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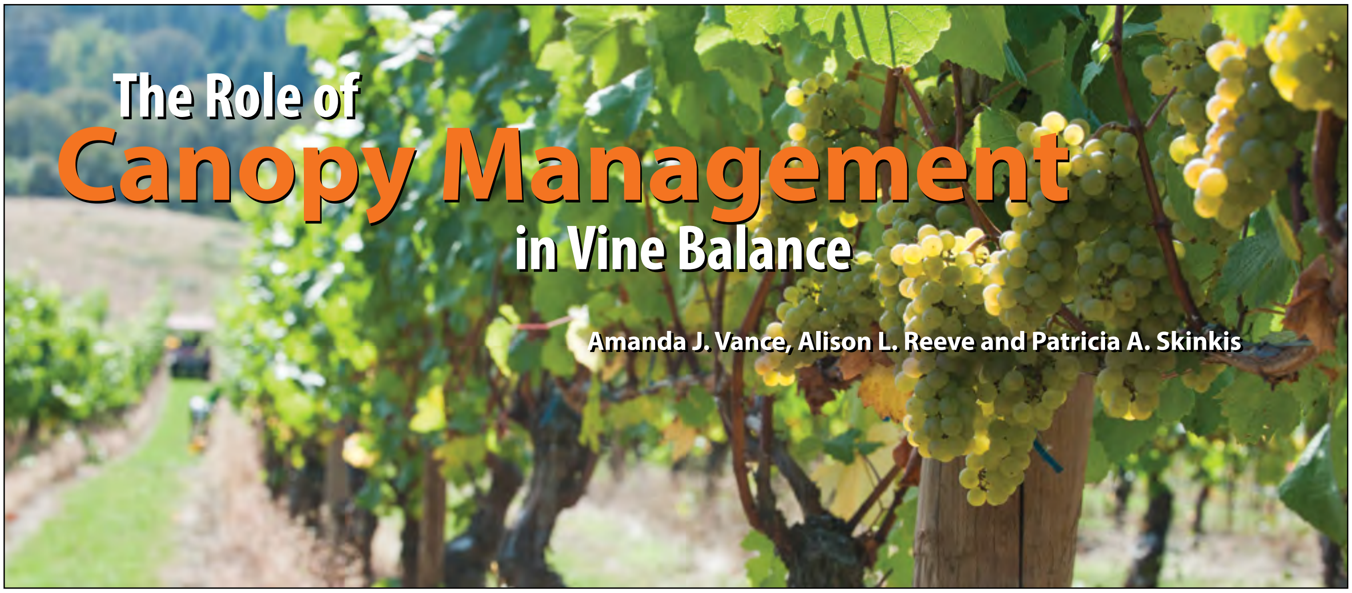

# The Role of Canopy Management in Vine Balance

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Canopy management is critical for successful winegrape production. The canopy can be managed either directly or indirectly through vineyard practices. Indirect methods of vine canopy management start with vineyard design decisions and basic management of nutrients and soil water. Such methods as irrigation, fertilization, weed control, and cover cropping are important for maintaining vine health but also indirectly alter vine growth and canopy size through nutrient and water availability. Direct practices such as shoot thinning, leaf removal, hedging, and crop thinning are used to modify the canopy for a specific target of shoot density, crop level, or cluster exposure. While direct canopy management practices can make a canopy less dense or increase exposure, they do not allow the vine to reach physiological vine balance; however, indirect canopy management methods effectively influence vine size, thereby affecting physiological vine balance. Vineyards with excessive canopy growth need more direct canopy management as a quick fix to achieve proper microclimate for fruit development, but other management must take place to alter the vine balance long-term. Vines with a weak canopy typically require methods such as irrigation and fertilizer to increase vine size relative to fruit yield.

The goal of vineyard production is to achieve vine balance where adequate canopy size and sunlight exposure result in more favorable and sustainable vine growth and fruit quality requiring fewer direct canopy management methods during the growing season. The majority of vineyards in Oregon are trained to vertically shoot positioned (VSP) training systems, and canopy management practices are required to some degree, no matter what the vine balance may be. It is estimated that canopy management costs for a Pinot noir vineyard in western Oregon totals more than $2,100 per acre (Julian et al. 2008), so it is important to know how and why certain practices are used. This publication will provide you with basic information on the impacts of canopy management methods and will help you better identify ways to achieve vine balance. For more information about vine balance, see *Understanding Vine Balance: An Important Concept In Vineyard Management*.

