



# Proceedings of the Symposium on Establishing and Managing Vineyards to Meet or Exceed Winery Specifications

February 5–7, 2011  
Midwest Grape and Wine Conference  
St. Charles, Missouri

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Institute for Continental Climate Viticulture and Enology  
College of Agriculture, Food and Natural Resources, University of Missouri  
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# Proceedings of the Symposium on Establishing and Managing Vineyards to Meet or Exceed Winery Expectations

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**Midwest Grape and Wine Conference  
St. Charles, Mo.**

**Editors:**

R. Keith Striegler  
Andy Allen  
Jackie Harris

Institute for Continental Climate Viticulture and Enology  
College of Agriculture, Food and Natural Resources, University of Missouri  
Missouri Wine and Grape Board

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**On the cover** (clockwise from top left):

Fruit color and composition can be improved and herbaceousness reduced through good canopy management practices, including shoot thinning, leaf removal, and cluster thinning as demonstrated for (1) high-wire cordon and (2) Vertical Shoot Position trellised vines.

(3) A grape harvester signal used to differentiate fruit quality during harvest.

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# Symposium Agenda

**Saturday, Feb. 5, 2011**

**Dr. Keith Striegler, Moderator**

- 8:00–9:00 a.m.      How Do You Make a Winemaker Smile?**  
*Russell Smithyman, St. Michelle Wine Estates, Prosser, Wash.*
- 9:00–10:00 a.m.    Soil Variability and the Economics of Nonuniformity**  
*Dr. Robert Wample, Soil and Topography Information Inc., Clovis, Calif.*
- 10:15–11:15 a.m.   Viticultural Options to Achieve Desired Grape Yield and Quality**  
*Dr. Paolo Sabbatini, Michigan State University, East Lansing, Mich.*
- 11:15 a.m.–noon    Reducing Herbaceous Aromas in Cabernet Franc**  
*Dr. Justine Vanden Heuvel, Cornell University, Geneva, N.Y.*

**Sunday, Feb. 6, 2011**

**Dr. Keith Striegler, Moderator**

- 8:00–9:00 a.m.      Response of Traminette to Rootstock and Three Different Training Systems in Virginia**  
*Dr. Tony Wolf, Virginia Tech University, Winchester, Va.*
- 9:00–10:00 a.m.    The Use of Remote Sensing for Vineyard Differential Harvesting**  
*Russell Smithyman, St. Michelle Wine Estates, Prosser, Wash.*
- 10:15–11:30 a.m.   Meeting the Expectations of the Customer, Whether a Winery or Consumer**  
*Dana M. Merrill, Mesa Vineyard Management Inc. and Pomar Junction Vineyard and Winery, Templeton, Calif.*



# How Do You Make a Winemaker Smile?

**Russell Smithyman**

Ste. Michelle Wine Estates

Prosser, Wash.

## Introduction

Whether the wine industry is experiencing depression or growth, grape growers need to continually market their fruit to pay for current production costs and to recover the investment required to develop a vineyard. In the same fashion that a winery must create a reputation to sustain wine sales, grape growers must establish a positive reputation for their vineyard to optimize long-term profitability. And although many factors influence a vineyard's image, the most important determinant in creating a positive reputation is the production of grapes that allow the winemaker to craft quality wines. Hence, a grower intent on developing a positive reputation for a vineyard should have a strong interest in the wines produced from that vineyard's fruit.

Vineyard location and management have the greatest influence on fruit quality and ultimately on wine quality. But because quality is subjective and each winery has different objectives for its wines, building a strong relationship with the winery also is necessary to align fruit quality characteristics with desired wine styles. Many wineries have adopted a tiered quality structure for placing wines in different price ranges, thereby providing growers with more options for their fruit. A good relationship between the winery and the grower allows for structuring contracts that benefit both parties. Such a contract should convey a philosophy of producing the best quality fruit at a given price and should ensure that both parties understand the expectations for the fruit to be produced. If you have to refer to the contract during the growing season, then something is wrong with the relationship. Selecting a winery that can optimally express a vineyard's quality characteristics provides the best opportunity for improving a vineyard's reputation and long-term profitability.



## **Vineyard site selection**

Vineyard site selection is the most important factor influencing potential grape yield and fruit quality, and thus the decision of where to plant a vineyard affects profitability for the rest of the vineyard's life. However, good site selection does not always result in sustained success. A number of optimal vineyard sites are mismanaged, resulting in inferior wines being produced. Often, vineyard establishment near other successful producers provides enough incentive for wineries to desire the fruit. Many vineyards, though, are being planted in new locations across the United States that have not previously had grape production, thus vineyard quality must be demonstrated. When evaluating a vineyard site, growers should consider soil properties, surrounding geography, mesoclimate and access to labor and transportation, as well as winery interest in the area and varieties suitable for the location.

## **Vineyard design and management**

Once a vineyard site is selected, its design and management become the main factors in determining potential fruit quality. Managing a vineyard with a philosophy of producing the best quality fruit at a given price increases the potential for better quality wine. Vine spacing, trellising, row orientation and training should be matched with varieties appropriate for the site's conditions and for optimizing desired production and quality. The irrigation system and vineyard floor management also should be considered to enhance vineyard productivity and quality. Proper canopy management is essential for improving fruit quality once the vineyard is established, and starts with sufficient pruning for the site, season and wine style. Although retaining extra buds to ensure desired crop levels is tempting, the time and expense of removing extra growth later can make this practice prohibitive. Excessive canopy growth also potentially reduces fruit quality. Hence, obtaining optimal vegetative growth and crop levels as early as possible and then maintaining balance between vegetation and crop for the remainder of the season typically enhances fruit quality. Canopy management during the growing season includes shoot, leaf and cluster thinning, either mechanically or by hand. Prudent irrigation management can also control canopy growth in areas where rainfall is limited, whereas mechanical hedging may be required in areas with high rainfall or excessive vigor to maintain balance between vegetation and crop. Maintaining a healthy canopy also is important to achieve optimal fruit quality. Pests and disease can greatly reduce yield and quality,

so using management practices that inhibit or reduce their populations is critical. Additionally, vine nutrient status should be evaluated during the season to optimize vine productivity. Vineyard canopy management practices should be determined and then performed to achieve a desired wine style that enhances the vineyard's reputation.

Vineyard management focused on quality also may include organic, biodynamic or another type of certified sustainable production. It also may require additional vineyard practices due to unforeseen events. The extra expense is often worthwhile in building a strong relationship with the winery and usually results in enhanced wine quality. Executing management practices in a timely fashion is also important for optimal quality and developing a relationship with the winery. New technology to improve vineyard management and quality is becoming more available and is easy to use. Remote sensing of canopy size, soil moisture monitoring and differential harvesting are just a few practices where use of technology has improved fruit and wine quality. Thus, the use of new technology can greatly enhance vineyard profitability and image. From site development to harvest procedures, the management of the vineyard greatly influences not only fruit quality but also the vineyard's relationship with the winery.

## **Summary**

Working closely with a winery to craft wines that express a vineyard's full potential is the best method for improving a vineyard's reputation and thus potential profitability. This requires a strong relationship with the winemaker and a shared desire to produce the best quality wine possible. Selecting a winery that provides information on desired styles and produces wines that enhance your site's characteristics is preferable to promote your vineyard's reputation. Although site selection is often considered the most important consideration for potential production and quality, vineyard design and management are equally important in establishing a quality vineyard reputation. Once a vineyard is established with goals in mind, canopy management is necessary to provide fruit for the wine style desired. Being able to adapt to unforeseen circumstances and wanting to provide the best quality fruit possible cultivates a strong relationship with the winery. Using new technology can even further enhance productivity and quality. Providing the winery with fruit that suits a desired wine style will make not only the winemaker smile but the grower as well.



# Soil Variability and the Economics of Nonuniformity

**Dr. Robert L. Wample**

Plant Physiologist

Soil and Topography Information Inc.

The current popular concept of sustainability is multifaceted, comprising goals of environmental sustainability, social responsibility and economic sustainability. Most growers of wine grapes and of other crops do their best to meet all three goals. Of these goals, economic sustainability is the most important, however, because without it, achieving the other two will not be possible. One of the most overlooked factors in our efforts to achieve economic sustainability is the effect of field variability, or nonuniformity.

Although most growers are aware of variability in their fields, they are rarely able to accurately diagnosis the causes of the variability and, consequently, they are unable to solve the problem and thereby achieve maximum potential uniformity. Overcoming field variability, assuming the objective is to bring low-yielding or lower-quality portions of the field up to the yield or quality levels found elsewhere in the field, results in higher economic returns. The simple reason for this is that under most agriculture management practices the input costs are the same per acre regardless of the yield and quality of the product produced. The typical cause of the reduced yield or quality associated with field variability is uncontrolled or unplanned plant stress. This stress could be caused by a wide range of environmental factors, such as water shortages and temperature extremes; poor management practices; and soil variability that, in the past, could not be precisely accounted for and resulted in making compromises in management practices. Complicating the interpretation of plant stress is the increased susceptibility of plants to insect and disease pressure caused by many forms of stress. Stress-induced diseases are common in biological systems. Because soil represents at least 50 percent of the environment in which plants live, understanding and managing the soil, and its inherent variability, is important in managing plant stress. Fortunately, tremendous progress has been made in the past 10 years in developing techniques to create detailed maps of soil variability.

With this improved understanding of the three-dimensional soil physical and chemical properties within a field, one can make much more precise recommendations to improve crop management.

Crop management is a major factor in achieving the desired yield and quality characteristics established for a specific crop and location. Grapevine management practices such as choice of trellis system, pruning practices, canopy management and crop adjustment can be applied uniformly across the vineyard. However, depending upon the potential of some areas of a field, applying differential pruning and crop adjustment to those specific areas might be desirable. These differences reflect variability in crop growth and productivity, which are often caused by variability in soil characteristics. Many growers recognize the potential value of being able to apply differential management practices to overcome this variability; however, without adequate soil information, their management practices are limited to managing the lowest common denominator, which is usually associated with obvious problem areas. Their effort to increase uniformity in soil nutritional characteristics is one of the original management practices. Unfortunately, until now, one could not accurately, precisely and economically establish the levels of plant nutrients within a field such that differential fertilizer applications could be used to achieve field uniformity. Hence, the typical practice was to apply the same amount of fertilizer across the entire field with the hope of bringing the majority of the field to some “minimal operating level” for the nutrient being applied. However, this often resulted in some areas of the field having more than necessary to produce the crop, while other areas were still at marginal levels. To overcome this problem, additional fertilizers would be applied, which would further complicate the effort to manage field nonuniformity. This approach also results in higher management costs for fertilizers and soil amendments, while potentially increasing the susceptibility to some pests and diseases.

A similar problem regarding nonuniformity of soil water occurs in most commercial agricultural fields, especially in regions that depend upon irrigation to achieve desired crop production. Unfortunately, if this problem is not recognized prior to planting, especially of permanent crops, it is difficult to manage. Soil water problems can include areas with too much water as well as those with too little water. Soil water problems may also involve differences in infiltration rate and saturated hydraulic flow, which influence the ability to apply and retain water in the root zone. Furthermore, a lack of knowledge about how water will move laterally in the

subsurface within a field, through either mass flow, differences in soil-water matrix potential or capillary activity, makes this problem very difficult to solve. Once again, our inability to achieve the required soil moisture increases the potential for plant stress and, consequently, plant susceptibility to biological stresses.

Developing management practices to overcome nonuniformity and achieve the desired yield and quality can be approached using reactive and proactive practices. By definition, management requires the establishment of achievable goals and a set of procedures and decision-making practices to accomplish these goals. Depending on luck, as some growers seem to do, is not generally considered a viable approach. Although some of the steps required for reactive and proactive approaches are the same, the economics of these two general approaches are very different.

