Introduction

Grapevine pruning is an important and labor-intensive vineyard management task. Grapevine buds contain compressed shoots that will grow and produce a crop in the forthcoming season. Retaining fruitful buds is the primary method of manipulating shoot density and cluster number for the following season. When pruning, it’s important to cut away and discard one-year-old wood and to select and retain specific buds for the following season. The results of ineffective or incomplete dormant pruning are excessive shoot density and a congested canopy that impairs airflow and light penetration, creating a greater susceptibility to fungal disease. Failing to prune out infected tissues will increase the incidence of woodborne diseases and limit vineyard productivity over time. In the short term, ineffective dormant pruning will compromise crop quantity and quality. In the long term, it will compromise vineyard health and sustainability. This publication contains a basic discussion of commercially important pruning strategies and considerations for bunch grapes in the eastern United States.

When to Prune

It is necessary to prune every year. Pruning should occur later in the dormant season and before budbreak (Figure 1). The dormant season typically spans from November through April in the eastern United States. Deciding when to start pruning often depends on vineyard acreage and available labor. Vineyards with low labor-to-acreage ratios (few hands, many acres) may start pruning in December, while vineyards with high labor-to-acreage ratios (many hands, few acres) may wait until March. However, pruning in the fall is less desirable than in the late winter or early spring due to the increased chance of cold injury (Reynolds and Wolf 2008). If labor is limited and pruning must begin earlier, cultivars that have greater cold hardiness or more fruitful secondary buds (e.g., several hybrids) should be pruned before those that are less cold hardy and have less fruitful secondary buds (e.g., several Vitis vinifera cultivars). See Dami (2007) for a table of relative cold hardiness across grape genotypes. Postpone pruning until colder temperatures are less of a threat to allow for cold injury assessment and to adjust for bud number retention. Regardless of when pruning starts, the goal should be to finish before budbreak.
What to Prune

The goal of pruning in the first two years after planting is to establish the permanent vine structures (e.g., trunks, cordons) and shape the vine to accommodate the intended training system. In young vineyards, the woody canes to be retained as trunks and other permanent portions of the grapevine should be roughly 3/8 inch in diameter. New grape growers commonly fail to prune off enough wood in the first two years after vine establishment. When wood is less than 3/8 inch in diameter, growers should prune vines aggressively so that retained buds will produce larger shoots to develop as trunks and cordons the following year. After permanent vine structures have been established, pruning is implemented on one-year-old (if spur pruning) and two-year-old (if cane pruning) tissues to maintain crop yield and canopy architecture.

Shoots are the vegetative green tissues produced from a grapevine bud. Grapevine shoots grow and mature into canes (woody tissues) over the course of a growing season. When dormant pruning, the pruner should retain the desired grapevine buds from canes. Desirable canes are from 3 to 5 feet in length, 1/3 to 3/8 inch in diameter (slightly larger than the diameter of a pencil), and have had ample sunlight exposure in previous seasons (resulting in a brown/cinnamon color). Canes larger or smaller than this size range are less desirable for retention at dormant pruning. Thin, dried, dead, and hollowed-out “straw canes” should not be retained. Larger canes (commonly called “bull canes”) may contain buds that produce shoots with lower cluster numbers and/or reduced cold tolerance. Canes that were vigorous growers in the previous season often have longer internodes (space between buds; see below) and fewer buds per cane length; thus, vigorous vines may result in difficulty retaining the desired bud number within a confined fruit zone.

Nodes are the swollen, thick sections of shoots and canes. The internode is the slimmer section between nodes. Buds are numbered in ascending order starting at the base of the cane/spur (e.g., noncount bud, count bud 1, count bud 2).

Bud fruitfulness differs among cultivars. Noncount basal buds are not often fruitful on Vitis vinifera cultivars (e.g., ‘Cabernet Sauvignon’), which means the shoot that develops from a noncount bud is unlikely to bear clusters. Many hybrid cultivars (e.g., ‘Seyval blanc’ and ‘Vidal blanc’) contain fruitful noncount buds, meaning the shoot developing from the noncount bud will often produce clusters. Bud fruitfulness may vary along the length of a dormant cane, depending on the cultivar (Meneguzzi et al. 2020). The few count buds at the basal end of a cane may be more fruitful than those more apically positioned on a cane and vice versa.