## Why does microclimate matter?

It is important to consider the microclimate inside the main canopy and at the fruit zone when choosing how and when to conduct canopy management

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practices. Canopy density affects the exposure of leaves of the inner and outer canopy influencing the photosynthetic efficiency of the leaves. Exposure of fruit clusters to sunlight and air flow can impact fruit quality in different ways. Here are important growth responses that are influenced by microclimate.

- **Fueling the canopy** — Leaves on the outer surface of the vine canopy absorb or reflect more than 94% of the sunlight that hits them, and less than 6% of light is available for leaves in the interior of the canopy. As a result, the outer layer of leaves is the most efficient in using sunlight to produce carbohydrates via photosynthesis. Leaves within the canopy under one or more layers of leaves will not work to their full potential and become net users of nutrients rather than producers of more carbohydrates for the vine to support the canopy and fruit. When leaves are too unproductive under multiple leaf layers, they turn yellow and abscise (Figure 1). This can be found in VSP vines with high vigor and high canopy density, and it occurs in the lower third of the canopy.

- **Developing buds and fruit for next year** — Buds for growth next year are initiated in late spring and early summer on shoots grown in the current season. Those newly forming buds develop the initial components of flower clusters, and adequate sunlight exposure of shoots is critical to obtain sufficient floral initiation and fruitfulness of shoots in the following season. Buds that develop on shoots in dense canopies with low light exposure have fewer inflorescences (flower clusters) per shoot than those canopies that are better exposed.

- **Reducing disease** — The less dense a canopy is, the more it allows for increased air flow, faster drying of leaves, and improved spray penetration. All of these factors create conditions within the canopy that are less conducive to disease infection and outbreaks, and they also improve the efficacy of pesticide applications.

- **Enhancing fruit quality** — Studies conducted in highly vigorous vineyards with dense canopies show that fruit can have high pH and unripe flavors caused by compounds in the berries (methoxypyrazines or C6 alcohols such as hexanol) while those canopies with open fruit zones and well exposed fruit can result in higher sugars, color (anthocyanins), and positive aroma and flavor compounds such as norisoprenoids and terpenes.

It is important to remember that having too little canopy and overexposed fruit can have negative results on vine health, productivity, and fruit quality. Maintaining a healthy vine size and canopy density should be the goal in vineyard management and is critical to achieve optimum airflow and sunlight exposure.

Figure 1. Leaves inside a dense VSP canopy of vigorous vines are often shaded and turn yellow when there is a lack of sunlight. Because these leaves have little function at very low sunlight intensities inside the canopy, they are sacrificed by the vine. (Photo: Alison L. Reeve, © Oregon State University)

## Direct canopy management methods

Most canopy management practices are carried out during the growing season from shoot thinning shortly after bud break to crop thinning in late summer. These methods effectively change the canopy microclimate and may reduce shoot number or leaf area of the vine. However, the vine continues to grow based on its growth potential for the given site, which is dictated by soil moisture and nutrient availability. As a result, grapevines usually continue to grow even after modifications have been made to the canopy and will result in growth of leaves, lateral shoots, or secondary fruit. The more vigorous the vine is, the more the vine will continue to grow and compensate for what was lost, resulting in increased lateral growth and shoot diameter. It is important to remember that canopy management methods can change microclimate for beneficial impacts, but these practices do not directly alter the true vine balance. To understand this more, we provide a brief explanation of each practice and how it affects the canopy and fruit of the grapevine.