Reactive practices are applied following the observations that something is obviously wrong and that the desired yield or quality goals are not being achieved. Generally, at this point, an economic loss is inevitable. Therefore, regardless of the corrective measures applied, some measure of economic sustainability will be lost. After applying initial corrective measures, the next step is to identify the cause of the problem. This may involve consulting experts to ensure a correct diagnosis; otherwise, the potential is high for applying a cure for a problem that does not exist, resulting in higher costs without achieving the needed result. Obviously, if the cause of the problem cannot be determined, applying an appropriate cure would be difficult, and applying an inappropriate cure not only might make the problem worse but also would undoubtedly result in future economic losses. If allowed to persist, these losses could grow to significant levels quickly. To ensure economic viability, however, weigh the cost of the proposed cure against the economic loss. Once the decision to apply a cure has been made, assessing its effectiveness is essential so that successful treatment can be achieved.

Proactive management requires that potential sources of nonuniformity be identified, ideally, prior to planting the crop or, in many cases, after the crop is planted. The objective of proactive management is to minimize variability within a management unit; reaching this goal will reduce the probability of all forms of plant stress and thus achieve the desired yield and quality goals. Understanding the sources of variability and their consequences is essential. The ability to predict their effect on crop yield and quality validates our understanding from the crop management

perspective. From an economic perspective, we must also assess the potential for managing the various sources of variability and the economics of these management practices, which then must be compared to the potential losses if the sources of variability are not controlled. A critical element of proactive management is recognizing the losses that can occur if these proactive decisions are not made. Although this process seems daunting, with good information about the local environment, including the soil, making good decisions is possible. Having access to precise and accurate soil information is the most significant change we have experienced in performing this process.

Even the best of efforts to minimize the effects of variability can be overwhelmed by weather extremes. Fortunately, such extremes are infrequent and, most often, our efforts can improve crop uniformity and maximize the potential for positive economic returns. Understand, however, that within any given field soil variability accounts for over 50 percent of the nonuniformity in crop yield and quality.

Improving the uniformity of growing conditions allows our management practices to be more precise and profitable. In general, one can reduce overall inputs during land preparation, including soil amendments and fertilizers, by making differential rather than uniform applications. Development of more appropriate irrigation blocks and management strategies saves water and energy. Better water management also reduces plant stress and the susceptibility to secondary biological stresses such as powdery mildew, as well as insect and mite attacks. Better information about soil variability also permits more precise sampling and placement of soil moisture sensors to further improve irrigation management. Greater crop uniformity results in higher yield and quality and, consequently, higher profits. This also improves on-farm management decisions regarding the harvest, yield predictions and cash flow projections. Having the ability to accurately predict crop yield and quality characteristics can also result in better prices and future opportunities.

The following are examples of reduced inputs during site preparation and establishment:

- The cost of ripping to overcome restrictive layers that limit root penetration and, therefore, water and nutrient availability can be significantly reduced with precise soil information. The cost of ripping can range from \$300 to \$500 per acre. Ripping only those areas of a field that have significant restrictive layers can save thousands of dollars. In addition, sometimes ripping can bring poor-quality soil more in contact with the

plants, exposing them to salts or other elements that have migrated down through the soil profile over time.

- Variable rate applications of soil amendments such as sulfur to reduce soil pH or dolomitic lime to increase pH can reduce costs. Even small fields rarely have a uniform pH across the entire area. Variable rate applications of soil amendments to achieve more uniform pH can increase the uniformity of nutrient availability and also avoid developing new nonuniform pH problems that can be caused by applying a uniform rate of soil amendment across the field.
- Establishing target nutrient levels and overcoming field variability before planting can result in significant savings while providing better plant establishment and growth conditions that pay off by bringing permanent crops into production earlier. Getting a crop just one year earlier than is generally expected can more than pay for the cost of soil mapping. For annual crops, more uniform and vigorous plant development increases the potential for better yield and quality. An example of the potential savings is provided by a 35-acre vineyard establishment project performed in early 2009: Based on Soil Information System (SIS) information, the recommended costs of soil amendments and fertilizers, including the cost of variable rate application, resulted in a savings of \$1,414 compared to the one-size-fits-all application recommendations. When this information is scaled up to 200 acres, the cost savings, assuming the same proportions, amounts to \$15,000. The added savings is primarily due to reductions in soil amendment and fertilizer costs, which amounted to \$51,800 compared to \$88,000.
- Irrigation design and management, especially in low rainfall areas, are critical to achieving good crop growth and quality. Irrigation management is perhaps the most powerful management tool we have in many areas. Achieving more uniform soil moisture demands a good understanding of the soil water-holding capacity and infiltration rates. The latter factor is to ensure that the applied water reaches the root zone rather than evaporating from the surface in the case of low infiltration rates. The alternative situation is that the root zone water-holding capacity is exceeded and, with a high infiltration rate, the water and nutrients will pass through the root zone and become potential sources

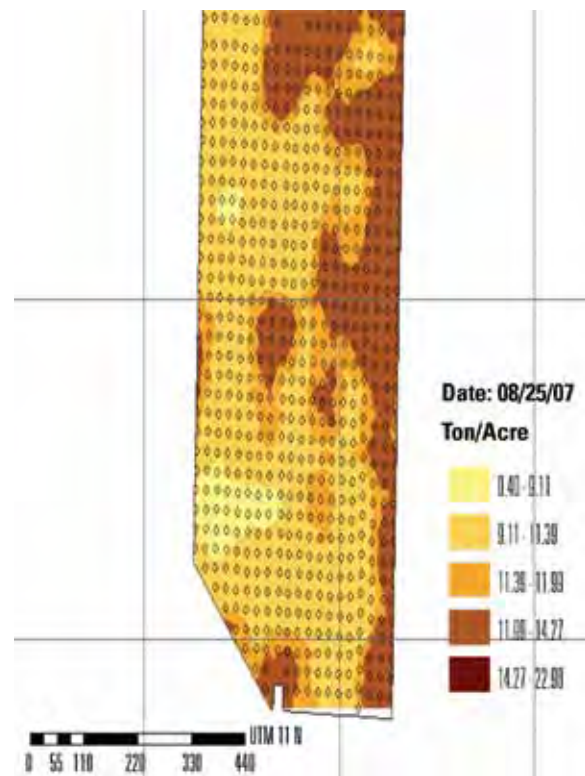


of aquifer contamination, and the nutrients will be out of reach of the roots. During the initial phases of irrigation system design, having a more precise idea of what the specific crop root zone may be, and hence, the water-holding capacity and infiltration rate information, can result in a more intelligent design. Although this may result in slightly higher installation costs, these costs can typically be recovered in water and energy savings as well as reduced management costs by designing irrigation sets to match the unique soil conditions and their pattern in the fields. Furthermore, improved irrigation management can lead to better yields and higher quality, as discussed above. Better management may also reduce crop susceptibility to pest and disease pressure through better plant health and crop microclimate management. Having precise information regarding the variability in soil water-holding capacity is essential in choosing the best location for soil moisture monitoring devices. When necessary, this information can also be used to help calibrate the device. Knowing what percentage and areas of the field have water-holding capacity similar to that in the location where the monitoring device is placed can be very helpful in making management decisions.

Once a field is planted, with either permanent or annual crops, understanding the variability in nutrient status that may have existed and the practices that were applied to reduce that variability can be helpful in establishing more efficient and precise scouting procedures. Using the nutrient maps provided by Soil and Topography Information LLC (STI), one can easily select specific locations within a field that would be expected to have either high or low levels of a specific nutrient. Developing a sampling protocol to target these areas can (a) establish the effectiveness of the variable rate application of amendments and fertilizers; (b) help select areas of the field that would be most likely to show off-target nutrient levels, by using these areas to take petiole and leaf samples for analysis; and (c) use sampling sites derived by STI to establish updated soil nutrient maps by taking new soil samples for analysis at the targeted areas with known spatial representation using the SIS software.

Some relatively recent research results show the potential for using the soil information derived by the STI system to predict crop yield and quality distribution across a field. This has been tested on only wine grapes at this point, but the results are promising. The results are based on a 45-acre

field of cabernet sauvignon located near Lodi, Calif., and an 80-acre cabernet sauvignon vineyard located near Madera, Calif. The Lodi vineyard was hand-pruned and managed for high-quality fruit production; the Madera vineyard was machine-pruned and was aimed more at higher yields. Both vineyards were sampled on a GPS-based grid of 10 samples per acre. Four clusters per vine were collected at each site, and data were collected for cluster weight, berry weight, Brix, pH and anthocyanin level. The total number of clusters per vine at each collection site had been determined and all of the data was geo-referenced, so the data were able to be used to calculate yield and to develop yield and quality (Brix and anthocyanin) maps.



**Figure 1. Shape file for anthocyanins in an 80-acre cabernet sauvignon vineyard.**

These maps were subsequently superimposed on soil maps developed by STI. Using a principal component analysis analytical procedure, the dominant soil characteristics associated with the regions of high and low fruit yield and quality characteristics were identified. Using this procedure, 95 percent of the variability in these yield and quality traits was accounted for with five or six soil properties. Interestingly, despite the fact that the soils in these two vineyards were significantly different, the soil characteristics associated with a specific fruit characteristic (berry size, yield, Brix, anthocyanin) were the same. The fact that the soil factors were the same for both sites is a good indication that the relationship may be more universal and, hence, useful in efforts to improve yield and quality predictions by more precise sampling practices based on soil characteristics.

The results indicated that higher anthocyanin levels are associated with deeper soil profiles with a thicker subsurface layer, decreased soil moisture in the soil profile accompanied by a higher level of compaction at a deeper depth of the profile. Higher Brix levels were associated with shallower soil profiles with a thicker subsurface layer and thinner surface layer, with increased soil moisture and more compaction throughout the profile. Once the anthocyanin levels were mapped across the field, this information was converted to a shape file (Figure 1) that was input to an on-board computer

attached to an Oxbo-Korvan grape harvester that used GPS locations to direct the fruit from any given location across the field into either the high or low anthocyanin gondolas accompanying the harvester. The differentially harvested fruit was transferred to separate trucks for hauling to the winery, where separate 40-ton wine lots were fermented, processed and bottled. Subsequent blind tasting indicated that the high-anthocyanin wine was significantly better than the low-anthocyanin wine.

When we consider the ability to segregate the high-anthocyanin fruit and produce a higher quality wine, the economics are quite favorable. Based on the maps produced for anthocyanin levels, about 40 percent (32 acres) of the 80-acre Madera vineyard was at the higher quality. If we estimate that these areas yielded at the lower level of 10 tons per acre, this would result in about 320 tons of fruit. As a general rule, we could anticipate a yield of about 160 gallons, or 256,000 bottles, of wine from the 320 tons of fruit. Based on an estimated increase in wine quality of one price point, or \$2 per bottle, the result from differential harvest of this fruit would be \$512,000.

Another interesting outcome of this work was the ability to quantify the cost of the variability across these fields. As an example, the Madera vineyard had a yield range from around 10 tons per acre to 13 tons per acre. About 30 percent of the field (24 acres) produced 13 tons or more per acre, and the remaining 70 percent (56 acres) produced 10 tons or less per acre. Assuming a price of \$300 per ton, the value of the crop was \$261,600. If we could get the entire field to yield 13 tons per acre, the crop value would be \$312,000. Hence the “loss” due to nonuniformity is \$50,400, or \$630 per acre. The cost to map this 80-acre vineyard would be about \$12,000, or \$150 per acre. Assuming the information derived from this could result in improved yield on the 70 percent of the field currently producing only 10 tons per acre, an increase of only 40 tons, or 0.7 tons per acre, would be required to break even. An increase of only one ton per acre would result in a net increase of about \$5,000. Note that this \$5,000 increase could be accomplished repeatedly over the life of the vineyard and perhaps increased as the tonnage improved with a better understanding of the properties controlling yield.

