can be minimized by retaining, where possible, buds that originate close to the cordon and by retaining base shoots that arise directly from the old wood of the cordon. Cordons with poorly spaced spurs or wide gaps in spur positions should be renovated or replaced. If the cordon is free of disease, renovation may be all that is necessary to reestablish uniform distribution of spurs along the cordon. Renovation entails removing all one-year-old wood and spur extensions from the near barren cordon. Leave a ¼- to ½-inch crown at the base of these extensions. The removal of this older wood stimulates a proliferation of base shoots from the retained crowns. The base shoots, which will be of low fruitfulness, can be trained and used to provide fruitful spurs for the following season. Severe pruning in renovation is necessary to stimulate base shoot development. Renovation temporarily reduces vine productivity, so it should be used only as needed and on a small proportion of vines in any one year. Replacement of cordons is advised if the cordon is diseased, cold injured, or otherwise undesirable. It is extremely difficult to establish a new, parallel cordon while the original cordon is still alive and present. Therefore, cut out the old cordon at the time the new cane is laid down. The new cane can originate near the graft union, anywhere on the trunk, or anywhere proximal to the diseased or barren region of the cordon. Do not attempt to establish a cordon using a cane originating from the opposing cordon of a bilaterally cordon-trained vine.

High Bilateral Cordon

Bilateral cordons are trained along the top wire of the trellis (Figure 6.10) in a manner similar to the low bilateral cordon system. Spurs or short canes are retained on the lower sides of cordons to promote downward shoot growth. Downward growth is further encouraged by positioning or “combing” shoots downward two to three times during the growing season. This positioning, which is first done near the time of bloom, is necessary to ensure sunlight penetration into the fruiting and renewal region of the canopy.

Figure 6.10. Highwire cordon training system. The drawing shows an optional training wire 36 to 48 inches off the ground and the vine 6 ½ feet off the ground pruned with spurs or short canes.

ADVANTAGES

1. This system uses a very low-cost trellis.

2. High training is well suited to varieties that have a trailing growth habit, especially those of native American origin (for example, Norton).

3. The fruiting and renewal region of the vine receives excellent illumination, provided that shoot positioning is performed.

4. Pruning is rapid and cane tying is minimized.

5. This system is well adapted to mechanical harvesting and pruning.

DISADVANTAGES

1. A large area of perennial wood must be retained and exposed to possible winter injury.

2. Varieties with upright growth habits can be difficult to manage.

Divided Canopy Systems

Divided canopy training systems consist of at least two curtains of foliage per unit length of row. Two systems, both having horizontally divided planes of foliage, are described here. Divided canopy training systems are more elaborate and more expensive to establish than nondivided training systems. Canopy division can be used to take advantage of the large surface area of leaves produced by large vines. Conversion of nondivided canopy vines to divided canopy training has resulted in significant yield increases and sometimes increased fruit and wine quality. Canopy division is not justified, however, when cane prunings average less than 0.4 pound per foot of row (for example, 3.2 pounds with vines spaced at 8 feet) in nondivided canopy training systems. Because of the higher establishment costs, divided canopy training is not generally promoted for new vineyards: the same yield increases afforded by divided canopies can be achieved at lower cost by establishing more closely spaced, nondivided canopy rows. Similarly, the reduction in canopy density afforded by canopy division can be achieved by spacing vines farther apart in the row. The practicality of closely spaced rows hinges on the availability of narrow vineyard equipment. (See chapter 7.) Finally, it should be noted that the added costs of divided canopy training systems is wasted if the grower fails to maintain truly divided curtains of foliage.

Geneva Double Curtain

The top of the trellis is fitted with cross arms 4 feet wide (Figure 6.11). Cordon wires are supported on either end of the cross arms. Bilateral cordons extend from trunks that alternate, by vine, between one side of the trellis and the other. Cordons are pruned to spurs on their lower sides. Shoot positioning is required to maintain canopy separation and to promote sunlight penetration into the fruiting and renewal region.