### Shoot thinning

Shoot thinning is conducted shortly after budbreak and before shoots are 6 inches in length so that shoots may be easily removed without pruning shears and without damaging other shoots. It is used to reduce the number of shoots per vine for optimized production and canopy density. The fruit yield potential is related to the amount of shoot thinning, so this practice will also help manage crop level to some degree. The typical recommendation is 3 to 5 shoots per linear foot of row. Ultimately, dormant pruning should remove most unnecessary buds prior to bud break, and shoot thinning is conducted to remove late emerging buds such as adventitious buds that grow at the head of the vine or along the cordon or underdeveloped shoots. High-vigor vines in western Oregon have been found to produce three shoots growing from each bud, leading to significant canopy density if shoot thinning is not conducted. Shoot thinning is conducted exclusively by hand in Oregon vineyards and costs $405 per acre (Julian et al. 2008). Equipment has only recently been developed for mechanical shoot thinning, and it is being used in large production vineyards in Washington and California.

Shoot thinning reduces competition between shoots within the vine for carbohydrate and nutrient resources to grow and develop in the early part of the growing season when leaves are not fully capable of photosynthesizing to produce their own carbohydrates. Leaving fewer shoots on weak vines is a good way to ensure better growth. However, leaving too few shoots on highly vigorous vines can lead to increased shoot growth and potentially more canopy management passes to maintain an open canopy. Additionally, leaving too few shoots on vigorous vines will also decrease yields, further altering vine balance. In western Oregon, it is typical for growers to conduct more than one shoot-thinning pass to ensure that regrowth is removed and that the canopies do not become dense and shaded.

**Impacts on fruit quality.** Shoot thinning has been shown to result in higher Brix and pH in fruit and sometimes results in an increase in berry skin phenolics and anthocyanins. These effects are likely due to a combination of managed crop levels and increased sunlight exposure of the canopy and fruit.

### Leaf removal

Cluster zone leaf removal is typically conducted in and around the cluster zone to allow varying levels of sunlight exposure and air flow. This practice can be conducted from early to mid-season. Avoid beginning your leaf removal practices late in the season as it can result in sun- or heat-burned fruit (Figure 2). It is important to expose clusters earlier in berry development when the berry is producing photo-protective flavonoid

Figure 2. Late season leaf removal can cause berries to burn from overexposure. Berries may form dark areas on the skin or become shriveled and dark. (Photo: © Patricia A. Skinkis, Oregon State University)

compounds. Research shows that the earlier berries are exposed to visible light or UV, the more the level of flavonoids increases, providing further protection from the sun's rays (Koyama et al. 2012). Conducting the first leaf removal pass through the vineyard at or around véraison (onset of ripening) will expose fruit to increased sunlight and heat load that may result in burn since the berries have lower levels of these photo-protective compounds and the cells are beginning to soften and become more tender.

Research in the Willamette Valley of Oregon shows that removing nearly all of the leaves in the cluster zone of VSP-trained vines from bloom to bunch closure results in reduced disease incidence and increased fruit quality without causing sun or heat burning of fruit. Most growers begin removing leaves at the fruit set or pea-size stage and often choose to remove leaves on only the morning-sun side of the vine, keeping leaf cover over the fruit on the afternoon-sun side of the canopy to prevent burn. The benefit of more aggressive leaf removal in cool years is to increase airflow and exposure to aid in disease prevention. Studies in the Willamette Valley have shown that fruit zone leaf removal reduces the incidence and severity of both powdery mildew and Botrytis bunch rot compared to vines with no leaf removal. Less disease results in a more efficient canopy, less culling of unmarketable fruit prior to harvest, and higher overall fruit quality.

Leaf removal should be done with caution in the warmer, drier regions of southern and eastern Oregon. Vine canopies in these warmer regions are typically smaller and there is less shading of the cluster zone. As a result, there is a greater potential for sunburn of fruit since the temperatures are higher and relative humidity lower than in the Willamette Valley. Some leaf removal may be beneficial depending on the vineyard, grape variety, and climate in southern and eastern Oregon. If there are heavy disease situations, there may be a benefit of increasing the cluster zone exposure using leaf removal.