How Much to Retain

Because between-vine spacing is variable, determining how many buds to retain depends on canopy length. Recommended shoot density is typically between three and five shoots per linear foot of canopy (Smart and Robinson 1991; Figure 3). As count buds are anticipated to turn into fruitful shoots, the recommended count bud density to retain would parallel the target shoot density (note: bud densities in ‘Concord’, ‘Niagara’, and other American juice grape cultivars are much greater than those of hybrid and Vitis vinifera wine grape cultivars). To determine how many count buds should be retained per vine, multiply the desired shoot density per foot by the feet of canopy an individual vine should fill. For example, 25 count buds per vine should be retained at dormant pruning if 5 shoots per linear foot of canopy are desired on a vine trained to a single-canopy system (e.g., low-bilateral cordon with vertical shoot positioning, or VSP). The recommended retained bud number per vine varies across popular training systems planted at different vine spacings (Table 1). Higher bud densities can be retained in systems that have single fruiting zones with canopies that are

Figure 2. Noncount/basal bud (green arrow), count bud 1 (purple arrow), and count bud 2 (blue arrow) on a one-year-old spur. The count buds are often fruitful; noncount buds are often not fruitful except in hybrid cultivars. The count buds are borne at cane nodes, the swollen sections of a cane that encompass the slimmer internode sections. Photo courtesy of Cain Hickey.

Figure 3. The vine pictured demonstrates the recommended shoot density of roughly four shoots per linear foot of canopy in a low, bilateral cordon-trained ‘Merlot’ vine with vertical shoot positioning. The vine was shoot thinned roughly one week before the photo was taken. Photo courtesy of Cain Hickey.
Table 1. Bud number retention per vine with various target bud densities in popular training systems (vertical shoot positioning and trailing shoot positioning) and vine spacings.

<table>
<thead>
<tr>
<th>Training System Example</th>
<th>Fruit Zone Number</th>
<th>Between-Vine Spacing (feet)</th>
<th>Retained Bud Number Per Vine (3 buds per foot of row target)</th>
<th>Retained Bud Number Per Vine (4 buds per foot of row target)</th>
<th>Retained Bud Number Per Vine (5 buds per foot of row target)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low, bilateral cordon (VSP) or high, bilateral cordon (trailing)</td>
<td>1</td>
<td>4</td>
<td>12</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>15</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>18</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>Lyre, low bilateral cordon (VSP) or Geneva double curtain (trailing)</td>
<td>2</td>
<td>4</td>
<td>24</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>36</td>
<td>48</td>
<td>60</td>
</tr>
</tbody>
</table>

divided via shoot training (e.g., Watson and Ballerina). Such systems promote greater fruit zone space and limit cluster density relative to systems with confined canopies and fruit zones (e.g., the VSP system).

Optimal dormant pruning weights are between 0.2 to 0.4 pound per linear foot of cordon (Smart and Robinson 1991). That means a single-cordon vine should produce roughly 1 to 2 pounds of pruning weight in a well-balanced, healthy vineyard with a between-vine spacing of 5 feet. The “optimal” pruning weight will largely be determined by the interaction of several factors, including cultivar, training system, cultural practices, growing site, and production goals. Growers are encouraged to spot check vine pruning weights throughout each cultivar and block, particularly where vine size appears to be declining and/or soil water and mineral nutrient resources are limited. Pruning weights can be taken with a hanging field scale or a fishing scale. Flag several vines and return to record their dormant cane weights and yield on a perennial basis to determine crop load and vine productivity over time. Fewer buds should be retained on vines that have reduced pruning weight and crop yield over time. Growers are encouraged to work with Penn State or Virginia Tech extension educators and specialists to determine the cause of lower vine productivity. For further information on balanced pruning and the concepts of vine balance, see Bates (2003), Skinkis (2013), Smart and Robinson (1991), and Kliewer and Dokoozlian (2005).

