This page intentionally blank.
PREFACE

Approximately 150 persons attended the 1989 Ohio Grape-Wine Short Course, which was held at the Westlake Holiday Inn in Cleveland on February 20-22. Those attending were from 10 states, not including Ohio, and represented many areas of the grape and wine industry. This course was sponsored by the Department of Horticulture, The Ohio State University, Ohio Agricultural Research and Development Center, Ohio Cooperative Extension Service, Ohio Wine Producers Association and Ohio Grape Industries Committee.

All publications of the Ohio Agricultural Research and Development Center are available to all potential clientele on a nondiscriminatory basis without regard to race, color, creed, religion, sexual orientation, national origin, sex, age, handicap, or Vietnam-era veteran status.

7/89-750
This page intentionally blank.
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steps to an Award-Winning Seyval Wine</td>
<td>1</td>
</tr>
<tr>
<td>by John Herbert</td>
<td></td>
</tr>
<tr>
<td>Viticultural Strengths and Weaknesses of Seyval</td>
<td>3</td>
</tr>
<tr>
<td>by Martin Kaps</td>
<td></td>
</tr>
<tr>
<td>Understanding Pumps for a Small Winery</td>
<td>6</td>
</tr>
<tr>
<td>by Sudhir K. Sastry</td>
<td></td>
</tr>
<tr>
<td>Epidemiology and Control of Powdery Mildew</td>
<td>9</td>
</tr>
<tr>
<td>by Roger C. Pearson</td>
<td></td>
</tr>
<tr>
<td>Sulfur Dioxide: Amount and Time of Application for Better Wine</td>
<td>13</td>
</tr>
<tr>
<td>Quality, by Christopher Stamp and James F. Gallander</td>
<td></td>
</tr>
<tr>
<td>The Cluster Thinning Window--How Big Is It?</td>
<td>18</td>
</tr>
<tr>
<td>by Garth A. Cahoon</td>
<td></td>
</tr>
<tr>
<td>Have You Considered an Ice Wine?</td>
<td>20</td>
</tr>
<tr>
<td>by Jack M. Lucia</td>
<td></td>
</tr>
<tr>
<td>Practical Aspects of Sterile Bottling</td>
<td>22</td>
</tr>
<tr>
<td>by John Herbert</td>
<td></td>
</tr>
<tr>
<td>Fruit Color Development of Reliance Grapes</td>
<td>24</td>
</tr>
<tr>
<td>by Yu Gao, David Scurlock, Joel Lehman and G.A. Cahoon</td>
<td></td>
</tr>
<tr>
<td>Survey and Control Attempts of Grape Root Borer and Erineum Mite...</td>
<td>28</td>
</tr>
<tr>
<td>by Jozef L.W. Keularts and Roger N. Williams</td>
<td></td>
</tr>
<tr>
<td>Effects of Foliar Phylloxera, Daktulosphaira vitifoliae (Fitch).....</td>
<td>31</td>
</tr>
<tr>
<td>on Yield of 'Seyval' Grapes, by Murdick McLeod and Roger Williams</td>
<td></td>
</tr>
<tr>
<td>Maturity Assessment for Improving Wine Quality</td>
<td>33</td>
</tr>
<tr>
<td>by James Gallander and Judy Stetson</td>
<td></td>
</tr>
<tr>
<td>Soil Management: Compaction, Fragipans and Related Problems</td>
<td>35</td>
</tr>
<tr>
<td>by Martin Kaps</td>
<td></td>
</tr>
<tr>
<td>The Use of Ascorbic Acid (Vitamin C) As An Antioxidant</td>
<td>39</td>
</tr>
<tr>
<td>in Ohio Wines, by Mike Horvath and James Gallander</td>
<td></td>
</tr>
<tr>
<td>Rapid Microbiological Methods for a Small Winery</td>
<td>43</td>
</tr>
<tr>
<td>by Jack M. Lucia</td>
<td></td>
</tr>
<tr>
<td>Phomopsis Cane and Leaf Spot and Fruit Rot</td>
<td>46</td>
</tr>
<tr>
<td>by Roger C. Pearson</td>
<td></td>
</tr>
<tr>
<td>Building a Vineyard Nutrition Program</td>
<td>52</td>
</tr>
<tr>
<td>by G.A. Cahoon</td>
<td></td>
</tr>
</tbody>
</table>
This page intentionally blank.
STEPS TO AN AWARD-WINNING SEYVAL WINE

John Herbert
Wagner Vineyards
Lodi, NY 14860

A fine wine begins with ripe, sound fruit. At Wagner Vineyards, we found Seyval grapes need to be blossomed-thinned to achieve optimum fruit ripening and minimize winter injury.

Factors which influence our decision to harvest include:

1. Brix (20°-22°)
2. pH (3.2-3.4)
3. TA (1.0-.8 gr/100 ml)
4. Condition of fruit and weather

Machine harvesting allows us to maintain a flexible and orderly schedule. We harvest the grapes in a few predawn hours to be processed over a 24-hour period.

The grapes are harvested cold (40-45°F), and the bulk bins into which they are picked keep them cold. This allows the grapes to receive an average of 12 hours of skin contact under optimum conditions—uncrushed and cold.

No SO₂ is used before fermentation. Through experimentation, we have found that treating the juice with 8 lb of bentonite per 1000 gallons juice before fermentation gives complete heat stability in finished wine.

After the grapes are pressed, the juice is held at 50°F for 24 to 36 hours settling time, then racked tank to tank. The lees are rough filtered and blended back into the settled juice.

The yeast is started in unsettled juice at the time of pressing. We've found a rate of 100 gr/1000 gal in 5%/vol. juice makes a very adequate starter for barrel fermentation. This starter is aerated vigorously several times in the next 36 to 48 hours.