## Summary

Variability, or nonuniformity, interferes with our ability to be precise. This inability is an obstacle to achieving a truly sustainable farming system in both direct (loss of yield and quality with higher input costs) and indirect (need to increase pesticide use, runoff, and loss of water and fertilizers) ways. Understanding the sources of variability and determining which of these are the dominant factors influencing crop production and quality is an important step in overcoming these losses. Because over 50 percent of the variability experienced within a field is due to soil variability, acquiring precise and accurate soil information is an important component in determining which variables can be effectively managed and thereby improves the sustainability of your farming system. These improvements have both short- and long-term economic value.



# Viticultural Options to Achieve Desired Grape Yield and Quality

Dr. Paolo Sabbatini and Dr. G. Stanley Howell

Department of Horticulture  
Michigan State University

## Abstract

Grape growing in Michigan and in other cool-climate locations is challenged by several limitations, mainly related to high frost and winter injury risk, short growing season, reduced heat accumulation and, consequently, an enormous year-to-year seasonal variation in yield and fruit quality. Therefore, vines can be stressed from either undercropping (spring frost, poor set, winter damage) or overcropping in years with good seasonal production potential coupled with financial pressure on growers to recover the previous year's lost production. Under these cultural conditions, it is pivotal to achieve a long-term physiological balance in the vineyard between vine growth and reproduction to obtain maximum yield coupled with fruit maturity and quality in relation to seasonal climate variations. To achieve such balance, key production components must play a central role in achieving desired grape yield and fruit quality. These components include cultivar and site selection, pruning and training, crop control and canopy management, and will be the focus of this manuscript.

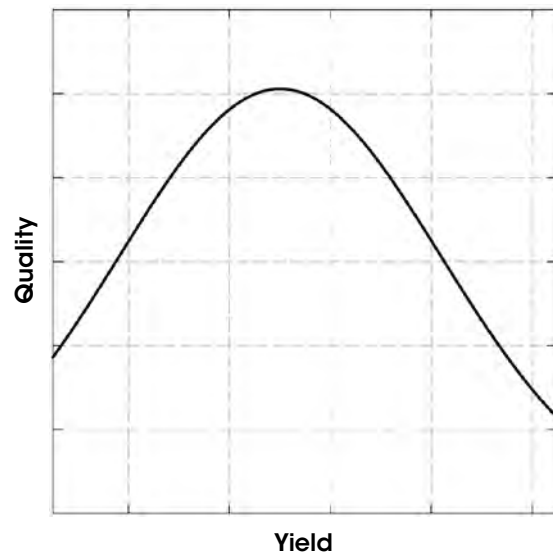
## Introduction

### *The challenge*

Vineyards vary widely around the world for the quantity and quality of grapes they produce. To achieve the goal of improved yield (t/acre, kg/vine) and fruit quality, it is essential to understand the concept of quality and the impact of the environment on vine physiology and berry growth. The definition of quality, sometimes described as optimal maturity or ripeness, varies depending upon the style of wine being made. We should keep in mind the comments of Dr. Shaulis when asked about fruit ripeness: "Ripe grapes are whatever the person or company buying the grapes says that it is" (N.J. Shaulis, personal communication, 1976). Ultimately, this means that growers have to adapt their viticultural practices to wineries' needs to produce quality fruit for the target wine style, independently of the definition of quality.

However, quality grapes can be described as a complex array of components (Bisson 2001) that together contribute to the quality of the final product (wine) and often referred to as

technological maturity. The main components are basic fruit chemistry (sugar, pH, acid), berry metabolites (arginine and glutathione), phenolics, anthocyanins, terpenes, berry protein and taste (sensory evaluation). All those components are influenced by the interaction of cultivar, rootstock, site, seasonal specific factors, viticultural practices and winemaking techniques. Considering the dynamic interaction between environment, cultural practices and the complexity of the whole vine physiology, the relationship between fruit quality and yield is never linear (Carbonneau 1996), but curvilinear (Figure 1)



**Figure 1. Diagrammatic representation of the quality potential in relation to yield** (elaborated from Carbonneau, 1996).

with different optima, one for each vine or vineyard in each location and always relative to the vine balance (Howell 2001) and the vine canopy management (Table 1).

## ***Climate issues***

Location of the vineyard (macro- and mesoclimate) is extremely important (Geiger 1965). The best sites provide maximum sunlight during the growing season and mild winter temperatures (Table 2). Minimum winter temperatures are, in general, used to describe sites for their potential for growing grapes (Howell et al. 1987). Excellent sites are characterized by temperatures that do not drop below 10 degrees F, and they are suitable for tender *Vitis vinifera* grapes. Poor sites have winter temperatures that can reach minus 10 degrees F at least five times in 10 years, and they are not suitable for growing grapes. Acceptable sites are characterized by winter temperatures that reach minus 5 degrees F no more than three to four times in 10 years, with a long-term minimum temperature that does not fall below minus 10 degrees F. These temperatures are acceptable for most of the commercial grape cultivars (Table 3), also, if tender to very-tender cultivars (e.g., *vinifera*) would suffer severe damage no more than once in 10 years (Zabadal et al. 2009).

The site's slope can also influence vine performance. Cooler northern slopes may delay spring bud break, reducing the potential of spring frost. By contrast, southern facing slopes are warmer and promote earlier fruit ripening, which is very important in Michigan and other cool climate

growing regions. In such cool regions, grape production is limited by short growing seasons (140 to 160 days) and is similarly limited by low heat accumulation ( $\approx 2500 \pm 250$  growing degree days, base 50 degrees F, calculated from April 1). Such environmental limits reduce the ability of vines to fully ripen the crop, especially when vines are overcropped and vine canopy management is not done in a timely manner. In addition, vines cultivated in cool climates can begin growth late in the spring and also experience early fall frosts (often in September), collectively producing an uncommonly short growing season with the early fall frost potentially imposing a premature arrest of photosynthesis, and thus hindering fruit ripening.

### ***Nutrition issues***

Early vine development is also rendered less efficient by excessive spring nitrogen fertilizing, which is slow-acting and encourages the growth of shoots at the expense of cluster carbohydrate share. In some circumstances, it may also reduce fruit set, which can delay berry growth and the onset of veraison. Additionally, the impact of weather and fertilization goes beyond the current year's loss in crop and quality, and results in reduced wood maturation and cane and bud hardening, which leads to reduced resistance to winter freeze episodes (Howell 2000). Furthermore, the grapes show poor formation and storage of carbohydrate reserves, with a resulting negative impact on final bud differentiation the following spring. These impacts result in the problem recurring over the subsequent years. The overall result is inadequate fruit quality, which may be balanced only in part by crop-size control (Table 4).

### ***The decisions***

The number of days and heat accumulation, or growing degree days (GDD), required to mature a crop is also a very important consideration (Table 5). A minimum of 165 frost-free days are required for early maturing cultivars and up to 220 to 240 for late red cultivars. This information leads to a wine grape grower's selection of a cultivar to plant. This is an all-important decision, which may be so critical as to determine the outright survival of vines at the specific vineyard site. More often, however, the importance of one's choice of a wine grape cultivar is more complicated; the decision involves several factors and considers the extent of winter injury experienced by vines, the productivity of mature vines, the quality of grapes and wines, and the market demand and pricing for the grapes and wine. Growers often choose cultivars based on industry trends,



conversations and literature. Unfortunately, the choice of a cultivar is often speculative, and the existence of cultivar trials with either public or private results can increase the chances of picking a “winner.” In conclusion, the combined interaction of some viticultural factors in achieving desired yield and quality can be used to overcome several challenges but can be only partially manipulated (Table 6) and can greatly reduce the uncertainty in the prediction of yield and the delivery of grapes of consistent quality to the winery.

## Material and methods

For review purposes, this manuscript discusses two experiments: (1) crop control of cabernet franc and (2) canopy management of pinot noir. Both cultural practices have a great impact on yield and quality of the grapes. The experiments were conducted in 2009 at the Southwest Michigan Research and Extension Center (SWMREC in Benton Harbor; 42.0841 degrees latitude and -86.3570 degrees longitude) of Michigan State University. Pinot noir and cabernet franc, on 3309 C rootstock, were trellised with a Vertical Shoot Positioning system with spacing of 1.8 m in rows and 3.0 m between rows and trained to a cane pruned, low head.

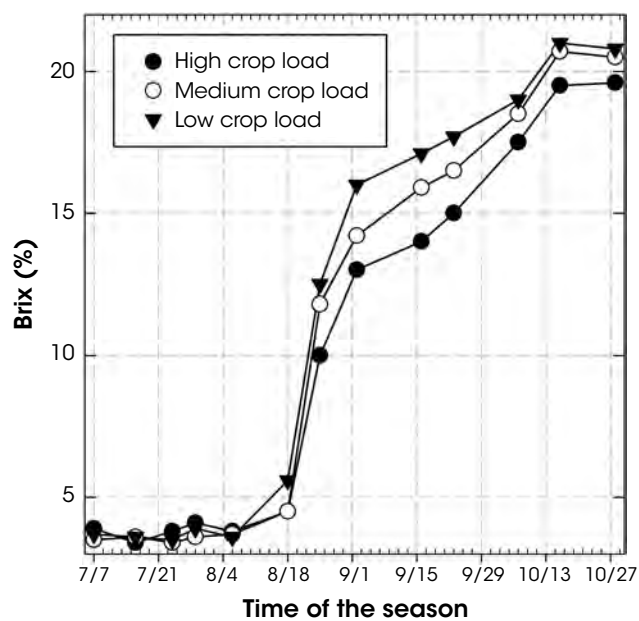
Michigan climate is characterized by a short growing season (150 to 175 days from 0°C to 0°C) with cool-climate conditions ( $\approx 2,500 \pm 250$  GDD). Yield and quality are limited by several factors, such as winter cold, spring freeze (50 percent frost damage can occur as late as May 15), early fall frost, high humidity and potential for rainfall during harvest season (Howell and Sabbatini 2008).

In Experiment I, cabernet franc yield per vine was adjusted via cluster thinning after fruit set to produce three levels of crop load (high, medium and low) with the goal to evaluate treatment impact on fruit ripening, and basic fruit chemistry evolution was measured from fruit set to harvest.

In Experiment II, pinot noir (clones UCD 9 and UCD 29) were exposed to three leaf pulling treatments in the cluster zone, and were applied before, during and after veraison. Treatments consisted of non leaf-pulled Control (C), Leaf Pulling (LP) and Leaf Pulling combined with Shoot Trimming (LP+ST). The shoot-trimming treatment consisted of removing the terminal portion of the growing shoots (10 inches, or 25 cm) at the same time as the leaf-pulling treatment. A comparable amount of leaf area was removed each of the three times of treatment application.

## Results and Discussion

**Experiment I. Cabernet franc.** In this experiment, crop level manipulation had a limited effect on all the viticultural parameters (Table 7). In particular, decreasing the crop level by 15 and 30 percent respectively from the high level, did not affect the basic fruit chemistry at harvest. However, when the berry fruit chemistry was followed during the season, the low yield vines had earlier accumulation of sugar (Brix) than the medium and high yields. The difference was higher after veraison and disappeared only at the end of the long and warm season in Michigan, 2007. These data remind us that the timing of harvest for wine grapes is one of the most crucial decisions in the process of winemaking. The time of harvest is determined primarily by the ripeness of the grape as measured by sugar, acid and tannin. However, the weather can often dictate the timetable of harvesting with the threat of rain (bunch rot), early fall frost or vine diseases. Therefore, the data shown in Figure 2 suggest that if the harvest were just 15 days earlier, the chemistry makeup of the grapes in vines with different levels of yield would be completely different, affecting the quality of the resulting wines.



