Care of Established Vineyards

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Vine Canopy Objectives

The vine’s canopy is defined as the sum total of its leaves and shoots. The management of this canopy, to achieve good vine health, good wood maturity for the winter, and optimal wine grape quality, is one of the most important activities for growers in cool climates. Some principles of canopy management, paraphrased from an outstanding paper by Dr. Richard Smart (in the South African Journal of Enology and Viticulture, Vol. 11, 1990) are summarized below:

1. **Maximize Sunlight Interception.** This is critical both for proper ripening of the fruit and for good wood maturity. Ideal sun exposure has been shown to occur in vines with narrow vertical canopies, i.e. those with growth spreading out less than 1 foot in width along the trellis. Also in the ideal vine canopy, the leaves and shoots are spread out so that the canopy is never more than 1-3 leaf layers thick at any point. A final rule-of-thumb is that “gaps” should exist in the ideally exposed canopy . . . literally, places where one can look through the vine from one side to the other. A vine with gaps in 20-40% of its surface area will provide good sun exposure even for those leaves and clusters located in the deep interior portion of the vine canopy. Choice of an appropriate training system, balanced dormant pruning, and timely shoot positioning (or summer pruning) will all contribute to achieving good sun exposure in the vineyard.

2. **Minimize Shading.** Vines that fail to meet the sun exposure criteria listed in (1) above will, to varying degrees, be shaded. That is, excessive growth of leaves and shoots beyond a desirable width, depth, and density will create so many layers of foliage, i.e. so much “overgrowth,” that the leaves and fruit underneath them will be shaded. Shading of fruit and shoots renders the vine vulnerable to a host of maladies. Reported effects of shading on the fruit include lower sugar accumulation, higher titratable acidity, higher must pH, excessive must potassium, reduced pigmentation, and increased incidence of bunch rots. All of these problems can make winemaking more difficult and adversely affect wine quality. Further, shading increases humidity inside the vine canopy and reduces airflow, creating ideal conditions for mildew. Also, shaded leaves turn yellow and senesce prematurely, at which point they become useless to the vine. Again, proper training, balanced pruning, and application of shoot positioning and/or summer pruning techniques can all serve to minimize shading.

3. **Balanced Growth.** In the healthy, productive vine, there is a good balance between vegetative (leaf and shoot) growth and fruit or crop load. A vine with a good balance between vegetation and crop will usually show good sunlight interception and minimal interior shading. Both fruit and wood maturity will be good. Proper dormant pruning is the key to achieving balanced growth.

**Choosing a Training System**

Growing grapes in cold climates is challenging by itself. However, managing the cultivar to the training system is one key element in obtaining satisfactory performance from grapevines. With a good match, one can expect to have grapes with less disease, enhanced ripening of fruit, improved cane survival rates and an ample supply of fruitful buds.

The purpose of training the vine is to place its trunk, canes and resulting leaves, shoots and fruit in an optimal arrangement on the trellis. The training system selected will affect the exposure of foliage and fruit to sunlight. The height of the training system will affect the vine’s ability to intercept reflected heat from the vineyard floor. This can help reduce acid in the ripening fruit, particularly in late season wine cultivars. Through its effect on foliage density, the training system will determine the amount of airflow through the vine and the susceptibility to disease.
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The major factors to be considered in selecting a trellis system:

1. **Simplicity** - simple training systems are often the most economically viable but may restrict yield and quality.

2. **Growth habit of the cultivar** - the training system should adapt to the growth habit of the cultivar. *Vitis vinifera* cultivars typically exhibit an upright growth habit while American cultivars based on *V. labrusca* have a downward (procumbent, trailing) growth habit. Northern and French hybrid cultivars exhibit an intermediate growth habit ranging from procumbent to semi-upright. Cultivars with a procumbent or semi-procumbent growth habit do not adapt well to training systems designed for cultivars with upright growth habits, whereas, cultivars with semi-upright growth habits adapt well to training systems designed for cultivars with procumbent growth habits.