Leaf removal in the cluster zone can be conducted by hand or by machine (Figure 3). Leaf removal machines use different methods by which to remove leaves from the vine, including pulsed air, which shreds the leaf blade, or suction and cutting to remove the leaf blade from the petiole. Hand leaf removal can be more costly than mechanical leaf removal, but it can clean the cluster zone more precisely than mechanical methods. Leaf removal machines can be dialed in


Figure 3. Photograph (a), above, shows a bloom-time canopy with no leaf removal. Photograph (b) shows how mechanical leaf removal is used on both sides of a VSP-trained canopy to reduce leaf cover by approximately 50%. Photograph (c) shows hand leaf removal on both sides of the canopy (c). (Photos: Patricia A. Skinkis, © Oregon State University)

to produce different intensities of leaf removal, but it requires that you choose the right machine for your canopy needs and determine the best settings to use in achieving the amount and location of leaf removal that you desire. Finally, it is important to note that the earlier leaf removal is conducted, the more passes are required to clean up new leaves that emerge or laterals that grow from lower nodes. In these cases, mechanical leaf removal can be an advantage as you can conduct earlier leaf removal with more timely follow-up removal during the season.

**Impacts on vine carbohydrate development.** In healthy vines, cluster zone leaf removal does not greatly affect net carbohydrate production for the fruit or vine when conducted shortly after fruit set. Relatively few leaves are removed from the cluster zone when using this practice with as little as 1 to 2 leaves removed per shoot or as many as 5 per shoot with complete cluster zone leaf removal. Most VSP canopies in Oregon have plenty of leaves per shoot when the canopy is full (30-plus leaves), and this is sufficient for vine carbohydrate production. Leaf removal before fruit set may lead to reduced carbohydrates available to the developing flower and may result in lower fruit set. By late season, cluster zone leaves are the oldest and are less effective at photosynthesizing than mid-canopy leaves or leaves on lateral shoots due to older age, reduced nitrogen level or exposure to sunlight. Lower vigor vines that have a sparse canopy likely do not need much if any leaf removal. Removing leaves in the cluster zone of low-vigor vines may cause problems as the canopy is more limited or the fruit is exposed to more sunlight than in a higher-vigor vine. This may lead to delayed color and sugar accumulation in the fruit. For most vineyards in western Oregon, there is adequate canopy to support the development of fruit, and the benefit of increased fruit exposure outweighs the loss of these leaves.

**Impacts of fruit quality.** Removal of leaves in the cluster zone increases sunlight exposure of grape clusters which, when performed early in berry development (at or prior to fruit set), can increase production of secondary metabolites in the berry. As mentioned previously, the berry produces photo-protective flavonoids, many of which also are precursors to desirable berry ripeness compounds at harvest in red winegrapes. These flavonoids include phenolics, anthocyanins, and tannins. Fruit exposure in aromatic white winegrape cultivars has also been shown to increase aroma compounds. Research in Oregon during both warm and cool seasons indicates that while leaf pulling can enhance fruit composition at harvest, there is rarely an appreciable difference between leaf removal and no leaf removal on basic ripening parameters including Brix, pH or titratable acidity.

## Hedging

Hedging is a common practice for VSP-trained vines in Oregon. The goal is to remove excess primary and lateral shoot growth from the top and sides of the canopy (Figure 4). This is needed to prevent shading and entanglement of shoots between vine rows and to allow worker and tractor traffic through the vineyard. Hedging is

Figure 4. Hedged rows (left) have the correct canopy height-to-row-width ratio to reduce canopy and fruit zone shading while unhedged rows (right) have excessive growth beyond the trellis. (Photo: Patricia A. Skinkis, © Oregon State University)

conducted in Oregon from fruit set to véraison and is important to maintain adequate light exposure of leaves, fruit, and developing buds in dense canopies that have excessive vegetative growth. Although hedging decreases canopy by cutting primary and lateral shoots, it does not directly decrease the vine's inherent vigor and can further promote growth by inducing lateral shoot growth in vigorous vines when conducted in early to mid-summer.

Hedging too early in the growing season should be avoided as it can initiate lateral growth and increase canopy density. Hedging at bloom can be used to increase fruit set of some cultivars as it removes the actively growing shoot tip, which is the primary carbohydrate sink during bloom and may be in competition with the inflorescence for resources. By removing shoot tips, this temporarily makes these resources available to the blooming inflorescence. Hedging is usually not necessary during the ripening phase if it has been done earlier in the season, as shoot growth has largely ceased at that point. Hedging is often conducted with mechanical hedging machines, which remove the shoot tips and laterals, but may also be done by labor crews using machetes.