**Pruning Methods**

The two pruning methods commonly used in bunch wine grape vineyards are spur pruning and cane pruning, which are associated with training method by virtue of where the fruitful one-year-old wood originates. The fruitful wood can originate from either a cordon or the head region.

**Spur Pruning (with Cordon Training)**

Spur pruning is commonly implemented with cordon training (Figure 4). A cordon is a horizontally trained extension of the trunk that is retained for multiple years; spurs originate along the length of a cordon. Spur pruning is implemented by cutting last year’s shoots (now one-year-old woody canes) down to spurs. Spurs are short canes; they are called “spurs” due to their physical appearance after cutting the cane. Spurs typically contain one or two buds each in cordon-trained, vertical-shoot-positioned *Vitis vinifera* vineyards but may contain two to four buds each in high-wire and Geneva-double-curtain-trained cultivars such as ‘Chambourcin’, ‘Chancellor’, and ‘Norton’. Four to seven buds per spur are often retained in ‘Concord’, ‘Niagara’, and other American juice grape cultivars; given the high bud numbers retained on one-year-old wood, one may view these situations as being similar to cordon training with cane pruning.

![Figure 4. Before (top) and after (bottom) spur pruning in a low, bilateral cordon system trained to vertical shoot positioning. The green arrows represent the two cordons; the purple arrows represent spurs. Photos courtesy of Cain Hickey.](image-url)
A good spur pruning strategy is to retain one-year-old spurs that are positioned as close as possible to the cordon. An example of this strategy can be seen in the bottom photo in Figure 4; the farthest right purple arrow points to a retained spur that was lower than two other canes removed from that cordon region. Maintaining low-positioned grapevine spurs ensures clusters are maintained in a confined fruit zone region, which promotes efficient and effective spraying, leaf removal, and harvestability. Further, maintaining low-positioned spurs ensures the amount of exposed canopy leaf area is maintained over time. It is also good practice to remove spurs that are oriented horizontally or originate from the bottom of the cordon.

Like trunks, cordons are perennial structures. However, they can have a limited productive lifespan of about seven to ten years or less, depending on the prevalence of wood and trunk diseases and previous pruning decisions. Cordons will thus need periodic replacement throughout the lifespan of the vineyard. It is time to replace cordons when they become largely void of one-year-old (fruitful) wood as this will reduce crop production. Figure 5 shows a cordon that is past the recommended replacement stage due to excessive “blind wood”—the low number of fruitful buds could be a function of historical poor pruning decisions or woodborne disease. Vineyards characterized by a high incidence of cordons void of productive grapevine buds will have compromised crop yields and reduced economic incomes.

Figure 5. A cordon with almost 2 feet devoid of spurs. This cordon is well past due for replacement, which is essentially accomplished by cane pruning. Photo courtesy of Cain Hickey.

Cane Pruning (with Head Training)
Cane pruning is implemented with head training; canes originate from the head region of the vine (Figure 6). Cane pruning does not use cordons. Instead, new one-year-old canes are laid down on the fruiting wire every year. Each bud that originates along the length of the one-year-old renewal canes has the potential to be fruitful in a similar fashion to the count buds on the abovementioned one-year-old spurs. It might be helpful to think of a cane as a long spur that requires the support of a wire due to its length and consequent inability to support itself.