3. **Vine vigor** – the balance between vine vigor and capacity which influences yield and grape quality. The training system should accommodate the vine vigor which is influenced by the cultivar and soil fertility. Within a simple (single curtain) training system, wider in-row vine spacing is used to accommodate vigor, but vine spacing alone may not be enough and a double curtain or split canopy system may need to be used.

4. **The cold tolerance of the cultivar.** How adaptable is the training system to practices that would provide additional winter protection, or recovery from winter injury? Cane-pruned systems tend to be more compatible for tolerating winter injury than spur-pruned, cordon systems.

5. **Economic factors** - the cost and benefits of the more expensive trellis systems must be considered. How adapted is the training system to mechanization?


According to Dr. Richard Smart in Practical Winery and Vineyard July/August 1997: “We now have the means at our disposal to convert high vigor vineyards, which are prone to disease and produce low quality fruit, into productive ones with less disease and much improved quality. There is a trellising system to successfully make the most of nearly every vineyard.”
Mid-wire Cordon with Vertical Shoot Positioning (VSP)

This system begins with a short trunk trained to a low cordon wire, 30” to 42” off the ground. Cordons off this short trunk are trained on this wire and spurs from these cordons provide the fruiting wood to produce the crop (Figure 13A). Three or more sets of catch wires spaced 10 to 12” apart are fixed above the cordon wire (Figure 13B). The catch wires act as foliage traps. The narrow canopy allows sunlight to reach the fruit and renewal zones. Many shoots will naturally grow between the wires that support them in a narrow vertical wall, the rest need to be positioned manually which often requires three of more passes through the vineyard to accomplish the task. With the cordon closer to the ground, reflected heat from the vineyard floor may aid in maturing the crop, but the vineyard will be more prone to spring frosts under radiation freeze conditions.

Figure 13A. Mid-wire Cordon with VSP.

Figure 13B. Three common VSP catch wire configurations.
Some Northern hybrids and other cultivars having a semi-upright growth character are easily trained to this system. Local growers have had success using VSP for Frontenac, Frontenac Gris and Prairie Star. When used for cultivars that have strong downward (procumbent) growth characteristics, such as La Crescent, additional labor is required to maintain the shoots upright and between the catch wires. For cultivars with a strong apical dominance characteristic, spurs should be pruned to two nodes. Vertical shoot position training systems were developed for *V. vinifera* cultivars that have an upright growth habit and exhibit moderate vine vigor. With many northern hybrids cultivars exhibiting high to very high vigor, particularly on fertile (high OM) sites, additional in-row spacing and/or sets of catch wires are often needed, or training to split canopy systems such as the Smart-Dyson or Scott-Henry may be required. In addition, hedging the tops and sides of the vines, and leaf pulling may be required. The system is easy to establish, learn and can be mechanized, but has addition materials and cultural expenses.

**Single Curtain Bilateral Cordon**

![Figure 14. Single Curtain Bilateral Cordon.](image)

The Single Curtain Bilateral Cordon (High Wire Renewal System or High-wire Cordon) is widely used in the cooler climates for cultivars exhibiting procumbent to semi-upright growth habits as it is simple and effective. In this system, two wires are typically used (Figure 14). The mid-wire, set at 3- to 4-feet to support the trunk and the top wire at 6-feet, where the cordons are trained horizontally. Short canes and spurs are selected, preferably with the canes pointing in a downward direction. The fruit remains near the top wire, with most of the foliage below it.

This is one of the simplest and cheapest ways of training vines and many practices can be mechanized. Shoot positioning, often referred to as “combing”, is practiced to encourage them to grow downwards, and is typically accomplished with one pass through the vineyard. Fruit exposure to sunlight is good and exposure of buds at the base of canes to enhance next season’s crop is likewise very good. The extra height above the ground sometimes provides protection from frost layers below (Jackson, 2001).

Foliage management, although not time consuming, must be undertaken carefully. If shoots are not positioned downwards before fruit set, berries will develop in shade and on later exposure will very likely sunburn. In addition, berries may produce excess tannin, which gives bitter characteristics; however Northern hybrid cultivars are characteristically low in tannins. Bird damage may sometimes be greater with this system (Jackson, 2001).