**Figure 2. Effect of yield per vine in cabernet franc on sugar accumulation (Brix) during the growing season (from fruit set to harvest).**

**Experiment II. Pinot noir.** Harvest data showed no influence of the canopy management treatments on yield, clusters per vine or cluster weight. This was as we had hoped. However, basic fruit chemistry at harvest (Table 8) shows an impact on Brix level of the treatments LP and LP+ST. The different treatments did not affect TA and pH. Brix was increased 14 percent and 6 percent in relation to the Control in the first two applications of treatments (preveraison and veraison) by removing leaves from the cluster zone. However, when the treatments were applied after veraison, the sugar accumulation in the berries was not influenced, indicating a reduced response of the clusters to the modified microenvironment (increase in temperature and light) achieved with leaf removal

techniques. Moreover, LP and LP+ST treatments showed no differences in any time of application. At harvest, color (anthocyanin) and total phenolics were measured (Table 9). Phenolic compounds and anthocyanin content increased with application of LP and LP+ST treatments, again in the first two times of canopy management, and to a greater extent in the preveraison application. There were no differences from Control at the last time for treatment application (after veraison), and there were never significant differences between LP and LP+ST treatments. Therefore, a late leaf-pulling treatment (after veraison) was not effective in increasing the quality of the grapes at harvest, measured by basic fruit chemistry parameters (Brix, pH and TA) and by color and total phenolic concentration.

## Conclusion

Yield and quality of grapes determine precise scheduling by winemakers often faced with an increasing mismatch between tonnage of grapes to be crushed and their quality. Yearly variation in fruit quality limits the opportunity to maximize the production of premium quality wines in cool climate conditions. Therefore, understanding and managing the dynamic relationship between site, weather, soil, water, phenological stage, vine and wine quality is a complex challenge for any grower. Without determining which key variables of many are effective under different growing conditions, the chances of improving vine yield and quality are at best accidental. An integrated approach in vineyard management that goes from the site selection to the cultural practices adopted will shape vineyard performance and achieve desired wine-quality goals.

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**Table 1. Desirable goals for a well-managed grapevine canopy and methods to achieve those goals.**

<b>Goal</b>	<b>Method</b>
Avoid internal canopy shading	Select trellis and within-row spacing.
Avoid excessive sun exposure	Shoot thin to desired spacing. In dense canopies, do selective leaf removal in fruiting zone.
Avoid shading of fruiting zone	Canopy height should not exceed row width. Run rows N-S. Tall, thin curtains of foliage desirable, but do not over expose fruit to sun.
Maximize crop of ripe fruit	Balance crop vines for region of culture (7–14 cm <sup>2</sup> leaf area/g fresh weight of fruit or pruning weights of 0.2–0.4 lbs/foot of canopy).
Identify problem canopies	Employ point quadrat methods.

Elaborated from Smart, R. E. 1985. Principles of grapevine canopy manipulation with implications for yield and quality: A review. *Am. J. Enol. Vitic.* 36:230–239.

**Table 2. Issues in site selection and challenges to quality grape production.**

<b>Issues</b>	<b>Characteristics</b>
Climate issues	(A) Macroclimate: regional climate, location, continental vs. maritime climate (1) Length of growing season, GDD (2) Frequency of damaging spring and/or fall frosts (3) Frequency of damaging winter temperatures (4) Seasonal variability in (1) or (2) above (B) Mesoclimate: the site climate (1) Slope and aspect (2) Value of GIS mapping (C) Microclimate: choice of trellis system
Soil issue	(A) Drainage Poor drainage limits growth and increases winter cold damage (B) Depth, type and texture Shallow soils limit root growth and water availability; coarse-textured soils excessively well-drained also water-limited (C) Fertility (D) Organic matter (E) Soil biology Many organisms vital for healthy soil (e.g., mycorrhiza, earthworms), some also damaging to vine (e.g., phylloxera, nematodes, root borer) (F) pH Too low can yield nutrient deficiencies and can also result in some toxicities

Source: Wolf, T. K., J. D. Boyer, T. E. Martinson, and F. A. Westover. 2008. Characteristics of a quality grape site. *In* Wine Grape Production Guide for Eastern North America. T. K. Wolf (ed.), pp. 14–36. Natural Resource, Agriculture, and Engineering Service. Ithaca, NY.

**Table 3. Median killing temperature in midwinter for tender *vinifera* and cold-hardy hybrid cultivars.**

<b>Cultivar (<i>V. vinifera</i>)</b>	<b>Median killing temp (°F)</b>	<b>Cultivar (hybrids)</b>	<b>Median killing temp (°F)</b>
Muscat ottonel	-6	Traminette	-22
Merlot	-9	Vidal blanc	-22
Pinot gris	-10	Chardonel	-22
Pinot noir	-10	Chambourcin	-23
Sauvignon blanc	-10	Seyval	-23
Zinfandel	-11	Vignoles	-26
Cabernet sauvignon	-11	Marechal Foch	-27
Gewurztraminer	-12	Frontenac	> -35
Chardonnay	-13	Frontenac gris	> -35
Riesling	-14	Marquette	> -35
Cabernet franc	-17		

Source: Zabaddal, T., P. Sabbatini and D. Elsner. 2009. Wine Grape Varieties for Michigan and Other Cold Climate Viticultural Regions. Bulletin CD-007, Michigan State University Extension.


**Table 4. Choices available for crop control/vine balance and conditions favoring each.**

<b>Method</b>	<b>Implementation</b>
Balanced pruning	Methods and cultivar limits; growth-yield relationship works for CVs that have moderate size clusters and minimal crop from noncount positions.
Balanced cropping	Pruning and crop adjustment for CVs with very large clusters and/or large production from noncount node positions. Valuable also as a means to reduce losses due to late spring frosts. Follow up with: <ol style="list-style-type: none"> <li>(1) Shoot thinning</li> <li>(2) Flower cluster thinning</li> <li>(3) Cluster thinning (CT post set): Utility in regions with variable growing season length and heat. Utility of 1200 GDD and crop estimation.</li> <li>(4) CT (green drop): Done at veraison. Eliminates least-ripe clusters from vine.</li> <li>(5) CT (postveraison): Not desirable.</li> </ol>

**Table 5. Growing degree days (GDD) calculated from April 1 (base 50 degrees F) for ripening important white and red cool climate cultivars.**

GDD (base 50°F, from April 1)	Red cultivar	White cultivar
1800	Marechal Foch	
1900		Müller Thurgau, Seyval blanc
2000		Vignoles, Pinot gris, Muscat ottonel
2100	Pinot noir, Meunier, Gamay, Frontenac, Marquette	Traminer, Chardonnay, Sauvignon blanc, Chardonel, Frontenac gris
2200		Traminette
2300	Chambourcin	Vidal blanc
2400	Cabernet franc	Riesling
2500	Cabernet franc, Merlot	Viognier, Roussanne, Marsanne
3200	Cabernet sauvignon	

**Table 6. Schematic representation of the factors related to grape quality and cultural management options to achieve the desired viticultural goal.**

The Drivers of Quality			
<i>More important Less control</i>			<i>Less important More control</i>
Site selection	Vineyard establishment	Vineyard management	Vinification
GDD accumulation Frost-free days Minimum winter temperature Fluctuating temperatures during winter	Rootstock choice Cultivar choice Planting density Source of vines	Trellis system Training system Canopy management Crop load Harvest time	Yeast selection Temperature of fermentation Bottle aging Barrel maturation

**Table 7. Effect of yield per vine in cabernet franc on basic viticultural parameters.**

Measured or calculated*	Crop load level		
	High	Medium	Low
Yield (t/acre)	3.9 a	3.3 ab	2.7 b
Yield (kg/vine)	5.4 a	4.6 ab	3.7 b
Cluster/vine	36.9 a	31.8 ab	24.1 b
Cluster weight (g)	145.4 a	145.6 a	167.1 a
% SS (Brix)	21.6 a	21.4 a	20.7 a
pH	3.5 a	3.4 a	3.4 a
TA (g/L)	6.9 a	6.5 a	6.5 a

\*Means in a row followed by the same letter are not significantly different at P=0.05 by the Tukey HSD test.

**Table 8. Effect of leaf pulling and shoot trimming treatment on basic viticultural parameters in pinot noir.**

Treatment*	Control	LP	LP+ST
<b>Preveraison</b>			
Brix (%)	18.1 a	21.0 b	19.3 b
TA (g/L)	7.7 a	6.9 a	7.4 a
pH	3.7 a	3.7 a	3.5 a
<b>Veraison</b>			
Brix (%)	18.7 a	20.2 b	19.7 b
TA (g/L)	7.9 a	6.9 a	8.5 a
pH	3.7 a	3.7 a	3.7 a
<b>After veraison</b>			
Brix (%)	17.9 a	16.9 a	18.2 a
TA (g/L)	8.6 a	10.4 a	8.8 a
pH	3.5 a	3.4 a	3.6 a

\*Means in a row followed by the same letter are not significantly different at P=0.05 by the Tukey HSD test.

**Table 9. Effect of leaf-pulling and shoot-trimming treatment on (A) phenolic (ab.u./ml,  $\lambda=280\text{nm}$ ) and (B) anthocyanin (mg/ml,  $\lambda=520\text{nm}$ ) concentrations in pinot noir (mean of the two clones).**

	Treatment*		
	Control	LP	LP+ST
<b>A</b>			
Preveraison	0.59 a	0.74 b	0.83 b
Veraison	0.64 a	0.64 a	0.50 a
After veraison	0.50 a	0.44 a	0.50 a
<b>B</b>			
Preveraison	77.7 a	135.9 b	97.4 b
Veraison	79.6 a	119.9 b	95.9 b
After veraison	75.7 a	74.9 a	80.8 a

\*Means in a row followed by the same letter are not significantly different at P=0.05 by the Tukey HSD test.





# Reducing Herbaceous Aromas in Cabernet Franc

Justin J. Scheiner, Dr. Gavin L. Sacks and Dr. Justine E. Vanden Heuvel

Cornell University

Geneva, NY

## Abstract

The presentation will report on three studies focusing on herbaceous aromas in red wine grapes: a multivariate study to determine the major environmental and viticultural factors that impact the concentration of 3-isobutyl-2-methoxypyrazine (IBMP), and two field studies investigating the impacts of leaf removal and shoot tipping on IBMP concentration.

A multivariate study was conducted to determine the major environmental and viticultural factors that impact the concentration of IBMP in cabernet franc grapes. Vine measurements and fruit samples were taken from individual vines from two, five-vine panels per vineyard at 10 and eight commercial cabernet franc vineyards in 2008 and 2009, respectively. Temperature, rainfall and photosynthetically active radiation were monitored over the growing season at each site. IBMP was quantified in grapes at 30 days after anthesis (DAA), 50 DAA and harvest. In both years, significant differences were observed across sites for IBMP concentrations at all phenological stages. In the warmer 2008 growing season, IBMP concentrations at 50 DAA were significantly higher than in 2009 at all eight sites. Higher vine vigor resulted in greater IBMP concentration at 50 DAA, while decrease in IBMP from 50 DAA to harvest was greater in vineyards with higher crop loads, lower vigor and more advanced fruit maturity.

Shoot tipping was investigated as a potential tool for reducing IBMP concentration in cabernet franc. Although preveraison IBMP concentrations were impacted in one of two years, shoot tipping did not impact the concentration of IBMP in mature grapes, suggesting that it may not be an effective management strategy to reduce IBMP.