The region of the vine from which the renewal cane originates is referred to as the “head region,” which is the region where the vertical trunk splits into horizontally positioned grapevine wood (see Figure 6). The head region should start roughly 6 to 8 inches below the supporting wire so that the renewal canes are easily positioned and tied to that wire (Figure 7). Pruning, pulling brush, and tying canes are tasks that can be split between multiple vineyard passes when implementing cane pruning.
Choosing a Pruning Method

Vineyard design and variety selection can dictate appropriate pruning method. Mid-cane shoot growth depression has been reported in cane-pruned vineyards (Figure 8). Research has shown that, relative to spur-pruned vines, cane-pruned vines have reduced shoot density, cane weight, and dormant vine pruning weight (Hatch et al. 2019, White et al. 2020). In an attempt to reduce nonuniform shoot growth along the length of the cane, cane pruning/head training is often practiced in vineyards with between-vine spacing of 6 feet or less. In general, spur pruning is generally seen in commercial vineyards with between-vine spacing of 5 to 8 feet, while cane pruning is generally seen in commercial vineyards with between-vine spacing of 3 to 6 feet. Pruning method choice tends to be a regional phenomenon. Spur pruning is predominantly employed in the eastern United States, but cane pruning is increasingly adopted in wine grape vineyards in Pennsylvania and Virginia. Cane pruning is popular in Oregon ‘Pinot noir’ vineyards. Due to the ability to highly mechanize the practice, spur pruning is popular in eastern Washington vineyards. The decision to implement one pruning practice over the other will depend on the perceived advantages and disadvantages of each. Relative to spur-pruned vines, cane-pruned vines have been reported to have more clusters in ‘Cabernet Sauvignon’ (Hatch et al. 2019) and larger clusters in ‘Petit Manseng’ (White et al. 2020). Thus, despite the abovementioned difference in shoot density, crop yield is not dramatically different between spur- and cane-pruned vines (Hatch et al. 2019, Skinkis and Gregory 2017, White et al. 2020).

Wine grape cultivars are known to have differences in bud fertility by node location. For example, ‘Nebbiolo’ and ‘Sauvignon blanc’ have been reported to have low bud fertility in lower count nodes. Cane pruning increased crop yield when
Table 2. Select pros and cons of spur and cane pruning to help grower decision for pruning method adoption.

<table>
<thead>
<tr>
<th>Pruning Method</th>
<th>Tying Required</th>
<th>Complete Task Mechanization</th>
<th>Number of Unwanted Shoots to Thin</th>
<th>Number of Cuts Required</th>
<th>Size of Cuts</th>
<th>Appropriate for Vine Spacing Greater Than 5 Feet</th>
<th>Suitability in Cultivars with Low Basal Bud Fertility</th>
<th>Ability to Double/Delay Prune</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spur</td>
<td>No</td>
<td>Easy</td>
<td>Many</td>
<td>Many</td>
<td>Small</td>
<td>Excellent</td>
<td>Poor</td>
<td>Easy</td>
</tr>
<tr>
<td>Cane</td>
<td>Yes</td>
<td>Difficult</td>
<td>Few</td>
<td>Few</td>
<td>Large</td>
<td>Fair</td>
<td>Excellent</td>
<td>Difficult</td>
</tr>
</tbody>
</table>

compared to spur pruning in 'Sauvignon blanc' (Lockwood et al., 2016), a cultivar with lower basal bud fertility (Meneguzzi et al. 2020). Therefore, cane pruning may be most appropriate for cultivars with lower count buds of low fertility, such as 'Nebbiolo'. Several cultivars have fertile lower count buds and are fine candidates for spur pruning or cane pruning.

Recent research showed that bud fertility was greater from bud positions 4 through 10 when compared to bud positions 1 through 3; this was found to be the case in many French Vitis vinifera cultivars that are commonly grown throughout Pennsylvania and Virginia, such as 'Chardonnay', 'Pinot noir', 'Cabernet franc', and 'Merlot' (Meneguzzi et al. 2020). This work was conducted in one region with refined methods. More work should be conducted on cultivar-specific bud fertility as observed in the eastern United States.