Because this system is so easy to manage, growers are sometimes tempted to over crop the vines, a practice that leads to low °Brix (sugars or soluble solids) and poor quality wine. One other disadvantage is that because the trunk is up to
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two times the height of mid-wire systems, the first crop may be delayed by a year. Sometimes growers may crop at mid-height first, and take the trunk to the top wire the next year (Jackson, 2001).

Compared to the mid-wire cordon VSP system, the bilateral cordon system provides more space for shoot growth without trimming and so is easier to manage on a more vigorous site. In addition, positioning the shoots to grow downward, aids to suppress the vigor of the vines. All other things being equal, this extra leaf area can ripen a slightly heavier crop (Jackson, 2001).

**Four-Cane Kniffin**

Figure 15. Four-cane Kniffin training system.

The 4-Cane Kniffin system uses a two-wire trellis, with a lower wire placed at approximately 30-36” and a top wire about 60-70” above the ground (Figure 15). The trunk is trained to a head that almost reaches the top wire. Two canes each originating just below the top and bottom wires are retained with 7 or more nodes and tied to the wires with other canes originating near the wires being pruned back to 2-node renewal spurs. The canes tied to the wires are replaced each year. Additional labor is required to tie the canes to the wires each year. One problem with the Kniffin system is that for vigorous growing cultivars it is difficult to maintain quality on the bottom wire because of shading, and the system is not adapted to systematic shoot positioning or leaf removal. Also, the longer trunk, even if trained in a J style, can be rather bulky to lay down and cover for the winter. Similar to the 4-Cane Kniffin system, the 6-Cane Kniffin system has wires at 2.5, 4 and 6 feet and is suitable for low vigor sites.

**Umbrella Kniffin**

Figure 16. Umbrella Kniffin training system.
Umbrella Kniffin (Figure 16) is a variant of the Kniffin system. In the Umbrella, 2-4 canes are looped up and over the top wire and pulled down to a lower wire, where the tips are secured. The bending of the canes in this system overcomes apical dominance and helps to force and distribute growth more evenly along the cane than in a standard Kniffin system. It is suited for American cultivars requiring pruning to long canes. Extra labor is required to tie the canes to the lower wires, and it is not well adapted to shoot positioning.

**Fan System**

The Fan System allows for maximum flexibility to adjust to frequent winter injury with a minimal retention of permanent vine parts. It spreads the foliage nicely across the trellis resulting in good air circulation and sun exposure, but weeds under the vines can be a serious problem. This is suitable for most French hybrid cultivars and for certain Swenson hybrids such as La Crosse and St. Pepin. This system heads the trunk at a low trellis wire, 18-30” above the ground or even lower and 1-2 suckers are often retained to replace the trunk as needed. Two to 4 canes are spread over the trellis in a “fan” shape and tied at the middle (and if necessary, at the top wire). The fan system is not well adapted to systematic shoot positioning or leaf pulling.

The Spur Pruned Fan System (Figure 17A) is used for vines of low-medium vigor. There is a short trunk with a series of spurs (2-4 buds long). Canes growing from these spurs are arranged in a fan. The fruiting zone for this system is narrow and similar to a vine trained to a mid-wire cordon with VSP.

![Figure 17A. Fan System (Spur Pruned).](image17a)

![Figure 17B. Fan System (Cane Pruned).](image17b)

The Cane Pruned Fan System (Figure 17B) also has a short trunk, with canes arranged in a fan. There are renewal spurs at the bottom wire. This system works well for more vigorous vines that bear heavily. The fruiting zone is more spread out and will range from the height of the lowest cane to the most upright cane.

