**Introduction**

The practices collectively known as “canopy management” aim to maximize canopy leaf exposure and efficiency, maintain crop quantity and quality, decrease disease incidence and severity, and improve vineyard health and sustainability. Although labor-intensive, canopy management is not optional if the goal is annual production of high-quality grapes and wines. Shoot thinning is the first seasonal canopy management practice. Shoot thinning is practiced in wine grape vineyards and sometimes in Concord vineyards where crop management is of concern. Failure to shoot thin results in a highly congested canopy characterized by reduced airflow, high humidity, and extended damp periods. Wine grapes grown in crowded fruit zones will experience excessive disease incidence and severity. Shoot thinning is thus a necessary canopy management practice in wine grape vineyards in Pennsylvania and the eastern United States.

**Why to Thin Shoots**

Dormant pruning is the first step in crop regulation. Clusters are borne on shoots that emerge from the count buds retained during pruning. Shoot thinning is thus the second opportunity to regulate crop yield. Shoot thinning is particularly important when using a combination of cordon training and spur pruning. Basal buds are left at the base of retained spurs. Less fruitful or unfruitful shoots will emerge from the basal and latent buds located at the junction of the spur and cordon, and the net effect is often excessive shoot density without a tandem increase in crop. Relative to spur pruning, cane pruning limits the number of latent and basal noncount shoots present on a vine, resulting in fewer shoots per vine overall (Hatch et al. 2019, White et al. 2020). Less shoot thinning is required when practicing cane pruning compared to spur pruning (Table 1 and Figure 1).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Shoot Count (number/vine)</th>
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<tbody>
<tr>
<td></td>
<td>2013</td>
</tr>
<tr>
<td>Cordon training and spur pruning</td>
<td>46</td>
</tr>
<tr>
<td>Head training and cane pruning</td>
<td>24</td>
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</tbody>
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*Adapted from Hatch et al. (2019).*

Figure 1. Developing buds will become shoots in spur-pruned (left) and cane-pruned (right) systems. Note the excessive noncount/latent buds (green arrows) in the left photo; buds will develop into shoots and need to be thinned out to maintain canopy porosity. Photos courtesy of Rachael White, University of Georgia.
This is of particular importance if the availability of vineyard labor is more limited in the springtime than during the dormant period. Unwanted increases in shoot density can be further compounded if vines are pruned to excessive count bud numbers (greater than three to five per linear foot of cordon) when aiming to offset the threat of cold injury or spring frost. If neither cold injury nor frost damage occurs, shoot numbers will be too excessive for desirable canopy and crop health. Shoot thinning is highly important to achieve recommended shoot densities in this situation.

It is important to thin shoots because excessive shoot density will increase the incidence of cluster touching and thus bunch rot development. Canopy and cluster congestion will increase the amount of time it takes for tissues to dry and will further limit fungicide spray penetration. We do not need help promoting fungal diseases in our humid climate. Therefore, shoots should be thinned in the spring to optimize canopy porosity, maintain cluster health, and produce a balanced crop yield. The bottom photo in Figure 2 was the result of two factors: (1) excessive bud number retention at pruning, and (2) failure to shoot thin in the spring. The shaded parts of the several touching or overlapping clusters will be prone to bunch rot and have poor color and varietal character development (Fiola 2021). The top photo in Figure 2 shows an optimal shoot and cluster density that allows for good fungicide coverage and sunlight penetration into the fruit zone.

Figure 2. An optimal cluster and shoot density in ‘Cabernet Sauvignon’ at veraison (color change and sugar accumulation; top) and an overly congested ‘Merlot’ fruit zone at bunch closure (bottom). Note: the pictures show vines that are spur pruned and trained to cordon (blue arrows). Photos courtesy of Cain Hickey.

When to Thin Shoots

Shoots grow fast early in the season. This early period of rapid shoot growth often coincides with the period of frost threat, allowing for a very short window of opportunity to efficiently shoot thin (Fiola 2021, Smith and Centinari 2017), which is roughly between the 3- to 12-inch growth stage (Figure 3). Ideally, this window of opportunity occurs after the threat of frost has passed, letting shoot length be the single factor that dictates the timing of shoot thinning implementation. Bets must be hedged if the threat of frost remains and labor is scarce. Should shoot thinning start before the threat of frost has passed to increase the chances of finishing the task efficiently, or should shoot thinning commence after the threat of frost has passed, potentially beyond the growth stage when it is most efficiently implemented? It depends on the risk of frost at each site and block. A solution to this problem may be to start thinning as soon as fruitful versus nonfruitful shoots can be identified (3 to 5 inches) and use an active frost protection method, such as air mixing via a wind machine, to protect the retained shoots.

Fruitful shoots are valuable. However, they may be accidentally thinned if shoot thinning is conducted before clusters are visible. On the other hand, if shoot thinning is conducted too late, shoot tendrils will become attached to neighboring shoots and lignification will begin at the base of the shoot, precluding efficient shoot thinning. Hybrid cultivars tend to have more fruitful secondary shoots than vinifera cultivars. This “crop insurance” might serve as an impetus to thin hybrids first, particularly in vineyards subject to frequent late spring frosts that may kill primary shoots. On the other hand, it may be logical to shoot thin earlier bud-breaking cultivars (e.g., ‘Chardonnay’, ‘Merlot’, ‘Chardonel’, ‘Marquette’) before later breaking cultivars (e.g., ‘Petit Verdot’, ‘Cabernet Sauvignon’, ‘Chambourcin’) due to shoot growth differences on a given calendar date.