Field studies were conducted on cabernet franc and merlot to evaluate the effects of basal leaf removal timing and severity on IBMP concentration in grape berries. Treatments consisted of removing either 50 percent or 100 percent of leaves from the fruiting zone at either anthesis, 10 DAA, 40 DAA or 60 DAA. In the second year of the cabernet franc study, a 15-day postveraison leaf removal treatment was also included. In 2007, all leaf removal treatments significantly reduced IBMP concentrations compared to the control in cabernet franc berries at harvest, with the greatest reduction observed in the 100 percent leaf removal treatments at 10 DAA and 40 DAA. In 2008, the 100 percent leaf removal treatment at 10 DAA and the 50 percent and 100 percent leaf removal treatments at 40 DAA significantly reduced IBMP concentrations in mature cabernet franc berries. In the merlot trial, all leaf removal treatments significantly reduced IBMP concentrations at harvest. In summary, early season (10 to 40 DAA) basal leaf removal reduced IBMP accumulation preveraison compared to the control in both studies, suggesting that leaf removal at that time is a more effective management strategy to reduce IBMP accumulation in grape berries than leaf removal later in the season.

In the rest of our report, we provide a detailed account of our results from studies on the impact of leaf removal on IBMP.

## Introduction

The 3-alkyl-2-methoxypyrazines (MPs) are a class of odorants associated with “green,” herbaceous aromas of some Bordeaux wine grape (*Vitis vinifera* L.) cultivars. Quantitatively, 3-isobutyl-2-methoxypyrazine (IBMP) is the predominant MP in grapes and wine, typically an order of magnitude higher in concentration than 3-isopropyl-2-methoxypyrazine (IPMP) and 3-*sec*-butyl-2-methoxypyrazine (sBMP) (Alberts et al. 2009). The sensory detection threshold for IBMP is reported to range from 0.5 to 2 pg/g in water (Buttery et al. 1969, Kotseridis et al. 1998, Seifert et al. 1970) and 10 to 15 pg/g in red wine (de Boubée et al. 2000, Kotseridis et al. 1998). When present at concentrations near sensory threshold, MPs may contribute positively to wine quality by adding complexity and, in some cases, varietal character (Allen et al. 1991). At higher concentrations, MPs can result in excessive herbaceousness and suppressed fruitiness in wines (Allen and Lacey 1999, Hein et al. 2009, Pickering et al. 2005).

As vinification and cellaring practices have so far proven ineffective at reducing MP concentration in wines, viticultural management strategies that reduce MPs in the vineyard have thus been proposed to be the most effective way to control MP concentration in wine (Bogart and Bisson 2006).

In grape berries, IBMP begins to accumulate around 10 DAA with a peak in concentration occurring about 0 to 14 days prior to veraison, followed by a rapid decline during maturation (de Boubée et al. 2000, Hashizume and Samuta 1999, Ryona et al. 2008, Sala et al. 2004). IBMP concentrations in mature berries are reported to be less than 10 percent of their preveraison peak concentrations. Ryona et al. (2008) reported a strong correlation ( $R^2 = 0.936$ ) between IBMP concentrations in mature cabernet franc berries and preveraison peak concentrations, suggesting that final IBMP concentration is primarily determined preveraison, at least within the same viticultural region (Finger Lakes, N.Y.). Management practices that affect initial accumulation of MPs in grapes preveraison are expected to more dramatically impact final MP concentrations at harvest than interventions later in the season.

Recent work suggests that sun-exposed clusters accumulate less IBMP preveraison than shaded clusters within the same vine (Ryona et al. 2008) and that the proportional differences persist until harvest. Little work has been published on the effectiveness of specific vineyard practices (e.g. leaf removal) to reduce MP accumulation preveraison and subsequent levels at harvest. The objective of this study was to investigate the impact of timing and severity of leaf removal on IBMP concentration in cabernet franc in the Finger Lakes and in merlot on Long Island, N.Y.

## Materials and methods

**Experimental design.** Two commercial vineyards located in Ovid, N.Y., (42.67°N, 76.82°W; Finger Lakes American Viticultural Area, Cayuga Lake) and Cutchogue, N.Y., (40.99°N, 72.48°W; Long Island American Viticultural Area, North Fork) were used in this study. Vines at the Finger Lakes site were *Vitis vinifera* L. cv. cabernet franc cl. 1 grafted on 3309C rootstock trained to a Scott Henry system with four canes. The upper canes were at 1.3 meters height and shoots vertically positioned. The lower canes were at 1.0 meter height and shoots were positioned downward. The vines at the Long Island site were merlot cl. 181 grafted on 3309C rootstock trained to a combination of low wire cordon and a flat cane system with either two cordons or two canes at 1.0 meter height and shoots vertically positioned. Vine spacing was 2.0 meters between vines and 2.5 meters between rows for both sites. Vine management was performed according to the standard viticultural practices for *vinifera* in the Finger Lakes and Long Island regions. The experimental design was a randomized complete block with four replications. The experimental plot at each site consisted of four rows and each experimental unit consisted of eight contiguous vines in each row.

Treatments consisted of a control (no leaf removal), removing the first, third and fifth leaf from the base of each shoot at 10 DAA (10 DAA 50%), 40 DAA (40 DAA 50%), or 60 DAA (60 DAA 50%); and removing the first five leaves beginning at the base of each shoot at 10 DAA (10 DAA 100%), 40 DAA (40 DAA 100%) or 60 DAA (60 DAA 100%). Two additional treatments were added at the cabernet franc site in the second year of the study: removing the first, third and fifth leaf from the base of each shoot at 15 DAA (15 DAA 50%), or removing the first five leaves from the base of each shoot at 15 days after veraison (15 DAA 100%). All basal leaf removal treatments were applied by hand on all fruiting and nonfruiting shoots of each vine.

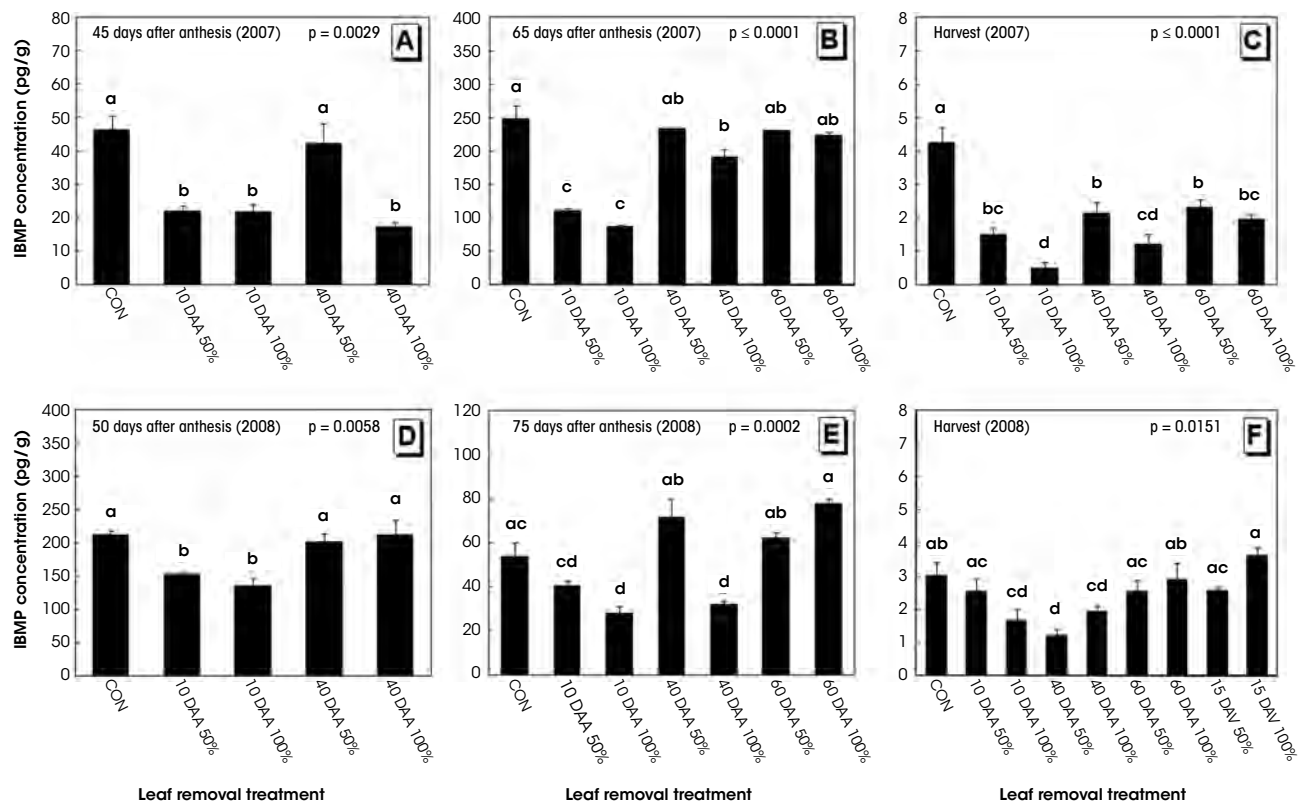
**Sampling and harvest.** Five days after each basal leaf removal treatment was imposed in 2007 (15, 45 and 65 DAA) and five to 15 days after each basal leaf removal treatment was imposed in 2008 (15, 50, 75 and 85 DAA) in cabernet franc, 50-berry samples were collected at random from each experimental unit for IBMP quantification. At harvest, 150 berries were collected at random from each treatment for IBMP quantification and chemical analysis. The berry samples were frozen followed by storage at minus 23 degrees C for later analysis.

**Berry analysis for 3-isobutyl-2-methoxypyrazine.** IBMP analysis was conducted using 50-berry samples. The extraction method was head space-solid phase micro extraction (HS-SPME), and quantification was performed by comprehensive two-dimensional gas chromatography time-of-flight mass spectrometry (GCxGC-TOF-MS), as described elsewhere (Ryona et al. 2009).

## Results and discussion

**Leaf removal in cabernet franc.** Leaf removal timing and severity impacted the concentration of IBMP preveraison and at harvest in both 2007 and 2008 (Figure 1). The period between veraison (65 DAA) and harvest (125 DAA) was marked by a decline in IBMP concentration. The IBMP concentration in mature fruit ranged from 0.5 to 4.3 pg/g (Figure 1C) and averaged 1.1 percent of the observed maxima (65 DAA). Although the only significant reduction in IBMP concentration at the three preharvest sample timings was observed for the 10 DAA 50 percent, 10 DAA 100 percent, and 40 DAA 100 percent treatments, all leaf removal treatments significantly reduced IBMP in mature berries with respect to the control (Figure 1C). The range in Brix of the cabernet franc berries at harvest in 2007 was 19.4 to 22.3 (Table 1), while TA ranged from 6.4 to 8.6 g/L across treatments.

At harvest in 2008 (124 DAA), the range in IBMP concentration across all treatments was 1.2 to 3.5 pg/g (Figure 1F) and averaged 1.3 percent of the observed preveraison (50 DAA) maxima. Although the 10 DAA 50 percent and 100 percent treatments significantly reduced IBMP concentrations at the preveraison sample timing, the 10 DAA 100 percent, 40 DAA 50 percent and 40 DAA 100 percent leaf removal treatments significantly reduced IBMP concentrations (range = 34 to 60 percent) at harvest. The range in Brix was 21.1 to 22.5, with no significant differences among treatments (Table 1). TA ranged from 5.5 to 6.8 g/L among treatments.