**Munson System**

The Munson system requires the special three-wire trellis (Figure 18A). A cross arm is mounted on each trellis post. A wire is fixed at each end of the cross arm. The third or middle wire runs through the posts 3”- 6” below the cross arms. The trunk is headed at this middle wire. Canes or cordons are run in both directions along the middle wire. As shoots grow from the canes, they are positioned to grow up and droop over the outside wires. The fruit all hang about shoulder level, in between the side wires, making harvest very convenient. Also, with the vine so spread out and open in the center, sun exposure and air circulation are excellent. A vigorous vine can be accommodated with a minimal amount of shading (Figure 18B). This system is suitable for cultivars with growth habit ranging from procumbent to semi-upright characteristics.
A modified Munson system has been developed for use in vineyards whose rows run east to west (i.e. face south). In a standard Munson system, vines in east-west rows will have excellent sun exposure on their south side, but foliage on their north sides will be shaded. The modified Munson system places the cross arms at an optimal angle (45 degrees for our latitude) for solar reception. The results have been promising – increased yield and better ripening of the canes for winter.

**Geneva double curtain**

Another variant of the divided trellis is the Geneva double curtain (GDC) (**Figure 19**). The GDC can be used for
vigor to very vigorous cultivars with procumbent to semi-upright growth habits that may become too large for high cordon training; especially on fertile sites. By going to the GDC, the vine vigor is distributed over a greater area and becomes more moderated. This system operates the same as the bilateral cordon system, but offers twice the amount of space for the vine canopy. GDC has two high curtain trellises installed 4 feet apart with each wire filling a single segment of both trellises. The minimum row width for this system should be 10 feet with 12 feet preferred. Training to the GDC is very similar to the bilateral cordon system, in that the shoots are encouraged to grow downwards from the top wire. This system enables a larger leaf area to be produced on a given area and also has the advantages of a single curtain for pruning and fruit exposure. Improved quality and dramatically increased yields can be expected (Jackson, 2001). Typically, yields can increase by 60% per vine.

One problem with the GDC is that keeping the large hanging “curtains” sorted out and efficiently absorbing light is time consuming task, and often at least two shoot positioning passes through the vineyard are required to keep the canopy open between the curtains. A poorly managed, overgrown canopy is a disaster. Allowing foliage to fill the gap between the two curtains creates a microclimate that annuls any advantages (Jackson, 2001). Many growers find they do not have the time or labor available to do it adequately and this effectively negates the advantages the GDG offers, attempting the grow the same cultivar on the site trained to a single curtain system would be an even greater disaster. Therefore, a grower must be committed to performing the necessary practices when the GDC is selected as the training system. It often requires an extra season of training to completely form the cordon because twice as much space is available for each vine. If the cordon or trunks are damaged by winter injury and must be replaced, it may take two seasons, rather than just one, to replace them. Thus, it is suited only to the most vigorous growing sites and for our hardiest cultivars. The system has been used in Minnesota with some success for Kay Gray, St. Croix and Beta. Edelweiss and Concord and other very vigorous cultivars may also benefit from this system.

**Mini-J System**

![Mini-J training system](image)

**Figure 20.** Mini-J training system.

If you have decided to grow a marginal or cold tender cultivar that requires winter protection, the trunk is trained at an angle to allow easier bending and burying of the trunk and vine in fall. You can also train the vine along the ground for 12” or so before it is trained upward onto the trellis to form the curved or Mini-J trunk (**Figure 20**). As the trunk grows thicker and heavier this method of training makes bending and covering much easier. This training system can be used for most trellis systems to help facilitate the covering of cold tender grapes.
A Note on Multiple Trunks

In a study done at Cornell University, vines of the Delaware cultivar with single trunks were compared to vines with two trunks. During a particularly severe winter, 95% of the vines with single trunks were killed to the ground. Ninety-five percent of the vines with double trunks lost one trunk, but only 40% of these vines lost both trunks, so 60% of the vines with multiple trunks had one trunk still functional. While the vineyard with single trunks had to be completely re-established (with a near complete loss of productivity), partial productivity of the second vineyard having multiple trunks was possible.

It has been previously stated in this guide that if you are growing grapes that are reliably cold hardy, multiple trunks may be of little value. However, in 2012, following an unusually warm March that advanced grape bud development, a mid-April freeze occurred when early bud-breaking cultivars such as Marquette and La Crescent were in the bud swell to early burst stages of development and caused considerable trunk and cordon injury to the vines. Multiple trunks require extra time to develop, require extra pruning and often have quality problems associated with them. However, multiple trunks are recommended if you are growing marginal cultivars that may regularly suffer cold injury, growing tender cultivars that need to be buried, or if you live in an extremely cold area.