There are pros and cons to both pruning strategies (Table 2). For example, while cane pruning may require less shoot thinning in the spring than spur pruning, canes must be tied to the supporting wire in the dormant period with cane pruning. Cane pruning shifts labor demand into the dormant season and therefore may be preferred over spur pruning by those who do not have enough labor to thin shoots within the narrow window of opportunity in the spring. However, aside from retaining several canes when cane pruning, spur pruning allows a grower to have more control over shoot density per linear foot of trellis. Cane pruning requires fewer cuts than spur pruning. Complete mechanization of spur pruning is possible; however, to our knowledge, full mechanization of pruning is not practiced in eastern U.S. wine grape vineyards. Mechanical prepruning can be accomplished in both spur- and cane-pruned vineyards; the height of the prepruner machine head will need to be adjusted according to the desired length of one-year-old wood to be left on the vine (e.g., shorter canes that are to be spur pruned, or longer canes that are to be cane pruned; Figure 9). Delayed and double pruning can easily be implemented when spur pruning, perhaps providing an advantage for spring frost avoidance.

A comparable strategy to maintain bud numbers and crop potential when cane pruning may be to retain three or four canes in the dormant season and cut the extra canes off once the threat of frost has passed in the spring. Additionally, a grower could tie purposefully long canes to the fruiting wires to exploit apical dominance to force budbreak on the extra retained apical buds. The grower could then go through and cut off the extra buds on the canes that extended beyond the point where they were fastened to the fruiting wire. Another option to hedge bets and maintain crop potential would be to lay down four total canes per vine and then shoot thin to desired bud densities.

Some growers may have concerns about cane pruning because they are familiar with spur pruning. It may be hard to imagine how the thin cane laid down as the new fruiting wood would produce as much crop as a thick, well-established spur-pruned cordon. Growers are encouraged to trial cane pruning on a small scale in their vineyard if the potential features of cane pruning presented herein pique interest. Several regional growers have already adopted cane pruning in their vineyards after learning about its merits at pruning workshops. It may be advantageous to trial cane pruning as a means of cordon replacement, particularly in situations where cordons or cordon regions are diseased or unproductive.

Double and Delayed Pruning

As the name implies, double pruning requires two vineyard passes. The order of operations when implementing double pruning on a cordon-trained vineyard is (1) preprune to spurs or long canes with excessive bud numbers, (2) cut tendrils and pull brush from the trellis, and (3) final prune with hand shears.

Figure 9. Mechanical prepruning is a good practice to reduce the most time-consuming and labor-intensive part of dormant pruning: brush pulling. In this photo, the machine head is positioned relatively high in the cane-pruned vineyard. The machine head can be lowered to cut out more brush than in spur-pruned vineyards. Photo courtesy of Cain Hickey.
to desired spur density or cane length. The first pass cuts out and removes a portion of the tops of the one-year-old grapevine canes from the trellis, and gas-powered hedge trimmers or tractor-mounted hedgers are often used for this step. An excessive number of buds are left after this first pass. After brush is pulled from the trellis, hand shears are used in the second pass to selectively retain the desired spurs and canes. Since brush is already pulled, the “final prune” is completed much faster with double pruning relative to standard pruning, and can therefore be implemented later in the dormant season. Final pruning later in the winter enables the pruner to assess cold injury and adjust bud number accordingly, potentially after the greatest threat of winter cold injury has passed.

Delayed pruning is a modification of double pruning. Delayed pruning exploits the cane apical dominance to encourage budbreak on apical buds and delay budbreak on the lower count buds that will be retained as spurs upon pruning completion. Apical buds break first, while the basal buds remain dormant or are at least relatively behind in development. Since the basal buds will be retained after final pruning, delayed pruning has the potential to reduce frost incidence in vineyards subject to spring frost. Exercise caution when choosing the timing of the delayed prune—if excessively delayed, crop yield can be reduced and fruit maturation delayed from the retained buds (Frioni et al. 2016). Preliminary work in the eastern United States has shown that final pruning when the most apical buds are at budbreak can delay budbreak and maintain crop yield and fruit composition from the retained lower count buds in both hybrid and Vitis vinifera cultivars.