**Figure 1** Impact of basal leaf removal severity and timing on IBMP concentration in Finger Lakes cabernet franc berries at (A) 45 days after anthesis (DAA), 2007; (B) 65 DAA, 2007; (C) harvest, 2007; (D) 50 DAA, 2008; (E) 75 DAA, 2008; (F) harvest, 2008. Each measurement represents the average of four field replicates. Values are mean  $\pm$  standard error. Means indicated by different letters are significantly different at  $p \leq 0.05$ , Fisher's Least Significant Difference. Adapted from Scheiner et al. 2010; used with permission of AJEV.

**Leaf removal in merlot.** At harvest (117 DAA), the range in IBMP concentration in merlot berries across treatments was 3.2 to 6.7 pg/g (Figure 2). Leaf removal at all timings and severities significantly reduced IBMP by a range of 37 to 52 percent compared to the control. Leaf removal timing and severity had no significant impact on Brix, TA and pH (Table 1).

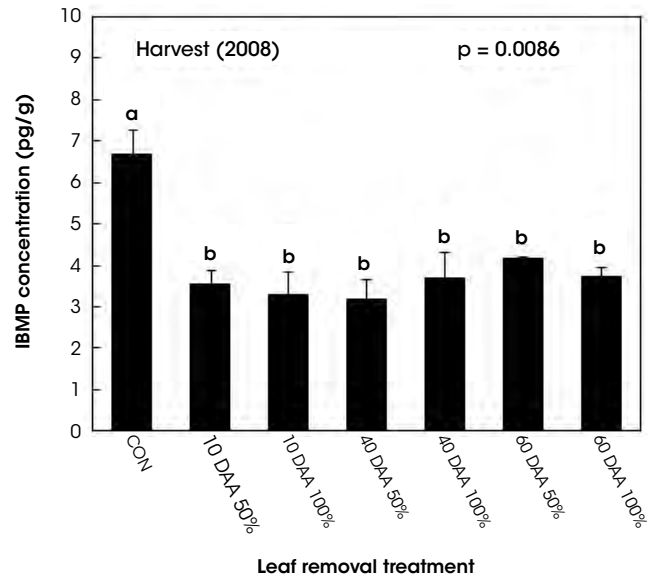
The highest concentrations of IBMP in cabernet franc were observed at the preveraison sample timings (65 DAA sampling in 2007 and 50 DAA sampling in 2008) (Figure 1). Differences in the apparent timing of the peak concentration in IBMP between years are likely a function of different sample timings. In agreement with our results, previous research has demonstrated that IBMP reaches a maximum in the two to three weeks prior to veraison (de Boubée et al. 2000, Lacey et al. 1991, Ryona et al. 2008).

The results reported here are in concordance with a recent observation that cluster light exposure preveraison reduces IBMP accumulation (Ryona et al. 2008). Because basal leaf removal

is widely shown to improve light penetration to the fruiting zone (Reynolds et al. 1996, Reynolds et al. 2006, Wolf et al. 1986, Zoecklein et al. 1992), the reductions in IBMP concentration that we observed are likely due to increased cluster light exposure. Except for one case (40 DAA 100% in 2007), the impact of the leaf removal treatment was not observable until more than 15 days after the treatment was imposed.

Across all three studies, the largest and most consistent decreases for IBMP at harvest were observed in the early leaf removal treatments. These results support the previous hypothesis that cluster light exposure preveraison inhibits accumulation preveraison but has little effect postveraison, and that the relative differences in IBMP established prior to fruit maturation persist until harvest (Ryona et al. 2008). Interestingly, treatments around veraison had lesser, but still significant, decreases in IBMP at harvest in some cases, indicating that accumulation and degradation may occur concurrently during lag phase.

Although the harvest concentrations of IBMP observed in this study are below reported sensory thresholds in red wine (de Boubée et al. 2000, Kotseridis et al. 1998), the leaf removal treatments in 2007 and 2008 reduced the final IBMP concentration in cabernet franc by up to 88 percent and 60 percent, respectively, and in merlot by up to 52 percent compared to the control. In cabernet franc, IBMP accumulation was reduced by up to 65 percent (2007) and up to 36 percent (2008) by the 10 DAA 50 percent and 10 DAA 100 percent treatments at the observed maximum IBMP concentrations. Our findings are consistent with other groups that have evaluated the effects of preveraison cluster light exposure on IBMP concentration (Allen et al. 1996, de Boubée 2003, Marais et al. 1999, Ryona et al. 2008).



**Figure 2** Impact of basal leaf removal severity and timing on IBMP concentration in Long Island merlot berries at harvest, 2008. Each measurement represents the average of four field replicates. Values are mean  $\pm$  standard error. Means indicated by different letters are significantly different at  $p \leq 0.05$ , Fischer's Least Significant Difference. Adapted from Scheiner et al. 2010; used with permission of AJEV.

## Conclusion

Basal leaf removal treatments reduced IBMP concentration in cabernet franc and merlot berries at harvest, with the most consistent and largest decreases at harvest observed with preveraison treatments. In cabernet franc, accumulation of IBMP in the preveraison period was reduced by leaf removal, likely due to improved light interception by the clusters. In a situation where IBMP is present in concentrations near detection, leaf removal during the growing season could be critical in reducing accumulation of IBMP. The earliest (10 DAA and 40 DAA) leaf removal treatments yielded the greatest benefit in reducing IBMP.

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**Table 1. Brix, titratable acidity (TA) and pH of cabernet franc and merlot in response to basal leaf removal treatments, 2007–08.**

Leaf removal treatment	Brix	Titratable acidity (g/L)	pH
<b>2007 cabernet franc</b>			
10 DAA 50%	21.1ab <sup>b</sup>	7.0cd <sup>c</sup>	-
10 DAA 100%	22.3a	6.4d	-
40 DAA 50%	20.5bc	7.6bc	-
40 DAA 100%	19.4c	7.3bd	-
60 DAA 50%	19.8c	8.0ab	-
60 DAA 100%	20.0bc	7.3bc	-
CON	20.1bc	8.6a	-
Significance <sup>a</sup>	*	*	-
<b>2008 cabernet franc</b>			
10 DAA 50%	22.0	6.4ab	3.63
10 DAA 100%	21.9	5.8cd	3.64
40 DAA 50%	21.7	5.7cd	3.65
40 DAA 100%	21.9	5.8cd	3.61
60 DAA 50%	21.4	6.1bc	3.66
60 DAA 100%	22.5	5.5d	3.65
15 DAV 50%	22.3	6.1bc	3.63
15 DAV 100%	22.0	5.7cd	3.65
CON	21.1	6.8a	3.71
Significance	ns	*	ns
<b>2008 merlot</b>			
10 DAA 50%	20.4	6.3	3.61
10 DAA 100%	20.4	5.9	3.66
40 DAA 50%	20.2	6.2	3.60
40 DAA 100%	20.8	6.0	3.63
60 DAA 50%	20.5	6.6	3.59
60 DAA 100%	21.0	6.2	3.63
CON	19.9	6.8	3.56
Significance	ns	ns	ns

<sup>a</sup> ns and \* indicate not significant at the 0.05 probability level and statistically significant at the 0.01 probability level, respectively.

<sup>b</sup> Means followed by different letters are significant at  $p \leq 0.01$  (Fisher's LSD).

<sup>c</sup> Not presented because of inconsistent data.

Adapted from Scheiner et al. 2010; used with permission of AJEV.



# Response of Traminette to Rootstock and Three Training Systems in Virginia

**Dr. Tony Wolf**

Alson H. Smith Jr. Agricultural Research and Extension Center  
Virginia Tech

## Abstract

Traminette grapevines, either grafted to C-3309 rootstock or own-rooted, were grown under three different training systems for six seasons in northern Virginia to evaluate vine response and grape and wine quality attributes. The training systems used were Vertical Shoot-Positioned (VSP), Smart-Dyson (SD) and Geneva Double Curtain (GDC). Vine size, as measured by weight of cane prunings per unit length of cordon, was optimal when *grafted* vines were trained to GDC but was suboptimal for *own-rooted* GDC-trained vines. Grafting and training to either SD or VSP typically produced excessive vine size and resulted in increased canopy shade. Crop yields were increased 50 to 75 percent with either SD or GDC training, compared to VSP. Primary fruit chemistry was not adversely affected by the greater crops achieved with canopy division. In fact, juice and wine flavor and aroma characteristics were often, though not always, improved by canopy division, despite the higher crop yields. While maintaining or improving wine quality potential, the increased yields with SD and GDC training can increase grower returns with Traminette.

## Introduction

Production of wine grapes in humid, temperate regions is often accompanied by disease and fruit-quality issues that arise as a result of the climatic conditions as well as the vine canopy characteristics associated with large, vigorous vines. The macroclimate of much of the grape-growing area of the mid-Atlantic region is humid and temperate with irregular summer precipitation that averages four or more inches of rainfall per month. Soils are of variable texture and depth, but many vineyard soils afford excess plant-available water. The goals of vine and canopy management in humid regions are similar to those in more-arid regions; these goals include achieving a balance of exposed leaf area and crop, minimizing mutual leaf shading, promoting canopy ventilation for disease management, avoiding unnecessary labor inputs, and promoting optimal fruit exposure to obtain high grape and wine quality. While the goals in arid and more-humid regions may be common, the range of canopy management practices needed in humid regions is frequently more extensive due to the extent and duration of vegetative growth common in these regions. Adaptive training systems are one of the management strategies useful in accommodating the canopies

of large, vigorous grapevines (Smart and Robinson 1991; Reynolds and Wolf 2008). This talk will review our research experiences with Traminette grown on three different training systems in northern Virginia.

Training system choice plays a critical role in advancing goals related to canopy management, sustainable crop yields, and high fruit and wine quality. High vine capacity can be accommodated to some extent by canopy division, which has the benefit of increased node fruitfulness and increased crop yields while occasionally reducing the production of superfluous leaf area. Reductions or termination of new leaf area development after veraison has the potential to reduce vegetative tones (e.g., IBMP) often found in cabernet sauvignon and cabernet franc. More-effective exposure of canopy leaves and fruit clusters has also been shown to increase the flavor and aroma components of certain aromatic varieties and to reduce fruit acidity in cooler climates. Although training system research often shows that canopy division results in no reduction and occasionally results in improvements in wine sensory or quantitative measures of aroma and flavor components, the approach is not universally accepted by industry. Some of the resistance may be due to real or perceived perceptions about yield/quality relationships. Additional resistance to more elaborate training arises from the initial costs, particularly when one considers that the need for canopy division may decrease if vine capacity declines over the lifespan of the vineyard. Training that is adaptable to vine capacity in time and space has certain advantages to systems that are ill-suited to modifications over the life of the vines.

This study was undertaken to evaluate the impact of training system on crop yield components; vine vegetative performance, including canopy characteristics; cold hardiness; and grape and wine sensory attributes of three varieties. The underlying hypothesis of the study was that the increased crop per vine afforded by canopy division would not negatively affect grape primary chemistry nor would those increased yields compromise measurable aroma and flavor attributes of resultant wines, so long as vines were cropped at tolerable crop loads. A formal report on one of the three varieties evaluated is provided by Zoecklein et al. (2008).

## Methods

Three grapevine varieties were evaluated under three different training systems at Winchester, Va.: two divided canopy systems, Geneva Double Curtain (GDC) and Smart-Dyson (SD), and the “standard,” as used in Virginia, nondivided Vertical Shoot-Positioned (VSP). The training system comparison was established in 1998, and viticultural and enological data were collected through the 2005 growing season. Enological data were generated by Dr. Bruce Zoecklein on Virginia Tech’s main campus. Row spacing was at 10 feet and vine spacing was 8 feet for all three training systems. Varieties evaluated were Traminette own-rooted, Traminette grafted to C-3309, Cabernet Franc (clone #1) and Viognier (clone #1). Soil was a Frederick-Poplimento loam (sandy-loam) with a variable rooting depth of up to 55 inches. Vines were not irrigated and were subject to pest management and other general cultural practices routinely used in the region.