**Developing trunks of different ages is recommended because trunks of the same age tend to respond to cold stress similarly.** One older and one newer trunk may allow for better bud survival on one than the other. When multiple trunks are cultivated, each remains smaller and more flexible for a longer period of time, facilitating winter protection. When one of the multiple trunks becomes too bulky to be covered, it simply can be removed, without loss of productivity. Also, developing multiple trunks is well suited for replacing cordons to maintain productivity as blind sections develop.

Building the Trellis

The choice of a training system goes hand in hand with the choice of trellising system. It is best to build the trellis during the first year when the trunks are being formed. This keeps the foliage off the ground, reduces the danger and severity of spring frost damage and allows better air circulation around the foliage. Keep in mind that some Grade 1-X or 1-1 vines could grow to 8 feet the first year and this growth could exceed the height of training stakes.

Trellis systems should be constructed to carry heavy crop loads, withstand high winds and last at least 20 years. Posts serve two functions: the line posts provide vertical support to trellis wires while end posts provide anchor points for tightening wire and maintaining wire tension. Wood posts usually prove to be superior to steel or concrete and are treated with chemical preservatives. Wood posts that have been commercially pressure treated with pentachlorophenol (PCP, or penta) or creosote should last some 20 years. Avoid using landscape timbers for line posts! They are not pressure-treated with preservative and do not last very long. Untreated native timber alternatives to treated post with exceptional resistance to decay include Osage orange, black locust and red mulberry. Eastern red cedar is rated as being very resistant to decay. Steel line posts can be a less expensive alternative to wood posts, but often do not provide sufficient lateral strength and the vine rows will lean over. This can be remedied by using a combination of steel and wood line posts.

The trellis should be 6 feet high overall and consist of line posts and sturdy braced end posts. End posts should be 5 to 6 inches in diameter for long trellis runs, and should be about 4 feet longer than the final height of the trellis. A horizontal (H-brace) or diagonal braced end post with 9 gauge low carbon (soft) steel brace wire attached to a post placed 6 to 7 feet from the end post can be used for any row length, and is required for rows that are over 600 feet long (**Figure 21A**). An anchored end post driven in at a 60 degree angle with either an earth anchor or tie back post set far enough back to form 60 degree angles can be used on rows less than 600 feet long (**Figure 21B**).
Line posts may be 3.5”-4” inches in diameter and should be 2 feet longer than the height of the trellis when a post driver is used to install them with the narrower end being inserted into the ground. When an auger is used, they should be 3 feet longer than the intended trellis height and inserted with the wider end going into the ground. Line posts for 7 foot vine spacing should be 21 or 28 feet apart. Line posts for 6 or 8 foot vine spacing should be 24 feet apart. Line post should never be spaced more than 30 feet apart. The number of wires is based on the chosen training system. The wire carrying the weight of vines should be 12.5 gauge high-tensile galvanized steel. The other wires on the trellis, such as catch wires, can be somewhat lighter.

High-tensile wire cannot be twisted and is very resistant to stretching. Therefore, crimping sleeves are used to tie off ends of wires to posts and other objects, and for splicing wires. Tension can be applied to lines less than 200 feet long with a Wirevise™ or Gripple®. For lines longer than 200 feet, in-line strainers are used. Load-bearing wires should be tensioned to about 250 pounds. A gauge can be constructed to measure the tension (Figure 22). During the winter, the wires will shrink and add additional tension. Therefore, some tension should be manually backed off, or tension springs on each wire can be used at an additional cost.

Attach the spring scale to the wire and pull the wire to the middle nail. Read the pounds tension required to pull the wire to the nail and multiply by 20 to determine the wire tension. For example: a pull of 12.5 lbs x 20 = 250 lbs tension on the wire.