**Impact on fruit quality.** Research on hedging shows variable impacts on fruit quality, including a potential alteration of yield, Brix, pH, and titratable acidity. These impacts are likely related to total leaf area or increased sunlight infiltration and photosynthetic efficiency of the canopy. Typical hedging practices (Figure 4) in vigorous VSP vines in western Oregon allow better canopy microclimate. Leaf pulling alone would have little benefit to exposing the clusters to sunlight as they would be shaded by laterals and the tops of primary shoots. Hedging helps in disease management by allowing better airflow and spray penetration, thereby reducing disease infection of fruit.

## Crop thinning

Crop thinning is a practice used to adjust fruit yields to obtain balance between fruit and canopy to achieve optimum ripeness. It is a common practice used in Oregon, primarily to restrict yield in cool climate regions with specific attention to Pinot noir production. Crop thinning is time-consuming and expensive, costing Oregon grape growers approximately $540 per acre each year (Julian et al. 2008), depending on intensity and selectivity of the method. While crop levels can also be reduced by altering bud number at pruning and then by shoot thinning early in the season, crop thinning may still be required to reduce yields to targets determined by production goals. Also, crop thinning can be used to remove lagging fruit or second crop that arises later in the season from adventitious shoots at the head of the vine or from lateral shoots in the mid- and upper canopy (Figure 5).

**Crop thinning level.** The amount of crop to remove during thinning depends on the yield potential, vine size, and growing region. Vigorous vines (large vine size) have large canopies and are generally capable of ripening more fruit than small, lower-vigor vines. However, it is generally found that cool climate winegrape regions like the Willamette Valley require more leaf area to fully ripen fruit compared to warmer climates that have more light intensity and heat units. Vines

Figure 5: Secondary clusters or "second crop" can form from lateral shoots that emerge from primary shoots. The primary crop is shown (near harvest) and a secondary crop cluster (in véraison) above the primary clusters of Pinot noir. (Photo: Patricia A. Skinkis, © Oregon State University)

in cool climate regions are often crop-thinned to a higher degree than warmer regions to be able to increase the canopy size relative to the yields. Different cultivars are grown between warm and cool regions, and this too may influence the crop thinning required. It is important to remember that reducing the crop level too much can lead to increased vegetative growth and canopy density, which negatively impacts fruit quality and vine productivity in the future.

Weak or low-vigor vines generally produce less fruit and may not require heavy crop thinning to bring them into balance. However, if the health status and vigor is very low, then crop thinning will be required to bring the vine back into balance and ensure that enough carbohydrates are being produced by the canopy to ripen the fruit and replenish nutrient reserves. In the case of weak vines or vines in areas with more water stress and smaller canopies, early season thinning may help manage the amount of fruit while encouraging healthy canopy growth.

**Impact of thinning on vine vigor.** The impact of crop thinning on vegetative growth depends on vine vigor and yield capacity of the cultivar and the crop-thinning method used (intensity and timing). Since shoots and fruit are both sinks for resources, namely water, nutrients, and carbohydrates, it is generally thought that heavy yields reduce vine growth and that removing fruit to achieve lighter yields can result in increased canopy growth and higher fruit quality. However, research worldwide shows conflicting evidence regarding these claims, suggesting that yield management is dependent on the balance of a given vineyard and cannot be explicitly described for a given region or cultivar.

**Timing of crop thinning.** Crop thinning can be done at any time from pre-bloom through just prior to harvest. Timing is important because shoots and flowers (or fruit) are competing with each other for resources within the vine, and, depending on when thinning is reduced, there may be different results for either the canopy or the fruit. Research suggests that pre-bloom thinning can lead to increased fruit set of the remaining clusters and can potentially increase vegetative growth. However, pre-bloom thinning is not typically used in regions (such as western Oregon) where fruit set can be unpredictable and variable by year. Growers fear that reducing their crop level too early could mean greater crop losses in a year with poor fruit set. Research in Oregon indicates that when only a small percentage of total crop level is removed prior to bloom or when there is adequate vigor to allow healthy canopy development, thinning does not influence fruit set. This may be due to the availability of adequate carbohydrate reserves for inflorescence development.