Comparisons were made of the two divided canopy systems, GDC and SD, and the nondivided VSP. SD represents a vertically divided canopy with the upper canopy confined between paired foliage wires, as with VSP. Shoots of the lower SD canopy originated from the same cordon as the upper canopy shoots and were manually positioned downward and held in that vertical position using a single foliage wire. GDC is a horizontally divided canopy with shoots oriented downward from cordons spaced 4 feet apart. Manual shoot positioning was performed each season shortly before bloom and again two to three weeks later to maintain two discrete canopies per vine. All three training systems used bilateral cordon-training and spur-pruning, with the VSP and SD cordons positioned 43 inches above ground and the GDC cordons positioned about 66 inches above ground. These three training systems are described in Reynolds and Wolf (2008).

Shoots were manually thinned shortly after bud break each year to about four shoots per foot of cordon for the VSP, the GDC and the upper canopy of the SD, and to about three shoots per foot of cordon for the lower SD canopy. Once cordons were fully developed, crops were further regulated to target crop levels of about 5 tons per acre for VSP and about 7.5 tons per acre for the divided canopy systems. Canopy management also included shoot positioning with all systems and shoot hedging with the VSP and the upper SD canopies to retain about 17 primary nodes per shoot. Shoot tipping was done, if necessary, with the GDC and SD-lower canopies to keep them off the

vineyard floor. Minimal leaf and summer lateral removal was done between fruit set and veraison to maintain no more than about two leaf layers in the fruit zone.

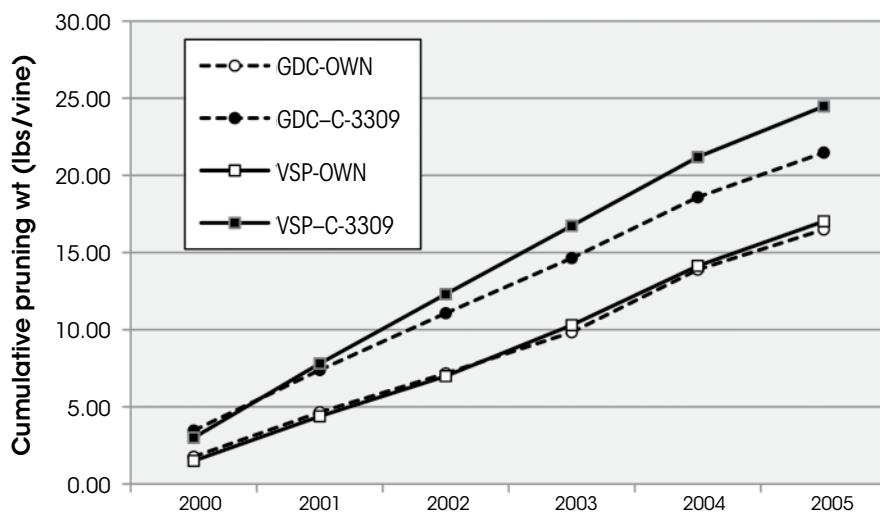
Components of crop yield were obtained at harvest and included clusters per vine, crop weight per vine, berry weight and berries per cluster. Berry weights were based on 50-berry samples randomly collected from each treatment replication. Separate data were collected for the upper and lower canopies of the SD-trained vines from 2002 through 2005. Cane pruning weights were obtained by vine in the dormant periods and were used with crop per vine to calculate crop loads. Measures of bud cold hardiness were periodically made using standardized laboratory methods. Grape juice, wine-making and wine analyses were conducted in the Wine Chemistry lab at Virginia Tech.

## Results and discussion

Annual and cumulative cane pruning weights were lowest for GDC and much greater for VSP-trained vines (Figure 1); SD-trained vines were comparable to VSP-trained vines with respect to pruning weights (data not shown). GDC pruning weights reflect the devigorating effect of downward shoot positioning, which is a previously reported response owing to reduced stomatal conductance. The lower pruning weights with GDC-trained vines reflected a smaller individual cane mass due, in part, to smaller diameter, but also due to fewer “ripe” nodes (nodes that bore visibly well-matured periderm) in the fall (data not shown).

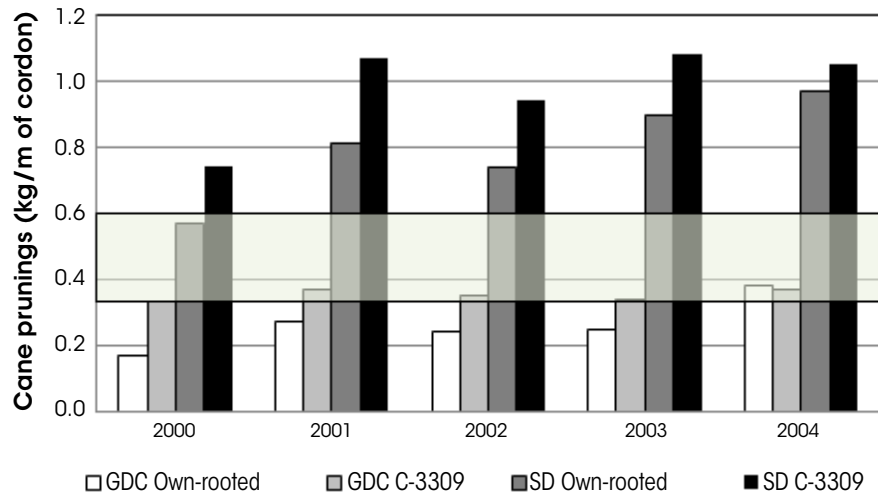
Vines grafted to C-3309 had greater annual and cumulative pruning weights than did own-rooted vines, regardless of training system (Figure 1).

Cane pruning weights per unit length of cordon provide a measure of vine



**Figure 1.** Traminette cumulative cane pruning weights over six growing seasons. Data are included only for VSP and GDC-trained vines. Traminette was grown either own-rooted (dashed lines) or grafted to C-3309 rootstock (solid lines).

“balance.” A generally accepted, optimal range for this index is from 0.30 to 0.60 kilograms per meter of cordon (Smart and Robinson 1991). Expressed in this manner, pruning weights varied from about 0.20 kg/m of cordon with nongrafted GDC-trained vines to more than 1.0 kg/m of cordon with grafted SD-trained vines (Figure 2).



**Figure 2. Traminette annual cane pruning weights for GDC- and SD-trained vines expressed as kilograms per meter of cordon. Traminette was grown either own-rooted or grafted to C-3309 rootstock. The shaded box defines a provisional, desirable range of vine size based on cane pruning weights (Smart and Robinson 1991).**

The grafted GDC-trained Traminette consistently fell within the optimal pruning weight window. On the other hand, SD-trained vines generally had excessive pruning weights, particularly for the grafted vines. VSP-trained vines were comparable to SD-trained vines (data not shown).

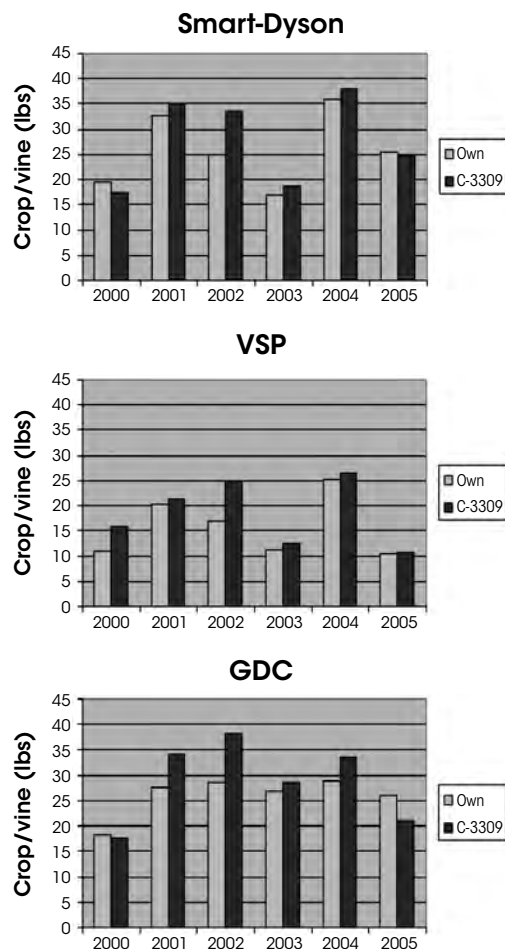
Crop levels per vine (Figure 3) were greatest with the divided canopy training systems and least with the VSP training, as anticipated. Crop per unit length of cordon was greatest with SD vines and was least for GDC-trained vines (data not shown). The two SD canopies, upper and lower, originate from the same cordon, and the apparent increase in crop per unit length of cordon reflects that arrangement. VSP-trained vines were intermediate to the other training systems with this cropping index. Crop load, or Ravaz index, is the ratio of crop weight to cane pruning weights for a given year and, as such, is a convenient measure of vine balance and can illustrate over- or undercropping situations. Optimal crop loads generally range from around 5 to 12 (i.e., 5 to 12 pounds of crop for each pound of prunings). With the possible exception of GDC own-rooted vines, all treatments were within or slightly below this range for the duration of the experiment (Table 1). In sum, vines were not overcropped, despite the rather large yields obtained in some years with the divided canopy training systems.



Components of yield affected by training included clusters per vine (obviously more on divided canopies), berry weight (often lower on the lower SD canopy compared to the upper SD canopy, but otherwise unaffected) and berries per cluster. Berries per cluster and cluster weights were consistently greater with vines grafted to C-3309 rootstock than for own-rooted vines (data not shown). Node fruitfulness — how many flower clusters were borne on shoots each spring — also varied by training system. Fruitfulness was increased both by GDC training and by grafting to C-3309 rootstock. The training effect can be explained by the greater sunlight interception of nodes borne at the top of the trellis with GDC, as opposed to lower positions on the canopy. The rootstock effect was significant and could partially explain the greater yields obtained with C-3309-trained vines. While these differences in fruitfulness were not of a large magnitude (e.g., 1.8 clusters per shoot for GDC vs. 1.6 clusters per shoot for VSP), they can sum to appreciable yield increases over a large planting.

Grapes for each treatment were harvested as close to a common target Brix level as possible to allow unbiased comparisons of secondary metabolites. We did not see measurable differences in the rate of fruit maturation between the upper and lower canopies of SD-trained vines (Table 2). For example, Brix at harvest for own-rooted vines in 2002 was 22.1 for upper and 22.4 for lower canopy. Brix for C-3309-trained vines the same year was 22.0 (upper) and 22.3 (lower). In fact, the only treatment difference in Brix observed at harvest was a *reduction* in Brix with the VSP-trained vines in 2004 (19 degrees Brix), compared to all other treatments (20 degrees Brix).