Adapted from: How to Build Orchard and Vineyard Trellises, US Steel, Pittsburg, PA

Figure 22. Building and using a tension gauge for high tensile trellis wires.
Trellis Considerations

- High-wire trellis training systems are used on vines with procumbent or trailing growth habits. High-wire trellis systems should have a 12.5 gauge high-tensile wire at 6 feet, near the top of the line post. An additional wire to support the trunks is optional.

- Vertical Shoot Positioning (VSP) training systems can be used on vines with upright growth habits. The VSP training system has a 12.5 gauge high-tensile mid-wire cordon wire at 36 to 42 inches off the ground with double catch wires spaced every 10-12 inches above. These catch wires can be of a lighter gauge wire.

- For the Kniffin and Fan Training systems, (2 or 3) wires placed at 2.5, 4 and 6 feet on the posts with staples will provide the framework for the vines.

- For the Munson system, the central wire can be led through holes drilled in the posts about 3-4” below the cross-arms. A 2x4 cross-arm 2 or 3 feet long is attached to the top of the post, and two more wires are attached to the tips, so that the trellis looks like a set of old fashioned phone wires.

- The trellis for use with the Geneva double curtain looks somewhat like the Munson trellis, but, as this is for extremely vigorous cultivars, must be more substantial than other trellises. The posts, cross-arms, wires and bracing must be capable of bearing the increased pressure, which this system will place on them. It is recommended that the end posts be at least 6” in diameter, with a horizontal end post system being better adapted than the anchored end post system. The cross-arms should be metal and the wires for the cordon should be 12.5 gauge high tensile galvanized wire. Prefab metal cross-arms are readily available.

- With any trellising system, the wires should be loosely stapled to the line posts to allow for changes in length of the wire with temperature and to let the load on the wires distribute to several line posts.

For detailed information on training systems and trellis construction:

- An excellent resource on trellis construction is the United States Steel bulletin How to Build Orchard and Vineyard Trellises. It was first published in 1982 and copies are still available.


- PowerPoint presentations:
## Vineyard Best Management Practices – Care of Established Vineyards

Rate your vineyard establishment practices:

<table>
<thead>
<tr>
<th>Management Area: Choosing a training system</th>
<th>Best Practices</th>
<th>Minor Adjustments Needed</th>
<th>Concern Exists: Examine Practice</th>
<th>Needs Improvements: Prioritize Changes Here</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth habit of the cultivar</td>
<td>Training system is adapted to the growth habit of each cultivar being grown.</td>
<td>Single curtain bilateral cordon training system was selected because it is adapted to most growth habits.</td>
<td>Mid-wire cordon with VSP training system was selected regardless of cultivars’ growth habit.</td>
<td>Growth habit of the cultivar was not considered in selecting the training system.</td>
</tr>
<tr>
<td>Cultivar vigor</td>
<td>Training system with adjustment for in-row vine spacing will accommodate the cultivar’s anticipated vigor at my vineyard site.</td>
<td>Training system with adjustment for in-row vine spacing will accommodate the cultivar’s anticipated vigor. Soil fertility was not considered.</td>
<td>Training system should accommodate the cultivar’s anticipated vigor. No adjustment for in-row spacing was made.</td>
<td>Cultivar vigor and site fertility were not considered in selecting the training system.</td>
</tr>
<tr>
<td>Cultivar cold hardiness</td>
<td>The cold hardiness of the cultivar was considered in selecting the training system.</td>
<td></td>
<td></td>
<td>The cold hardiness of the cultivar was not considered in selecting the training system.</td>
</tr>
<tr>
<td>Trellising materials</td>
<td>Selected trellising materials that would last at least 20 years.</td>
<td></td>
<td>Cut costs by using lesser quality materials.</td>
<td></td>
</tr>
<tr>
<td>End post design</td>
<td>Used an end post anchoring system appropriate for the row length.</td>
<td>Used an H-brace system regardless of row length.</td>
<td>Skimped on recommended distances between end post and anchor.</td>
<td>Uses an anchored end post system on rows greater than 600 ft.</td>
</tr>
</tbody>
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