Thinning at or near fruit set has been shown to increase concentration of such metabolites in the berry as phenolics (mouthfeel characters) and anthocyanins (color) by harvest. Having fewer clusters on the vine at fruit set allows the remaining clusters to develop with less competition. In small or weak vines, removing crop earlier in the season may help improve berry development because there is less competition, allowing for more vegetative growth to support the berries through ripening. Berry-size compensation, a phenomenon where berries enlarge post-thinning, is a concern for many winegrape growers and winemakers, but research shows that it is not a rule with early season thinning—various studies show mixed results. Work in Oregon Pinot noir crop thinning did not result in differences in berry size (Vance 2012).

Most grape growers in Oregon conduct cluster thinning between fruit set and bunch close or during lag phase. Thinning at lag phase allows growers to estimate yields and determine the amount of fruit to remove to achieve yield goals. A smaller percentage of the Oregon industry conducts cluster thinning at véraison. When clusters are thinned at véraison, the grower aims to remove fruit that is lagging in development and can be thinned based on the progression of color change in red cultivars. Research is being conducted at Oregon State University to determine the best timing and intensity of crop thinning, but very early crop thinning has not been found to be necessary for Pinot noir in most western Oregon vineyards.

In low-vigor or weak vines, thinning fruit late in the season may put a strain on canopy growth due to the competition between shoots and fruit for carbohydrates and nutrients earlier in the season. However, in vines with adequate canopy or high vigor, it is unclear whether maintaining a larger vine yield through much of the growing season and thinning at lag or véraison has any growth impact. In the case of the higher-vigor vines, it may be more beneficial to maintain higher fruit levels for a longer period of time to keep the canopy growth in check so as to allow more sunlight into the canopy and reduce canopy management costs. It is unclear if waiting until late season to conduct crop thinning has any impact on volatile aroma compounds in grapes. Further research is in progress to better understand the role of vine balance in fruit aroma development.

Pre-harvest cluster thinning is conducted to remove damaged and unmarketable fruit. Research in Oregon Pinot noir suggests that removing fruit at these late stages of development will not greatly impact sugar accumulation or berry secondary metabolite composition, but it will aid in harvest operations and reduce the amount of post-harvest sorting required.

**Impacts on fruit quality.** Crop thinning, when warranted, can help ensure that the fruit obtains adequate ripeness (Brix, pH, and titratable acidity). Some cluster-thinning studies indicate that with decreasing yield, there is increasing Brix and anthocyanins. Some data suggests that obtaining certain optimum yields results in more ripe characteristics. However, there is a point in some cultivars where there can be either too high or too low a crop level in terms of fruit quality.

Crop thinning is an important way to increase winegrape quality and balance vine growth when vegetative growth is lacking and crop loads are high relative to the vine size. However, the way that crop thinning is conducted (if at all) is dependent on your site, cultivar, and production methods. There are no set crop levels that will guarantee the best fruit quality. It is important to keep records of predicted and actual yields along with measurements of vine size (dormant pruning weight or leaf areas) to determine vine balance and how crop thinning is affecting fruit yield and composition for your vineyard.

## Indirect canopy management methods

Canopy size and fruit yield can be manipulated by key factors in vineyard management that influence soil moisture and nutrient availability. The following water and nutrient management techniques can have strong impacts on canopy and overall vine growth and productivity over time. These methods often require more than one growing season to see the full effects, though you may see shorter-term results in situations where water or nutrients are severely limited and a change in management practices restores the necessary requirements.

### Irrigation

Irrigation is an important tool for managing the canopy in warmer, drier winegrape production regions of Oregon. Some areas of the Willamette Valley may require irrigation, but many vineyards in the region cannot adequately control canopy size or fine-tune canopy management with irrigation. Areas of southern and eastern Oregon and eastern Washington require regular irrigation for vineyard production each season. Proper irrigation techniques can be used to improve vine balance and fruit composition in these drier regions. Early season irrigation can be used to manage canopy development; however, it must be used with caution as irrigation is required to maintain healthy shoot growth and ensure proper flower development and fruit set.

In many areas of western Oregon, early season irrigation is not required due to sufficient soil moisture.