At this time, the settled and racked must is inoculated, treated with .4 gr/liter yeast ghosts and racked into 50-gallon barrels for fermentation. Starting with cool must gets the fermentation off to a slow start. We now use Prise de Mousse (PDM) yeast exclusively for our barrel-fermented wines. We have conducted numerous comparisons using different yeast strains. Our conclusions indicate PDM yeast in conjunction with the use of yeast ghosts yields the best results. Excellent wine quality is achieved without the risk of a stuck fermentation that less vigorous yeast strains may cause.

In 2 to 3 days, the must has reached a temperature of 70° to 75°F and dropped to 12° to 14° Brix. This is when the must is inoculated for malolactic fermentation.
Ten to 15% of our Seyval harvest is tank fermented and does not go through M-L fermentation. Some of this wine will be blended later with the barrel-fermented wine. The non-M-L tank-fermented wine has a freshening effect on the blend. The barrel-fermented M-L wine provides the full, oaky, complex flavors and long finish.

We also have experimented with some extended lees contact after the primary fermentation is completed. We feel there are several benefits from this practice. The wine gains a fuller mouth feel, adding to the middle of the wine. It also allows the wine to remain undisturbed until M-L is completed. This is a critical time in the wine’s life, and each lot should be checked several times per week. Sulfide production and oxidation can easily occur until the wine has been racked and sulfured.

We try to have all of the wine racked by the end of the year. At this time we make an initial SO$_2$ addition of 50 ppm. Each lot is evaluated, and a representative lab blend is assembled. Generally, a portion of the total wine is returned to newer oak for aging. When the proper level of oak is achieved, the total blend is assembled, generally in April/May.

The blend is then checked for heat stability, and acid additions are evaluated. We find that most wines completing M-L benefit from an addition of tartaric acid. The pH is lowered, and excess potassium precipitates even if TA is not raised significantly. The wine is then cold stabilized, with bottling generally occurring in July or August.
VITICULTURAL STRENGTHS AND WEAKNESSES OF SEYVAL

Martin Kaps
Southwest Missouri State University
Mountain Grove, MO

Parentage and Distribution

Seyval blanc is the named variety Seyve-Villard 5276. The original mother vine was a cross of Seibel 5656 and Seibel 4986. The hybridizer, Berille Seyve Jr. (1895-1959), made the cross in 1921 at Bouge-Chambalaud, France. Bertille Seyve Jr. married the daughter of hybridizer Victor Villard. He distinguished his hybrids from those of his father (Seyve) and father-in-law (Villard) by naming them Seyve-Villard. The crosses made in France are known as hybrid direct producers (HDP), meaning that they grow and produce crops on their own roots. They were developed in response to the European phylloxera epidemic of the 1870's which destroyed vineyards of Vitis vinifera growing on their own roots.

Seyval is a standard grape variety for premium white wine production in the Eastern and Midwestern United States. It would be safe to say that every state that can successfully grow French-American hybrid grapes had Seyval plantings. This variety is likely to maintain its importance in the future in those states that cannot grow Vitis vinifera. Other white hybrid varieties that will compete with Seyval are Vidal blanc and Vignoles.

Vine Characteristics

Seyval is considered an early, midseason grape with approximately 90 to 100 days required from bloom until harvest. Bud break is in early- to mid-May in central Ohio with bloom 3 to 4 weeks later. Harvest season is in early- to mid-September (central Ohio). These development periods can vary 10 to 14 days from southern to northern Ohio. The Seyval vine is considered medium in vigor (vegetative growth). In Ohio this means pruning weights in the 1 to 2 pound range. Hardiness of the vine is considered moderate. Warming trends during the late winter, followed by cold temperatures are particularly damaging to vines of moderate or low hardiness. Any resulting trunk injury is susceptible to crown gall infection. Buds are killed by temperatures below -5°F. Seyval is also considered highly susceptible to powdery mildew, moderately susceptible to black rot and botrytis bunch rot, and slightly susceptible to downy mildew. It is also sensitive to sulfur containing compounds (wettable sulfur). Seyval is easily overcropped if too many buds are left on the vine.

Fruit Characteristics

Seyval has a yield potential of 4 to 6 tons per acre. Yield can be less than this for low vigor vines or exceed it for high vigor vines. Cluster number per shoot is 3 to 4. Cluster size is considered medium, conical shape, and a weight of one-half pound or greater when thinned or less than one-half pound when not thinned. Berries are small, round, green to golden yellow color at maturity and weigh 1.5 to 2 grams. Juice chemistry is in the range
of 19 to 21°Brix, 0.7 to 0.8% titratable acidity, and pH of 3.2 to 3.3. Maturation of Seyval under hot conditions can cause pH to rise too rapidly. This may require an earlier harvest at a lower °Brix so that pH is acceptable for wine stability.

**Vineyard Management**

Training of Seyval in Ohio is primarily to single curtain cordon system. A limited amount of Kniffen training (umbrella, 4-arm) is being used. It is advisable to double trunk the vine with a cordon established from each trunk to allow for continued production when there is trunk injury. Periodic trunk renewal at 3- to 6-year intervals will keep younger, more vigorous wood in place on the trellis which is more productive. In shallow topsoil sites, ridging along the plant row will provide a greater soil volume for rooting. There may also be reduced loss of applied pre-emergent herbicide due to leaching.

**Crop Regulation**

There is a close relationship between growth and yield in grapes. The amount of vegetative growth in one year will determine the cropping potential the following year. The amount of fruit yield in one year will also affect vegetative growth and maturity that same year. There are two techniques we have to obtain crop regulation. One is dormant season balance pruning and the second is cluster thinning.

If possible, dormant pruning is begun after winter low temperatures are experienced. A balance pruning formula of 20 plus 10 is used where 20 buds are left for the first pound of pruning weight plus 10 buds for each additional pound. A maximum of 50 buds are left. On sites that are subject to spring frost damage, double pruning may be advised. Extra buds are left on the vine at first pruning and then final bud number adjustment is made after danger of frost has past.