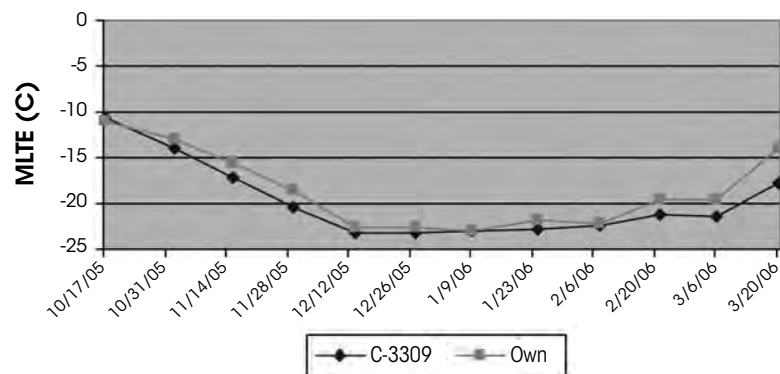
Secondary metabolite assessments were made as a means of predicting flavor and aroma impacts of training and rootstock. Some of the major findings from those analyses were as follows:



**Figure 3. Traminette crop per vine over six growing seasons as a function of training system and grafting, or not, to C-3309 rootstock.**

- GDC-trained vines tended to have higher glycoside concentrations in fruit than did the other two training systems.
- SD-lower canopy fruit also tended to have higher concentrations of glycosides than did upper canopy fruit.
- Concentrations of higher alcohols tended to be lower in GDC wines.
- Concentrations of esters (desirable) tended to be lower in VSP wines.
- Concentrations of monoterpenes were not consistent for any particular training system across the vintages.
- In sensory analyses, the SD-lower canopy wines had the greatest perception of vegetative aromas in two vintages for which this was assessed.
- Finally, GDC wines had greatest overall intensity, fruit aromas and fruity/sweet flavors.

Measures of dormant bud cold hardiness were made in most winters to address possible effects of training system on hardiness as well as to determine varietal and rootstock effects on hardiness. The Traminette data of 2005–06 showed a slight improvement in cold hardiness with the use of C-3309 rootstock, although the trend was not evaluated for statistical significance (Figure 4).



**Figure 4. Dormant bud cold hardiness of VSP-trained Traminette vines on C-3309 or own-rooted during the 2005–06 winter.**

## Conclusions

- Crop yields were increased 50 to 75 percent with canopy division (either SD or GDC).
- Crops were not excessive from a crop load or crop-to-leaf-area ratio; cane prunings per unit length of canopy were maintained, although marginally for GDC in one year.
- GDC training is devigorating and increases fruitfulness (clusters per shoot).
- Grafting increased capacity of Traminette for crop and vegetation production.

- Primary fruit chemistry was not adversely impacted by the higher crops achieved with canopy division.
- SD and GDC tended to result in higher fruit glycosides and free volatiles than did VSP.
- Juice and wine flavor and aroma components were generally not adversely affected by higher crops and were often improved with divided canopies, probably as a function of improved canopy conditions.
- Fruit maturation between the upper and lower canopies of SD-trained vines was not asynchronous.
- Bud cold hardiness was not adversely affected by training system, which is noteworthy given the greater yields of the divided canopy training.
- Increased yields achievable with SD or GDC training can increase grower returns.

## References

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**Table 1. Traminette crop load (Ravaz Index) for 2000, 2005 and 2000-04 average as function of training system and grafting to C-3309 rootstock.**

	<b>2000</b>	<b>2000-04 Avg</b>	<b>2005</b>
GDC-own	12.4	10.7	10.5
GDC-C-3309	5.7	8.4	7.4
SD-own	7.7	6.6	7.1
SD-C-3309	4.8	5.4	5.0
VSP-own	8.2	6.5	7.3
VSP-C-3309	5.3	4.9	5.8

**Table 2. Components of yield and crop primary chemistry associated with the upper and lower canopies of own-rooted and grafted (C-3309) Traminette vines during the 2002 season.**

	<b>Clusters per vine</b>	<b>Crop per canopy (lbs)</b>	<b>Cluster weight (g)</b>	<b>Brix</b>	<b>pH</b>	<b>TA (g/L)</b>
<b>Traminette/own-rooted</b>						
Upper canopy	30.9	14.6	217	22.1	3.19	5.81
Lower canopy	24.2	10	189	22.4	3.17	6.04
<i>Significance</i>	ns	**	ns	ns	ns	ns
<b>Traminette/C-3309</b>						
Upper canopy	40.7	18.9	212	22	3.17	5.71
Lower canopy	31	14.2	210	22.3	3.18	5.62
<i>Significance</i>	ns	**	ns	ns	ns	ns



# The Use of Remote Sensing for Vineyard Differential Harvesting

**Russell Smithyman**

Ste. Michelle Wine Estates  
Prosser, Wash.

Vine variability exists in all vineyards and often causes differences in fruit quality in different areas within the vineyard. Traditional methods of identifying internal vineyard variation are labor intensive, time consuming, expensive and, thus, impractical in larger vineyards. Hence, grape growers often manage blocks as though they were uniform and live with the inherent variation. However, when vineyards with high vine variability are farmed in this way, higher quality fruit within the block is often made into lower-priced wines because of the overall vineyard fruit quality. Many precision viticulture practices have been introduced in the past 20 years that endeavor to easily identify areas within vineyards that differ from each other, and provide the means to separately manage these areas to deliver more uniform fruit to the winery.

Precision viticulture uses a number of tools and technologies that allow vineyard attributes to be measured and displayed at high spatial resolution. By using this information, more precise management decisions can be made that increase the likelihood of producing more uniform fruit compared to conventional viticultural management. One method of identifying within-vineyard variation is to use aerial multispectral imaging to create normalized difference vegetative index (NDVI) maps. This process measures the proportions of light reflected back in the visible and near-infrared wavelengths and indicates the amount of leafy plant material. The more reflectance measured in the near infrared bands, the greater the amount of healthy plant material. In the case of wine grapes, more is not necessarily better. Vigorous vines with greater leaf area produce larger berries that ripen later with increased vegetal flavors. Vine stress reduces vigor and results in smaller berries that have more intense flavors and ripen earlier. More importantly, NDVI mapping has the potential to provide identification of canopy characteristics that produce fruit for specific wine styles.

In 2003, Ste. Michelle Wine Estates of Washington state began using remote sensing to investigate if it could provide information on canopy density and, hence, grape maturation. The goal was to identify areas within vineyards with differing quality parameters and then harvest those zones separately to provide winemakers with the flexibility to blend different fruit characteristics when creating



**Figure 1. A harvester at Ste. Michelle Wine Estates works in tandem with gondola drivers, coordinated by light signals to differentiate fruit quality during harvest.**

a desired wine style. Initially, blocks were divided into as many as 10 different vigor zones, which became unmanageable with the fruit quality differences too slight between zones. However, the differences between high and low vigor zones were significant. Two vigor zones were then identified from the NDVI mapping, and perimeter vines were flagged. Maps were distributed to hand-harvest crews to follow, but the harvest proved to be time-consuming and expensive. Efforts to separate grapes with a conventional machine harvester also proved inefficient, especially when harvesting was performed at night. Selecting and harvesting vigor zones by entire rows was also attempted. Although this method reduced the accuracy of the zonal harvest, four out of five tasters were able to distinguish wines produced from the differentially harvested areas.

A method to more precisely harvest vigor zones was created in 2006. A signaling system was developed to facilitate communication between the harvester operator and gondola drivers, who receive fruit from the harvester in the vineyard (Figure 1). The system employed a signal bar with a series of lights (red, white and amber) that were controlled by a personal digital assistant (PDA) with a Global Positioning System (GPS) card (Figure 2). The NDVI maps were loaded into the PDA, and signal lights were turned on and off based on the harvester location within the vineyard. NDVI maps were prepared with polygons created around the high- and low-vigor zones with a

15-foot buffer to allow gondola drivers working with the grape harvester time to make changes. Two gondola drivers, one following the other, proceeded down the row, with each driver designated a specific light color or vigor zone. Each gondola moved into position to receive fruit from the harvester when its designated light was illuminated. The fruit was then taken to different trucks and delivered to the winery, where separate wines were produced.



**Figure 2. The grape harvester signal used by Ste. Michelle Wine Estates to differentiate fruit quality during harvest.**

These endeavors to differentially harvest vineyards based on NDVI mapping have demonstrated that selectively harvested grapes can produce premium wines and provide winemakers with more blending options. In addition, the equipment was inexpensive to construct and the process was efficient and easy to use. The signal bar was constructed for \$200, software to coordinate the harvester and gondolas was purchased for \$1,500, and the aerial imagery cost \$3 per acre. Using the harvester signal to perform differential harvesting required minimal additional time or expense. Ste. Michelle Wine Estates has currently expanded its vineyard mapping using NDVI to 90 percent of its own acreage and has begun imaging selected contracted blocks outside the company. NDVI mapping has also proven to be an effective tool for facilitating preplanting decisions, irrigation maintenance and canopy management, including damage assessments resulting from pests, disease or growing conditions. However, the greatest return on investment has been the ability to provide winemakers with more uniform fruit, increased blending options and the potential for improved quality.





# Meeting the Expectations of the Customer, Whether a Winery or Consumer

**Dana Merrill**

Mesa Vineyard Management Inc. and  
Pomar Junction Vineyard and Winery  
Templeton, Calif

A vineyard or winery must be responsive to the expectations of its customers. The specific considerations and techniques described below have proven successful in California's Central Coast and may be applicable to growers in other locations.

Wine grapes present special marketing challenges as a commodity and value-added product versus a typical commodity crop. A marketing strategy, which may involve the use of brokers or outside expertise, is critical to success. Attracting winery buyers for grapes and then completing contract negotiations require key actions by growers. Areas of negotiation may include contract term, price, payment terms and the choice of hand- or machine-harvesting. All the contracts should be in writing to protect both grower and winery interests. Once contracts are in place, be sure to perform as promised and to maintain good ongoing communication with the buyers. In addition, seek input on the resulting wines with the intent of having customers return for future harvests.

Growers also have the option of making wine, directly or via a contract winery, rather than selling grapes as fruit. Making wine involves additional marketing challenges as well as opportunities. Wine may be sold in bulk or in branded cases, which may result in a grower becoming a winery. Other possible phases of wine marketing include identifying with local associations, promoting the brand and developing partnerships with tourism promotion for branded wines.

For growers and wineries, meeting consumer expectations is critical because return customers are required for success. The basic strategy is the same whether you are marketing grapes or wine: Solve problems for your buyers and the buyers will return. Be proactive, be dependable, do more than your customers expect, and you will be their supplier of choice. There may not always be enough customers for everyone, but there will be enough for you.

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# Speaker Contact Information

**Dana Merrill**

Owner  
Mesa Vineyard Management Inc.  
110 Gibson Road  
Templeton, CA 93465  
Pomar Junction Vineyard and Winery  
5036 S. El Pomar Road  
Templeton CA 93465  
E-mail: dmerrill@pomarjunction.com

**Dr. Paolo Sabbatini**

Assistant Professor  
Department of Horticulture  
Michigan State University  
East Lansing, MI, 48864  
E-mail: sabbatin@msu.edu

**Russell Smithyman**

Director of Viticulture  
Ste. Michelle Wine Estates  
660 Frontier Road  
Prosser, WA 99350  
E-mail: russell.smithyman@smwe.com

**Dr. R. Keith Striegler**

Director and Viticulture Program Leader  
Institute for Continental Climate Viticulture  
and Enology  
University of Missouri  
108 Eckles Hall  
Columbia, MO 65211  
E-mail: StrieglerK@missouri.edu

**Justine E. Vanden Heuvel**

Assistant Professor  
Horticultural Sciences  
Cornell University  
Geneva, NY 14456  
E-mail: jev32@cornell.edu

**Dr. Robert L. Wample**

Plant Physiologist  
Soil and Topography Information Inc.  
5596 N. Wright Ave.  
Clovis, CA 93619  
E-mail: r.wample@soilinfo.com

**Dr. Tony Wolf**

Professor of Viticulture  
Alson H. Smith Jr. Agricultural Research and  
Extension Center  
Virginia Tech  
595 Laurel Grove Road  
Winchester, VA 22602  
E-mail: vitis@vt.edu