However, irrigation may be required post-bloom as the region experiences dry summers with limited rainfall. Irrigation applied from fruit set to véraison can be used to ensure proper berry development and to allow adequate canopy growth. Fine-tuned irrigation strategies are required to allow vines to grow just enough canopy necessary to support the fruit without having excessive growth, thus better managing vine balance. From véraison to harvest, irrigation should be used to maintain a healthy, functioning canopy to ensure sugar production for the fruit and carbohydrate movement to storage reserves for next year.

**Methods to moderate canopy size with irrigation.** There are two irrigation management techniques that have been developed to optimize canopy growth and fruit quality while reducing water use: regulated deficit irrigation (RDI) and partial root-zone drying (PRD). Both methods utilize evapotranspiration (ET) to determine how much to irrigate. Evapotranspiration data is available from on-site weather stations or through local weather networks such as Agrimet for the Pacific Northwest (http://www.usbr.gov/pn/agrimet/wxdata.html).

- **Regulated Deficit Irrigation (RDI).** With the RDI method, the vineyard is irrigated to a certain percentage of full ET, which means that only a portion of the water a plant loses to the atmosphere in a given day is replaced by irrigation. Commonly, 50 to 70 percent of ET is provided to maintain canopy growth, berry cell division, or cell growth, while enhancing fruit exposure and reducing water use.
- **Partial Root-zone Drying (PRD).** With the PRD method, the vine is irrigated to a certain percent of full ET, but the water is applied to only a portion of the root zone. This requires two drip lines, one on either side of the vine row, and the different sides of the vine are irrigated on alternating schedules. The wetted root zone must be alternated regularly to avoid compensatory root growth (or death) in either side of the vine row. By leaving half of the root zone dry while watering the other, the vine is able to grow sufficiently while also responding to water stress though hormone signaling, thereby increasing secondary metabolites. This method was developed in Australia as a way to maintain vine yields and fruit quality while also decreasing water use. This method has not been widely used in the United States, and other studies suggest that the vine responses may not be the same across locations or cultivars.

The RDI and PRD methods indicate how much water should be provided to the vine to regulate growth. However, they do not indicate when to irrigate. Vine water status should be measured regularly in irrigated vineyards to determine when to irrigate. Water status is commonly measured with a pressure chamber, which measures how much pressure is required to move water through the leaf xylem tissue. These data, combined with ET data from your local weather station, should be used to answer the key questions when designing an irrigation management regime: when to begin irrigating and how much to apply. For detailed information about these irrigation techniques, see *Factors Influencing Grapevine Vigour and the Potential for Control with Partial Rootzone Drying*, and *Regulated Deficit Irrigation and Partial Rootzone Drying* (http://lwa.gov.au/files/products/national-program-sustainable-irrigation/pr020382/pr020382.pdf).

KEY TERM

**Evapotranspiration (ET)** – The amount of water that evaporates from the soil and is transpired by a plant in a given day. The ET can be determined by most weather stations or obtained from local or regional weather networks such as *Agrimet*.

## Fertilization

In general, grapes have relatively low nutrient demands compared to other perennial crops. However, most Oregon vineyards require some form of fertilization, whether it is macro- or micronutrient supplementation, for maintaining proper growth and fruitfulness. The decision to apply fertilizers should be based on visual observations of vine growth and interpretations of vine tissue analyses. Timing, formulation, application, and rate are critical considerations when developing a sound nutrient management program for the vineyard, and these factors must be considered with respect to vine health and the vine balance outcome desired. For example, many western Oregon vineyards require fertilization with the micronutrient boron, which is critical for normal flowering and fruit set. When vineyards are deficient, there can be reduced fruit set and lower yields. Also, nitrogen (N) plays an important role in both vegetative growth and fruitfulness of vines. Without adequate N, vines can become chlorotic, weak, and have reduced yields. Conversely, if there is too much N, grapevines can become overly vegetative and reduce fruit set and yields due to increased density and shading, or physiological disorders such as inflorescence necrosis. Furthermore, fruit may be severely deficient in N needed for fermentation depending on the vine N status. Because nutrients influence vine growth and fruit quality, it is important to consider management over the long term. For more detailed information on grapevine nutrient management and tissue sampling, see the online learning module, *Grapevine Nutrition (*EM 9024) at http://extension.oregonstate.edu/catalog/.