Dormant season balance pruning is not entirely effective at obtaining crop regulation due to base and latent bud production. These buds develop at the base of canes or on older wood (cordons) and are not counted in the balance pruning technique. Fruitful shoots can develop from these buds which can lead to over-cropping if additional crop reduction is not done. More severe pruning usually does not compensate, and the loss of buds due to winter low temperature or spring frost makes this undesirable. Methods of reducing base and latent bud number include long cane pruning rather than cordon pruning, and avoiding excessive spur number.

Cluster thinning is the second technique for regulating crop. It involves reducing cluster number per shoot to one basal cluster. Low pruning weight vines (1 pound or less) benefit from crop removal. This is important during the early years of vineyard establishment where the vine needs to be properly trained to the trellis. Cluster thinning will maintain a more consistent yield and pruning weight on the vine. In addition, °Brix will usually be improved and fruit maturity advanced.
On occasion, secondary crop can set on summer lateral shoot growth. There are year to year variations in the amount of secondary crop. Also, primary shoot number per vine appears to influence summer lateral production. Downward growing shoots have more laterals which bear a secondary crop. Avoiding training systems that promote downward shoot growth may be one way of reducing this.

Summary

Seyval's strengths are name recognition in the Eastern and Midwestern United States wine industry and potential for good yields. There lies the weakness of Seyval. With good yields is also the potential for over-cropping. That, combined with medium vine vigor increases the change for winter injury and crown gall infection. The key to overcoming this is proper management of the crop through good pruning and cluster thinning practices and prompt replacement of crown gall infected trunks.
"Which is the right selection of pumps for my winery?" The answer is likely: "It depends on the particular application." Pumps are essential components of any food processing operation, and are needed in wineries for transport of juice, wine, crushed grapes and other fluids. They are available in a wide range of designs, sizes and types, and it is worthwhile trying to understand their performance characteristics, advantages and limitations before settling on a choice. This is particularly important, because a well selected pump can mean significant savings in overall operational costs in a process operation.

Commercially available pumps may be classified into two broad categories, based on the method by which the fluid is moved. These are: 1) centrifugal type and 2) positive displacement type. These are intended for distinctly different types of uses, and operate as detailed below.

Centrifugal pumps operate by using centrifugal force, (the force which acts on all rotating objects, tending to throw them outward) as shown in Fig. 1. In the figure, the fluid enters at the center and is rotated by the motion of the impellers. This action creates a centrifugal force, which "flings" the fluid outward to the periphery of the pump, where the outlet pipe is located. Centrifugal pumps are useful in producing relatively large flow rates, provided the pressure drops in the downstream piping is not too large. In certain cases, these pumps have been used to pump products containing particulate matter, although this is not a common application for this type of pump. They are best suited to low viscosity products, such as juices, or sanitizing solutions for clean-in-place operations. One of the important points to remember is that these pumps are not "self priming", that is, they must be full of fluid when pumping begins. If a centrifugal pump is connected to a fluid line without being primed, no pumping action will result. Another important point is that these pumps should not be operated with a negative (suction pressure) on the inlet side.

Positive displacement pumps are those which exert a direct force on the fluid (in contrast to centrifugal force, which is indirect, or an outcome of rotation). These pumps are manufactured in a wide variety of designs, which fall into two broad categories; reciprocating and rotary. Reciprocating pumps involve a piston which moves back and forth within a cylinder. During the intake stroke, the piston is withdrawn, allowing fluid to enter the cylinder, and during the discharge stroke, fluid is pushed out of the cylinder to the exit. The opening and closing of inlet and exhaust valves ensures that fluid moves in the direction desired. The most common application for this type of pump is in milk homogenization, or pumping of solids (e.g., sausage stuffing). They typically operate at relatively low flow rates, against extremely high pressures. Because of the periodic nature of the piston motion, the flow from such a pump would be pulsating in character if only one piston is used. It is, therefore, common to use multiple pistons and cylinders that rotate out of
phase with each other to ensure a smoother flow.

The more common type of positive displacement pump is the rotary type, similar to the lobe-type pump illustrated in Fig. 2. The fluid enters at one side, and is carried around the periphery in the gap between the lobes and the pump housing to the opposite side, where it is discharged. There are a number of different types of rotary pumps; for example, the two lobes in Fig. 2 could be replaced by two intermeshing gears, resulting in a "gear" pump. Regardless of the specifics of the design, positive displacement pumps provide relatively low flow rates against high pressure heads. Unlike centrifugal pumps, positive displacement pumps are self-priming, (i.e., they do not need to be filled up to start pumping). Positive displacement pumps are sometimes used to pump solid suspensions; and would be more suited to pumping of crushed grapes than centrifugal pumps. If particulate integrity is desired, a gentle acting pump may be necessary. For this purpose, a number of "progressive cavity" pumps are available, which provide a gradual opening and closing of the pump cavity.

Once the type of pump has been selected, the sizing of the pump (i.e., horsepower) is important. This depends largely on the flow rate desired and the pressure head against which the product must be pumped. All pumps possess "characteristic curves" which are available from the manufacturers. These curves detail the flow rates versus pressure head characteristics of the pump in question. The most important point to remember is that for a given horsepower, the flow rate decreases as the pressure drop in the downstream piping increases. The pressure drop depends on the type and complexity of piping, as well as the height to which the liquid must be pumped, and other factors that may add to pressure drop in the line. Finally, the "sanitary" features of the pump are of importance.

A well-selected and sized pump is important to trouble-free operation in the plant, and can provide long and useful service.
Figure 1. Centrifugal Pump

Figure 2. Positive Displacement Pump (Rotary Lobe Type)
Epidemiology and Control of Powdery Mildew
Roger C. Pearson
Department of Plant Pathology
New York State Agricultural Experiment Station
Geneva, New York

We have been studying sources of primary inoculum for the powdery mildew fungus (Uncinula necator) since 1981. The literature from Europe, California, South Africa, and Australia indicates the fungus in those locations survives almost exclusively in the dormant buds of the grapevine. While on sabbatical leave in Germany in 1982, I studied the bud infection phenomenon and found that by mid-July the fungus had already infected axillary buds of growing shoots. While in Germany, I also learned to identify primary inoculum sources that arose from infected dormant buds. The infected shoots arising from infected dormant buds are called "flag shoots" and they are centers of disease development from which spores spread to the rest of the vineyard. Vineyard surveys in New York during the past 8 years have failed to provide evidence that bud infection is the source of primary inoculum.