Challenges Addressed during Dormant Pruning

Grapevine trunks and cordons can be infected by a suite of fungal and bacterial pathogens (Mondello et al. 2017). Infection due to these pathogens results in vine decline and even vine mortality. Signs of infection include wedge-shaped cankers visible in cross-sections of wood, dead wood, galls, and the collapse of vegetative growth. These infections move slowly, and in some cases, years pass between the time of infection and the occurrence of symptoms. Preventive strategies to mitigate infection of grapevines include double pruning, delayed pruning, and avoiding pruning preceding a rain event. Cane pruning or retraining a renewal shoot from the trunk are retroactive strategies to remove established infections of the grapevine cordons. For more information on grapevine trunk diseases, see Appel and Brown (2017).

Dormant buds, canes, and perennial wood can be injured by cold temperatures. Growers can monitor cold temperatures in the vineyard and check buds and wood for injury before pruning. Retaining more buds at dormant pruning may be sufficient to compensate for moderate injury to dormant buds.

More severe cold injury may require retraining vines or even replanting the vines. For more information on grapevine cold injury, see Chien and Moyer (2014).

Pruning Tools

Hand shears are necessary and sufficient to complete dormant pruning. Hand shears are used in most bunch grape vineyards throughout the world. Many manufacturers make hand shears, and some are of higher quality than others. It is recommended that growers consider purchasing name-brand shears from reputable manufacturers. Consult your local extension educator or specialist for assistance with choosing appropriate vineyard pruning tools. High-quality shears will help laborers prune more efficiently, fatigue less, and make clean cuts; moreover, the shears will last longer than cheaply made shears. High-quality hand shears can typically be found in catalogs and on popular garden, orchard, and vineyard supplier websites. Hand shears come in bypass and anvil forms, with different blade angles and sizes, and different handle sizes and setups (Figure 10). All types work well when their sharpness is maintained; a preference is often developed for one style of hand shears over another. Most
manufacturers make replaceable hand shear blades and blade sharpeners (the latter is highly recommended). Larger shears (commonly called “loppers”) help make larger cuts through grapevine wood (see Figure 10). Large shears give the pruner leverage and strength when making large cuts. Loppers are necessary for cordon replacement, conversion from cordon training/spur pruning to head training/cane pruning, and removing large amounts of dead or diseased wood that is two years old or older. Mechanical pruning tools such as battery-operated pruners are increasing in popularity due to their ability to improve the efficiency of dormant pruning. Mechanical tools reduce laborer fatigue so pruning efficiency can be maintained over extended periods. For all of these reasons, mechanical tools are especially worth consideration in larger (10 to 15 acres or more) commercial vineyards. Prepruning tools, such as gas-powered hedge trimmers, may also help dormant cane pruning efficiency in vineyards due to their ability to accomplish the first step in double pruning and reduce the labor required to pull brush from the trellis. Mechanical tools are not precise and therefore should not be used to final prune to the targeted bud and spur density.

**Summary**

This publication is intended to provide both veteran and new growers an overview of commercially popular pruning strategies and a greater depth of understanding of the theory behind pruning method practice. Dormant pruning is an important vineyard management decision because it sets the crop level and canopy density before green tissues are present. Growers must take several considerations into account when choosing a pruning method, including vineyard design, cultivar, and labor force throughout the year. Some growers may choose to adopt several different pruning strategies to successfully manage their various cultivars and vineyard blocks. Regardless of the pruning method, it is important to develop a plan that includes scheduling when and how each vineyard block will be pruned throughout the dormant season. Effective dormant pruning sets the stage for successful vineyard management throughout the forthcoming growing season.

**References**


**Adaptation**


Prepared by Cain Hickey, Penn State Extension Horticulture: Viticulture and Enology; and Tremain Hatch, viticulture extension/research associate, Virginia Tech Alison H. Smith Jr. Agricultural Research and Extension Center.

**extension.psu.edu**

Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

Where trade names appear, no discrimination is intended, and no endorsement by Penn State Extension is implied.

This publication is available in alternative media on request.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability, or protected veteran status.

© The Pennsylvania State University 2021

Code EE0523 06/21pod