## Vineyard floor management

The way the vineyard floor is managed with tillage or cover can significantly impact nutrient availability and soil moisture, thereby affecting vine growth. Vineyard floor management includes management of the vine row and the tractor row, and encompasses managing weeds, the use of cover crops, or tillage. No single practice is appropriate for all vineyards, so you will need to consider how to manage your vineyard floor block by block, and make decisions based on soil type, water and nutrient availability, vine vigor status, and your production goals.

There is adequate soil moisture through much of the growing season for many Willamette Valley vineyards, and vines can be grown without supplemental irrigation. Vineyards with adequate soil depth and soil moisture typically have higher vegetative vigor, and cover crops that compete for water or nutrients can help reduce vine vigor. Research conducted in a high-vigor Pinot noir vineyard in the Willamette Valley has shown that perennial grass cover reduces vine size by competing with the vines for nitrogen (Skinkis, in progress). Reduction in vine vigor led to natural yield reduction after 5 years under these conditions. By reducing vine size in this study, the vines were in better balance than in tilled, non-grass cover treatments and there was increased canopy and fruit exposure. In some years, fruit from vines grown with competitive grass cover had higher levels of anthocyanins and better aromatic profiles compared to fruit from vines growth without any competitive cover crops.

While devigoration may be necessary in some vineyards in western Oregon, other vineyards may require invigoration with increased nutrition, or soil moisture, or both to achieve vine balance. Cover crops can be used to enhance vine nutrition and soil moisture, depending on the species of cover crop chosen and the management methods used. Legumes can be planted and tilled into the alleys or mulched in the vine rows to increase nutrient availability to the vines and to manage weeds (Figure 6). Alternating permanent grass cover and tillage in alleys can be practiced to allow some level of competition but also to conserve soil moisture, thereby better managing vigor in moderately vigorous sites (Figure 7). Research conducted in the Willamette Valley shows that

Figure 6. A legume-cereal grain cover crop mix was grown and used as a vine-row mulch to enhance soil moisture, increase nutrient availability, and increase growth of young vines. (Photo: Patricia A. Skinkis, © Oregon State University)

Figure 7. By alternating management of the tractor-rows on either side of the vine row with tillage and a permanent grass cover crop, grape growers in western Oregon have been able to manage the balance between soil moisture and vine nutrient availability to moderate vine growth. (Photo: Amanda J. Vance, © Oregon State University)

alternating tillage and permanent grasses in alleys allows vines to fall into an intermediate vine vigor classification compared to vineyards that have complete tillage (high vigor) or permanent grass cover (lowered vigor). In more arid regions, keeping the vineyard floor bare will help reduce or eliminate soil moisture competition and help maintain vine growth.

However, there is interest in using some noncompetitive low-growing grasses in these regions to provide cover so as to avoid soil erosion and mite problems, which can occur with increasing dust when vineyard floors are kept bare. Some low-growing grasses may serve as a living mulch and effectively conserve soil moisture, particularly in the dry season when the grasses are quiescent (dormant).

For more information on vineyard floor management techniques and effects on vine growth and fruit composition, see Guerra and Steenwerth (2012).

## Summary

Canopy growth must be managed in premium winegrape production, and in-season management practices should be used in combination with indirect methods that influence canopy size and vigor.

Managing your canopy with vine balance in mind can help improve both the microclimate of the canopy and the fruit zone and will result in improved fruit composition.

Once basic vineyard management techniques such as soil moisture management, nutrient management, or vineyard floor management are determined, you only need to fine-tune the direct canopy management methods to achieve the right balance for your vineyard and production goals. It is important to remember that no one combination of management techniques will deliver the best balance or fruit quality in all situations. A customized plan needs to be made for each vineyard.

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Vance, A.J. 2012. *Impacts of Crop Level and Vine Vigor on Vine Balance and Fruit Composition in Oregon Pinot Noir.* Thesis. Oregon State University, Corvallis, OR.

## Further reading

For more general information on vine balance and canopy management, please see *eViticulture* (http://eViticulture.org), an online national Extension resource. For more detailed information on components of vine balance, please see the following:

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