Nevertheless, the vineyard surveys did shed light on possible sources of inoculum. The first evidence of infection was consistently observed in late May or early June as individual colonies of powdery mildew appearing on leaves of young shoots (commonly 4-8 inches long). The infected shoots were typically growing from the trunk or head of the vine in close proximity to the bark, rather than from buds on canes. In addition, disease generally developed throughout the vineyard in a short period of time. We suspected that this pattern of infection was most likely due to randomly distributed individual spores rather than from point sources of inoculum due to flag shoots.

The most obvious source of spores, in the absence of conidia from flag shoots, would be ascospores arising from the commonly observed black spherical fruiting bodies called cleistothecia. Cleistothecia are produced on most infected parts of the vine from late-July to frost. To determine if the cleistothecia were functional, experiments were conducted using those collected in spring. We were able to stimulate release of ascospores from cleistothecia and observe spore germination and infection of grape leaves. This information proved that cleistothecia were functional and could be the source of primary inoculum in New York vineyards. In addition, we found cleistothecia on the bark of vines in spring prior to bud break. This observation helped to explain the first appearance of infections on shoots in close proximity to bark.

In 1985, Dr. David Gadoury joined my laboratory as a post-doc and began intensive studies on the epidemiology of powdery mildew in light of this new information. He determined that the fungus had at least two mating types and they had to grow in contact with each other on the host before cleistothecia would form. He found that the formation of cleistothecia in the vineyard was dependent on the amount of disease, not host or environmental factors as previously reported. The more disease, the earlier one could observe cleistothecia.
Dr. Gadoury also studied the morphological development of cleistothecia. He observed special structures called "anchorage hyphae" that form shortly after the initiation of growth of the cleistothecium. The anchorage hyphae, as the name implied, function to hold the cleistothecium in place on the mildew colony during its development. Later, special appendages appear that are directed up and away from the cleistothecium. As soon as the cleistothecium turns black, it is morphologically mature, the anchorage hyphae break, and the cleistothecium is readily dislodged from the mildew colony by rainfall. In water it is randomly distributed to other parts of the vine or to the soil. When wet, the appendages are limp like a wet noodle and readily conform to the topography of the surface on which the cleistothecium rests. The appendages become stuck to the surface as they dry and firmly hold the cleistothecium in place. In this manner, cleistothecia are attached to the bark of vines.

Studies indicated that cleistothecia on leaves and cluster stems had less than a 5% survival rate and all of those on the soil were dead by spring. However, cleistothecia on the bark had a survival rate of up to 90%. We speculate that cleistothecia on bark are mature at the time of deposition and physiologically adapted to survival. Most of those remaining on the leaves and cluster stems are immature and not suited to winter survival. Those on the soil, although mature, do not survive, perhaps due to biological degradation.

Although cleistothecia mature morphologically within 30-40 days, they do not release their ascospores until spring. There are several physiological changes that precede spore discharge. During winter the cleistothecium is exposed to many cycles of wetting and drying. During this process, the cleistothecium swells to a sphere when wet and shrinks like a deflated ball when dry. This repeated process is associated with a thinning and weakening in the wall at the base of the cleistothecium where it will eventually break open. In addition, there is an increasing concentration of soluble solids in the cytoplasm due to chemical changes in the cleistothecium. This results in an increased uptake of water during rain, causing swelling and eventual breakage of the wall of the cleistothecium, followed immediately by ascospore discharge.

Under field conditions, ascospores are discharged during or shortly after rainfall amounts of 0.1 inch or more. Based on observations over a 4-year period, from 75 to 100% of the ascospores are discharged between bud break and bloom. The time of release does not appear to be dependent on variety. Temperatures from 50 to 88°F do not appear to have an effect on release. However, temperatures below 50°F not only delay release, they reduce the total number of ascospores released.

Conidia of the powdery mildew fungus are capable of germinating in a wide range of humidity conditions, but they do not germinate well in free water. Ascospores, on the other hand, are capable of germinating in water, as well as at relative humidities as low as 54%. Since release of ascospores occurs during rainfall, it is not surprising that they can also germinate under these conditions. The optimal temperatures for infection by ascospores is between 68 and 77°F. Infection is significantly reduced at 59°F or below. No
infection occurs at or below 41°F, nor does it occur at or above 88°F.

Dormant Sprays For Control of Powdery Mildew

After the discovery that cleistothecia overwinter on the bark of grapevines, we initiated studies to eradicate this source of inoculum. Premerge herbicide was tried first as an over-the-trellis, dormant application. It apparently killed the cleistothecia which caused a delay in the initial development of the powdery mildew epidemic. Premerge was very toxic and its registration was soon cancelled. Lime sulfur (calcium polysulfide) was tested as a substitute for Premerge and was found to be just as effective.

Trials in 1986 and 1988, using the highly susceptible hybrid Rosette, showed a 2-3 week delay in the development of powdery mildew on foliage was possible where lime sulfur at the rate of 36 gal/acre in 300 gallons of water/acre was applied prior to bud swell. However, by the end of the season, with no further fungicide treatments, the amount of disease on leaves in the dormant treatment plots equalled that in the nonsprayed plots. It is important to note that berries are susceptible to infection for only a finite period of time. By delaying the epidemic, the fruit have a chance to mature to a point where they are much less susceptible to infection. In 1986, fruit infection in Rosettes at Geneva and Naples, New York, was reduced from 58 to 43% in the nonsprayed checks to 12 and 14%, respectively, in the plots with dormant lime sulfur and no seasonal foliar sprays. Similar results were obtained in 1988.