Figure 6.11 (top). Geneva double curtain training system. Vines are spaced 8 feet apart in the row. (Adapted from Jordan et al., 1981.) The drawing shows the trunk training wire with the vine extending from one side of the trellis to the other, as explained above.

ADVANTAGES

1. Yields and fruit quality can be increased significantly compared with nondivided canopy training systems.

2. The Geneva double curtain system is well adapted to varieties having a trailing growth habit, such as those of native American origin.

DISADVANTAGES

1. A large amount of perennial wood must be maintained and exposed to winter injury.

2. Considerable shoot positioning is required to achieve and maintain complete canopy division, especially with upright-growing varieties.

Lyre, or U-Shaped, Training

This design consists of a quadrilateral training system. Cordons are located 36 to 42 inches above ground (Figure 6.12). An elaborate trellis structure consisting of up to 16 catch wires is used to confine developing shoots to two independent and vertical curtains of foliage. The two curtains must be separated by at least 3 and preferably 4 or more feet at their bases. (A separation of 3.5 feet is illustrated in Figure 6.12.) Shoots are trained to the independent curtains with the assistance of multiple catch wires. Shoot topping is performed when shoot tops elongate much beyond the top wires. Inner catch wires can be movable to reduce the number needed. It is imperative to maintain two independent curtains of foliage by repeated shoot positioning and use of catch wires during the growing season.

Figure 6.12 (bottom). U-shaped or open lyre divided canopy training system. This drawing shows the Davis-modified trellis design, which has moveable catch wires.

ADVANTAGES

1. This system is better suited than the Geneva double curtain system to varieties that exhibit a predominantly upright growth habit (for example, most vinifera varieties).

2. Reestablishment of the training system after winter injury may be more rapid than with the Geneva double curtain.

3. Greater yields can be achieved than with nondivided canopy training systems of the same row width.

DISADVANTAGES

1. The initial costs of trellis establishment for Lyre Training are signficantly higher than conventional trellis systems.

2. Shoot positioning and tying is still necessary to maintain complete canopy separation.

In conclusion, several training systems are suitable for commercial grape production in North Carolina. Advantages and disadvantages can be cited for each. Evaluate the growth potential of your vines, the availability of vineyard labor, and the hazards of winter injury before choosing a particular system. Conversion of inferior existing systems to superior systems is possible. However, converting from a high training system to a low training system is much more difficult than converting from a low to high system. Conversion of nondivided training systems to more elaborate divided-canopy training systems is also possible if rows are wide enough.

References

Adelsheim, D. 1992. Spacing, training, and trellising vinifera grapes in western Oregon. In: Oregon Winegrape Grower's Guide, 4th Edition. Ted Casteel, editor. pages 63 to 118. Oregon Winegrowers' Association, Portland, Oregon.

Jordan, T. D., R. M. Pool, T. J. Zabadal, and J. P. Tomkins. 1981. Cultural practices for commercial vineyards. Cornell University Extension Miscellaneous Bulletin Number 111, Ithaca, New York.

McGrew, J. R. 1978. Basic guide to pruning. 14 pages. American Wine Society, Rochester, New York

Shaulis, N. J., J. Einset, and A. B. Pack. 1968. Growing cold-tender grape varieties in New York. New York State Agricultural Experiment Station Bulletion Number 821.

Winkler, A. J., J. A. Cook, W. M. Kliewer, and L. A. Lider. 1974. General Viticulture. University of California Press, Berkeley, California.

Published by NORTH CAROLINA COOPERATIVE EXTENSION SERVICE and distributed in furtherance of the acts of Congress of May 8 and June 30, 1914. North Carolina State University and North Carolina A&T State University commit themselves to positive action to secure equal opportunity regardless of race, color, creed, national origin, religion, sex, age, or disability. In addition, the two Universities welcome all persons without regard to sexual orientation. North Carolina State University, North Carolina A&T State University, U.S. Department of Agriculture, and local governments cooperating.