Figure 3. The earliest stage to begin shoot thinning (approximately 3 inches; left), an ideal stage to shoot thin (approximately 5 to 7 inches; center), and the latest stage to efficiently shoot thin before shoots lignify at the base and tendrils grab neighboring shoots (approximately 10 to 12 inches; right). Photos courtesy of Rachael White, University of Georgia.
How to Thin Shoots

Basal, diseased, unfruitful, and otherwise short or malformed shoots are good candidates for thinning. Fruitful shoots that emerge from count bud positions on the spur or cane should be retained (Figure 4). Typically, shoot thinning is needed across the entire length of a cordon-trained/spur-pruned vine, while shoot thinning is focused only on the head region of a head-trained/cane-pruned vine. Saving basal or unfruitful shoots is advised when a spur renewal is needed to fill a missing gap in productivity on a region of the cordon or when a cane renewal is needed. If implemented within the above-recommended window of shoot growth (3 to 12 inches), shoots can easily be removed by hand. For shoots thinned much after they are 16 to 20 inches in height, a pair of hand shears will help separate shoots by cutting tendrils. Hand shears will also be necessary if shoots become lignified at the junction of the shoot and the one-year-old spur, which is more likely to occur as shoots continue their rapid growth expansion in the spring. Hand shears may also be necessary for thinning shoots if excessive bud numbers were retained on spurs during dormant pruning to compensate for potential frost or cold injury (see Figure 4). It is advised to first cut shoots away from the apical (top) portion of the spur to maintain lower renewal positions for next year. Mechanical, tractor-mounted shoot-thinning equipment is primarily used in large-acreage wine and juice grape production systems, such as those in Concord vineyards along the shores of Lake Erie.

Shoot Number

In the above text, the rather subjective terms “optimal” and “excessive” were used to describe shoot density. Shoot density should be adjusted to roughly 3 to 5 shoots per linear foot of trellis (Fiola 2021, Smith and Centinari 2017; Figure 5). On a per-vine basis, those densities equate to roughly 15 to 25 shoots if between-vine spacing is 5 feet, and 18 to 30 shoots if between vine spacing is 6 feet.

Assuming there are no incurred losses to pests, crop yield would be roughly 3.8 tons per acre if rows were spaced 9 feet apart, four shoots per linear foot of trellis were retained on a single-fruited-wire training system, the average cluster weight was 120 grams, and average shoot fruitfulness was 1.5 clusters per shoot. Crop yield would be roughly 4.8 tons per acre using the previous example but increasing shoot density to five shoots per linear foot of trellis. Those examples show how shoot density can drastically affect crop yield. However, as stated above, being too greedy with high shoot densities can increase fungal disease prevalence and reduce wine quality potential. Higher shoot densities can sometimes be retained in (1) American (e.g., ‘Concord’ and ‘Catawba’) and some hybrid (e.g., ‘Cayuga White,’ ‘Vidal blanc,’ ‘Traminette’) cultivars relative to vinifera cultivars, and (2) cultivars that are relatively more rot tolerant (‘Petit Verdot,’ ‘Petit Manseng’) compared to those that are relatively rot sensitive (‘Riesling,’ ‘Sauvignon blanc,’ ‘Pinot noir’). Vine vigor and health should also direct shoot thinning practice. Relatively lower shoot densities may be necessary to retain on young or unhealthy vines or vines grown on a low-vigor, rocky site; relatively higher shoot densities may moderate individual shoot vigor, increase crop yield, and help balance vine growth in situations where vine vigor is ample to excessive. Shoot density should be catered to each unique situation of cultivar, site, training, and production goals.
Figure 6. The most popular wine grape training system in the world, a vertical-shoot-positioned (VSP) system (top); a VSP system that has been retrofitted with several trellis crossarms to divide the canopy and increase canopy light interception and porosity (center); and a Scott-Henry system that positions shoots up and down to increase crop production and canopy light interception (bottom). Top and bottom photos courtesy of Rachael White, University of Georgia; center photo courtesy of Cain Hickey.

An excessive crop may fail to reach commercial maturity in a timely manner when an increase in shoot number does not also result in an increase in exposed leaf area that collects sunlight. Note that the crop can increase with shoot number, but high shoot density does not necessarily equate to greater light interception in the ubiquitous vertical-shoot-positioned (VSP) system (Figure 6). The “ceiling” for light interception in the VSP system is a function of foliar self-shading that occurs as a result of the space limitations of catch wire pairs that are only spaced 6 to 8 inches apart. On the other hand, greater shoot numbers can increase both crop and light interception in training systems that have one fruit zone and a divided canopy (see Figure 6). The increased space in the fruit zone and canopy in such systems may permit the retention of greater shoot densities while maintaining crop health and quality. Thus, greater shoot densities may be retained in divided, single-cordon/fruiting-wire training systems (e.g., Watson, Ballerina, “Y” or “split” VSP trellis, and Smart-Dyson) relative to nondivided systems (e.g., VSP, single high-wire). Greater shoot densities per vine are usually retained in divided, double-cordon/fruiting-wire training systems such as Geneva Double Curtain and Lyre systems.

Summary

Shoot thinning should not be thought of as an optional practice in wine grape vineyards; shoot thinning may also be warranted in Concord and juice grape production scenarios where vine size and health are limited. Relatively less shoot thinning will be required when the retained bud number during dormant pruning matches that of the desired shoot number, and when cane pruning is chosen over spur pruning. Shoot thinning is perhaps the most time-sensitive of all canopy management practices. There is a very short window of opportunity to thin shoots before there is an exponential increase in the labor required to complete the task. It is therefore highly advised that shoot thinning be started in a timely fashion and as soon as shoot fruitfulness can be determined. Starting shoot thinning as early as possible during the growing season will optimize the potential for retaining only the desired number of fruit-bearing shoots. Shoot thinning sets the stage for successful production of a healthy canopy that is less prone to fungal diseases, and a mature crop with high wine quality potential.

References and Further Reading


Adaptation


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