Experiments conducted with varieties of varying susceptibility indicated that dormant sprays may have a different impact on control of powdery mildew, depending on the variety. Dormant sprays of lime sulfur applied on Concord and Seyval provided better control of cluster infection than the full seasonal fungicide program (containing Bayleton, copper and/or sulfur) applied by the grower. Data from Chardonnay indicated that the dormant spray alone was not sufficient to control powdery mildew on this highly susceptible variety, but when combined with the full seasonal program, total control was significantly better than with either program alone.

Although the strategy of dormant sprays seems to be effective, the cost of lime sulfur at 36 gal/acre (currently $90/acre) is not commercially feasible. Therefore, we have been looking for alternatives to lime sulfur. Laboratory and limited field tests in 1988 indicated the most effective and cheapest alternative was copper sulfate used without lime. Bordeaux at 4-4-100, the fixed copper COCS, and Karathane were not as effective. Copper hydroxide and Bayleton had no activity.

There are several possible benefits from the use of dormant sprays; 1) in vineyards that had a severe powdery mildew problem the previous season, a dormant eradicant spray would reduce the total amount of overwintering inoculum to a manageable level so the grower would have a better chance for commercial control during the subsequent season; 2) the dormant spray may permit growers to eliminate several seasonal sprays on less sensitive varieties such as Concord; 3) the dormant sprays should improve the control
afforded by normal seasonal fungicide programs in highly susceptible varieties such as Chardonnay; 4) the dormant eradicant spray may be a useful tool in fungicide resistance management strategies; 5) partial control of diseases such as Phomopsis cane and leaf spot and angular leaf scorch may be an added benefit.

We are currently evaluating the efficacy of copper sulfate when used at different rates/acre and in different amounts of water/acre. We are also examining the potential for controlling other diseases in addition to powdery mildew using the dormant season, eradicant spray approach. Ultimately, we hope this approach will give most growers the opportunity to reduce the overall pesticide load in vineyards.
SULFUR DIOXIDE: AMOUNT AND TIME OF APPLICATION
FOR BETTER WINE QUALITY

Christopher Stamp and James F. Gallander
Department of Horticulture
OARDC/OSU, Wooster, Ohio

Sulfur dioxide has been and continues to be the most important wine preservative. In addition to its action against enzymatic browning, it aids in preventing the growth of unwanted yeast and bacteria. Though sulfur dioxide seems to be an ideal wine additive, it does have certain drawbacks, including concerns about its safety, especially for people suffering from asthma. Because of this, the wine industry is attempting to reduce its use of sulfur dioxide. It is important to maximize the utility of the sulfur dioxide. With careful sanitation, close attention to pH, the use of inert gases, and certain fining procedures to remove sulfur binding substances, the amount sulfur dioxide required to produce a stable wine can be reduced.

Traditionally, sulfur dioxide has been added in the early stages of wine production, usually to the grapes at crush or to the freshly pressed juice. The necessity of this early addition has been questioned in recent years, perhaps needlessly increasing the total sulfur dioxide level. Some sources recommend using no sulfur dioxide at all prior to fermentation, if clean sound grapes are used.

Sulfur dioxide added prior to, or during fermentation stimulates the production of sulfur binding substances. These substances, produced by yeast, include the undesirable compounds, pyruvic acid and acetaldehyde, which combine with the available sulfur dioxide. Since bound sulfur dioxide lacks most of the preservative qualities of free sulfur dioxide, further additions after fermentation are still necessary to achieve stability. Furthermore, without the antioxidative influence of sulfur dioxide, phenolics in the juice will polymerize and precipitate, leaving a more color stable wine. Unsulfured juice also exhibits a shorter lag phase allowing for quicker initiation of fermentation.

The primary advantage of sulfuring prior to fermentation is the inhibition of undesirable yeast and bacteria which have been shown to produce excessive levels of odiferous esters and outright spoilage. Sulfur dioxide also decreases browning in the must, which can result in bitterness.

While all wineries should keep sulfur dioxide additions to a minimum, usage should not be curtailed to the extent that wine quality suffers. The question is what stage during vinification should the initial addition of sulfur dioxide be made to maximize wine quality. To help answer this question, this study was conducted to determine the effect of sulfur dioxide addition at different stages of vinification on white table wine quality.

Materials and Methods

Vinification: After hand harvesting, Vignoles and Seyval blanc grapes from the experimental vineyards at OSU/OARDC, Wooster, Ohio, were transported...
to the enology laboratory for processing. The fruit was very clean and rot free. For each variety, the grapes were divided into 4 lots, and each lot was treated with 50 ppm sulfur dioxide at a different stage of vinification. These stages were after crushing, pressing, juice clarification, and alcoholic fermentation.

Each lot was replicated 3 times. All lots were destemmed, crushed and received one-hour skin contact time. After pressing, the juices were settled overnight at 32 degrees F and racked into glass carboys (15 L each). Each lot was inoculated with California Champagne yeast and fermented at 55 degrees F. Throughout the study, extreme care was taken to maintain a high degree of sanitation. At dryness, the wines were racked and treated with approximately 50 ppm sulfur dioxide to yield about 25 ppm free sulfur dioxide. During a 6-month period, the wines were cold stabilized, racked, bottled, and analyzed.

**Chemical Analysis:** Total acidity, pH, degrees Brix, volatile acidity (Cash Apparatus), ethanol (ebulliometer), and free and total sulfur dioxide were analyzed. Browning was determined by filtering a sample through an 0.45 u membrane filter and recording absorbance with a spectrophotometer at 420 nm wavelength. The higher the absorbance at 420 nm, the greater the degree of browning.

**Sensory Analysis:** The taste panel consisted of 11 judges, and each wine was served in a coded glass. Panelists were asked to score each wine for aroma, taste, and overall quality on a seven point hedonic scale, seven being the most acceptable.

**Results and Discussion**

Juice samples from the Seyval blanc and Vignoles were analyzed (Table 1). The grapes were harvested early to ensure disease-free fruit.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvest date</th>
<th>pH</th>
<th>Brix</th>
<th>T.A. g/100 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vignoles</td>
<td>Aug. 31</td>
<td>2.96</td>
<td>19.4</td>
<td>1.07</td>
</tr>
<tr>
<td>Seyval blanc</td>
<td>Sept. 3</td>
<td>3.14</td>
<td>20.7</td>
<td>0.83</td>
</tr>
</tbody>
</table>

While degree of browning varied among treatments, the wines were considered acceptable in color (Table 2). In cases where an especially pale wine is desired, as in a blending base for blush wine, the point of initial sulfur dioxide addition should be a consideration.
Table 2. Analyses of Vignoles and Seyval blanc wines treated with sulfur dioxide at different stages of vinification.

<table>
<thead>
<tr>
<th>Sulfur Dioxide treatment</th>
<th>pH</th>
<th>T.A. x</th>
<th>V.A. y</th>
<th>Abs. 420 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vignoles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crush</td>
<td>3.07</td>
<td>1.14</td>
<td>0.042</td>
<td>0.068</td>
</tr>
<tr>
<td>Press</td>
<td>3.12</td>
<td>1.24</td>
<td>0.050</td>
<td>0.082</td>
</tr>
<tr>
<td>Clarification</td>
<td>3.11</td>
<td>1.06</td>
<td>0.050</td>
<td>0.078</td>
</tr>
<tr>
<td>Post Fermentation</td>
<td>3.12</td>
<td>1.08</td>
<td>0.050</td>
<td>0.065</td>
</tr>
<tr>
<td><strong>Seyval blanc</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crush</td>
<td>3.26</td>
<td>0.98</td>
<td>0.037</td>
<td>0.054</td>
</tr>
<tr>
<td>Press</td>
<td>3.45</td>
<td>0.94</td>
<td>0.040</td>
<td>0.070</td>
</tr>
<tr>
<td>Clarification</td>
<td>3.40</td>
<td>1.03</td>
<td>0.044</td>
<td>0.068</td>
</tr>
<tr>
<td>Post Fermentation</td>
<td>3.25</td>
<td>0.87</td>
<td>0.112</td>
<td>0.061</td>
</tr>
</tbody>
</table>

xTitratable acidity as grams tartaric acid per 100 ml.

yVolatile acidity as grams acetic acid per 100 ml.

For both grape varieties, the browning levels were lowest for those treatments receiving sulfur dioxide at crush and after fermentation (Table 2). Wines from press and juice clarification treatments were highest in browning. For the crush treatment, a reducing environment was maintained and the phenolics were not allowed to oxidize. This treatment produced a lighter wine than those receiving sulfur dioxide at pressing and after clarification. In contrast, the post fermentation treatment allowed the juice to oxidize, which permitted the phenolics to polymerize and precipitate. This resulted in a pale and lower phenolic wine which is less prone to browning.

Wines from the press and juice clarification treatments were not different. These treatments had neither the advantage of an early reducing environment or being allowed to oxidize and precipitate browning substances.

It should be noted that the treatments receiving sulfur dioxide at crush, although showing little browning, may have a greater propensity for later browning. Research has shown that sulfur dioxide added to crush grapes may extract greater levels of monomeric flavonoids which, over time, can combine with polymeric tannins and subsequently precipitate. This can be controlled with the use of various fining agents such as PVPP, gelatin and casein.

Volatile acidity levels are a good measure of the soundness of the fermentation process. Volatile acidity develops as a natural by-product of a normal yeast fermentation, but detrimentally high levels are usually a result of bacterial spoilage, which sulfur dioxide tends to discourage.

Although sulfuring at crush produced wines with the lowest volatile acidity levels.
acidities in both varieties, the differences were not great in the Vignoles (Table 2). The low pH of 2.96 probably protected this wine from spoilage in those treatments where sulfur dioxide was withheld for a period of time. Also, careful sanitation and high quality grapes were important factors in maintaining acceptable volatile acidity levels in all Vignoles treatments.

The volatile acidity levels in the various wine treatments of the Seyval blanc were found to increase as sulfur dioxide was withheld. The delay in adding sulfur dioxide caused an increase in growth of spoilage bacteria. The volatile acidity of .112 g/100 ml in the post fermentation Seyval blanc wines was near the legal limit of .120 g/100 ml for white wines. Despite the near perfect appearance of these grapes, delaying sulfur dioxide addition until after fermentation was found to carry risks of excessive volatile acidity.

The results of the sensory evaluation indicated that the judges preferred those wine made with a sulfur dioxide addition at crush (Table 3).

Table 3. Sensory evaluation of Vignoles and Seyval blanc wines treated with sulfur dioxide at different stages of vinification.

<table>
<thead>
<tr>
<th>SO₂ Time</th>
<th>Aroma</th>
<th>Taste</th>
<th>Overall quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crush</td>
<td>4.9</td>
<td>5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>Press</td>
<td>4.4</td>
<td>4.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Clarification</td>
<td>4.4</td>
<td>4.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Post Fermentation</td>
<td>4.3</td>
<td>4.0</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Wines treated with sulfur dioxide at crush were scored highest in aroma, taste and overall quality. Vignoles wines treated at crush were significantly better in overall quality than any other treatment, while wines at post fermentation were rated lowest in both varieties. Seyval blanc wine receiving sulfur dioxide at crushing were significantly better than the juice clarification and post fermentation wines but not significantly better than the press treatment wines. A common complaint about the wines that received no sulfur dioxide prior to fermentation was lack of fruitfulness.

Although wines not receiving sulfur dioxide until after fermentation were comparable to the other treatments in color, they did poorly in sensory analysis. Volatile acidity could likely be a problem when treatment with sulfur dioxide is postponed until after fermentation, as seen in the Seyval
blanc. A dosage of only 50 ppm sulfur dioxide seems to greatly mitigate the chance of undesirably high volatile acid levels when added early in the vinification process. This study indicates that in the case of cool fermented white hybrid wine, it may be advantageous to make an initial addition of sulfur dioxide as early as possible, preferably at crush.
THE CLUSTER THINNING WINDOW--HOW BIG IS IT?

Garth A. Cahoon
Department of Horticulture
The Ohio State University/OARDC

Introduction

Cluster thinning of French hybrids is a cultural practice that has been recommended by this laboratory for many years. All of the experiments, from the initial research at the Southern Branch in 1973, to this most recent study, have indicated that additional crop control is necessary, beyond that which can be done through pruning. In addition, these experiments have clearly indicated that thinning to 1 cluster per shoot is the treatment of choice. Two clusters per shoot is generally not severe enough to produce the desired effect.

This most current study was initiated in the spring of 1987 and continued through 1988. Treatments were conducted on 420, 7- and 8-year-old Vidal grapevines and consisted of cluster thinning to 1 cluster per shoot at 3 times (pre-bloom, 1-week, and 2-weeks post-bloom) and 3 canopy densities. These canopy densities were created by thinning all vines to 16 shoots/foot of row on canes of 4, 8 and 12 nodes.

Considerable effort was made to hold the total number of fruiting shoots per vine constant during the remainder of the growing season. Also, the 4-node canes in this experiment were similar to 4-node cane treatments in a Seyval experiment reported at the short course in 1987.

Results and Discussion

Results for 1988 are presented in Table 1, and are similar to the 1987 data. Vines thinned at prebloom or 1-week post-bloom produced the same amount of fruit (25.4 lbs/vine); vines thinned 2-weeks post-bloom had a reduced yield (22.9 lbs/vine). On a per acre basis this is 6.92 and 6.24 tons, respectively. Cane length did not affect yield.

Cluster weight averaged slightly more than one-half pound for all treatments (.54 lb) and fruit maturity averaged 19.5° Brix. As thinning time after bloom increased, soluble solids increased and cluster weight decreased. Presumably this soluble solids effect was related to the decrease in yield and smaller clusters.

The quantity of sunlight inside the canopy increased as cane length decreased, but soluble solids and cluster weight were not affected. Total acid content was reduced as cane length increased, but was not affected by time of cluster thinning. Juice pH was not affected by any of the treatments. Total vine exposure to sunlight appeared to be adequate under all treatments. However, the decrease in acid content with increasing cane length indicated that clusters did receive different amounts of radiation.

Pruning weights for time of cluster thinning representing the 1987 growth
were not different. Both cane length and time of cluster thinning treatments had an effect on the foliar nutrient content. The potassium content was decreased, but calcium, magnesium and zinc were increased as cluster thinning time was delayed. Only calcium increased as cane length was increased.

Table 1. Effects of cane length and time of cluster thinning on yield and quality of Vidal grapevines. 1988, Hort Unit II.

<table>
<thead>
<tr>
<th>Cane Length</th>
<th>Cluster Cluster</th>
<th>Cluster Wt. lbs.</th>
<th>Yield lbs/vine</th>
<th>100 Berry wt. g</th>
<th>SS %</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>43.3</td>
<td>.56</td>
<td>24.3</td>
<td>163.4a</td>
<td>19.6</td>
</tr>
<tr>
<td>8</td>
<td>46.1</td>
<td>.54</td>
<td>25.8</td>
<td>158.6b</td>
<td>19.4</td>
</tr>
<tr>
<td>12</td>
<td>45.9</td>
<td>.54</td>
<td>25.6</td>
<td>157.5b</td>
<td>19.5</td>
</tr>
<tr>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>*</td>
<td>NS</td>
</tr>
</tbody>
</table>

Time of cluster thinning

| Pre-bloom | 45.8 | .55a | 25.4a | 158.8 | 19.2c |
| 1 wk Post | 44.5 | .57a | 25.4a | 158.2 | 19.5b |
| 2 wk Post | 45.0 | .51b | 22.9b | 162.5 | 19.8a |
| NS        | *    | **   | NS    | **    | **   |

Summary and Conclusions

This research conducted on Vidal over the past two years indicates rather clearly that cluster thinning can be done over at least a 3-week period; from approximately 1-week prebloom to 1-week post-bloom. Cluster thinning 1 week later than this, or 2 weeks post-bloom, stands a good chance of reducing cluster weight and yield by as much as 10%; thinning after 2 weeks post-bloom (data not shown) may reduce the crop by as much as 22%. Soluble solids and berry weight may be increased by thinning at these latter dates.

Producing the crop on canes of 4, 8 or 12 nodes in length produced less differences than expected, although the quantity of sunlight inside the canopy was increased as cane length increased. Soluble solids and total yield were not affected. As cane length increased, berry weight decreased, but cluster weight was not affected. Total acid content was reduced by cane length, but pH of the juice were not different among any of the treatments.

Both cane length and time of cluster thinning treatments had an effect on the foliar nutrient content. The potassium content was decreased, but calcium, magnesium and zinc were increased as cluster thinning time was delayed. Only calcium increased as cane length was increased.
HAVE YOU CONSIDERED AN ICE WINE?

Jack M. Lucia
The Taylor Wine Company
Hammondsport, NY

Introduction

Ice wine may be simply defined as wine made from naturally frozen grapes. German wine law mandates that the grapes be pressed while in a frozen state. The freezing process concentrates the solids in the berry which results in a very sweet and full flavored product.

Concentration of Sugars, Acids and Flavors

The concentrated solids in the grape are what makes ice wine so unique from other types of wines.

Dehydration: Berry dehydration is the first step in concentrating the grape solids. The grapes lose water as they hang past the normal harvest date due to wind action and sun exposure. Botrytis can also hasten dehydration and adds complexity to the flavor.

Freezing: Ice crystals of water begin to form as the ambient temperature in the vineyard approaches the freezing point of the berry. As the temperature decreases, the solids concentrate more and more. Below this temperature the entire berry becomes a solid frozen mass. The solids are now at maximum possible solids concentration.

Grape Variety and Vineyard Site

Selection of grape variety and vineyard site are two important factors that must be considered before harvest.

Varieties: Only varieties that will remain on the vine after normal harvest data can be considered for ice wine production. Riesling and Sylvaner are commonly used in Germany. Other varieties that have been successfully used in the Eastern United States are Catawba and Vidal.

Yield: One can expect 60% loss for Vidal and 80-90% loss for Catawba. This is due to clusters that fall off because of wind action along with bird, deer and raccoon damage. This means that 10 tons must be left in the vineyard so that 3-4 tons can be harvested.

Temperature at Harvest: The vineyard temperature must be at least 18°F or lower for about 3 successive days in order for the berries to freeze.

Transport to the Pressing Area: Measures must be taken to insure the berries remain in a frozen state during transit to the pressing area. This may require the use of insulated or refrigerated trucks if the distance from the vineyard to the press area is great.
Pressing

Low bar bladder type presses are usually not adequate for pressing the frozen berries. A press that can generate at least 6 bar is necessary.

Fermentation

The high solids content of the juice hinders fermentation. This makes the choice of yeast culture, addition of nutrients and fermentation temperature important. Ice wine fermentations are distinguished by high volatile acidity which is not necessarily a detriment to the final product. Formation of acetic acid appears to be hastened by the high sugar content of the juice.

Finished Product

Ice wines are characterized as dessert-style wines, amber in color with a honey, peach and apricot nose. The taste is a complex and full-flavored spicy character.
PRACTICAL ASPECTS OF STERILE BOTTLING

John Herbert
Wagner Estate Winery
Lodi, NY 14860

The commonly referred term of cold-sterile bottling may be misleading. What you are achieving is microbiological stability of wine by filtration. In the strictest sense, this may not remove very organism from the wine. What is important is the removal of any viable organisms (yeast, mold and certain bacteria) that may continue to grow in the wine after bottling. You must also guard against recontamination of the wine downstream of the final filter.

I feel there are three main areas to be discussed concerning microbiological stability by filtration.

The following is the procedure used by Wagner Vineyards. This procedure has proven to be very successful for us, and we are not contemplating any major changes at this time.

Removing and Maintaining a Low Population of Organisms Before Final Filtering

Preliminary DE filtration nominally rated 1-2 microns

A second pad filtration rated .8 microns

On bottling day a tight pad filtration of .45 microns immediately before passing through an absolute .45 micron membrane filter just ahead of the filler.

Tanks, pumps, hoses and filters are sanitized chemically before each wine movement except bottling day.

Preventing Contamination of Wine Downstream of Filter Prior to Bottling

Low pressure steam and hot H\textsubscript{2}O are generated to sterilize all wine contact surfaces downstream of plate and frame filter inlet. 200°F for 30 minutes.

After steaming, the system is cooled to room temperature using filtered H\textsubscript{2}O.

The integrity of the membrane filter is checked using a pressure-hold test.

Preventing Contamination of Bottles and Corks

Corker jaws are cleaned and sanitized every day of bottling.

Bottles are rinsed using hot filtered H\textsubscript{2}O just before entering bottling room.
Any surfaces on the filler that may not get up to temperature (plastic discs, rubber washers) are sanitized with ETOH.

Other Safeguards Employed to Maintain Low Organism Population in the Bottling Environment Are:

An iodophor bath is kept handy for hands, tools, etc., in case adjustments of equipment are necessary.

Filtered air passing though a UV light source is used to provide positive pressure in the bottling room.

Wall surfaces in the bottling room are sanitized periodically.

Sanitary clothing are worn by any employee who may need to enter the bottling room.
FRUIT COLOR DEVELOPMENT OF RELIANCE GRAPES
Yu Gao, David Scurlock, Joel Lehman and G.A. Cahoon
Department of Horticulture
The Ohio State University/OARDC
Wooster, OH

Introduction

Table grape industry in Ohio is becoming more and more popular. There is also a great demand of seedless grapes, especially red seedless grapes. A seedless table cultivar selection program is conducted at OARDC. ‘Reliance’, a red seedless cultivar released by Prof. James Moore from the University of Arkansas, is among those that showed very promising adaptation to Ohio conditions with superior quality. It has very high soluble solids, delicate labruscana aroma and flavor, which provides a sweet, pleasing taste (8). Its clusters are medium-large, cylindrical and well filled, but not excessively compact (8). Its vines are moderately disease resistant (8). It is exceptionally cold hardy. It has great potential to be the most predominant red seedless cultivar in the eastern United States. However, it is not a perfect cultivar. It has problems with its fruit color development, especially when vines are overloaded (i.e., more than one cluster per shoot left after pruning) and/or under poor light conditions.

Fruit color development is not a new problem. It has been studied for a long time with grapes, but not ‘Reliance’. Red color in grape fruit is mainly contributed by a group of pigments which are called anthocyanin. Red color of fruit is directly associated with anthocyanin synthesis. Studies showed that environmental factors, such as day/night temperature, solar radiation; growth regulators, such as ABA, NAA, and ethephon have a great effect on fruit color development (1,3,4,5,6,12). Low day temperature significantly increased the levels of anthocyanin pigments of cultivars ‘Cardinal’ and ‘Pinot noir’ with high and low light intensity (4). Cool day temperature (15°C) and night temperature (15°C) had a much greater effect on coloration than hot day/cool night, hot day/warm night, and cool day/warm night (6). Foliar application of ethephon improved coloration significantly (12). ABA cluster spray increased anthocyanin biosynthesis significantly (2,3).

Phenylalanine ammonia-lyse (PAL), a key enzyme in shikimic pathway, is regarded as a rate limiting enzyme for the flavonoid synthesis. Its activity has also been studied extensively (2,3,11). Flavanone synthetase, another key enzyme for anthocyanin production was shown to be more strongly correlated to its composition of anthocyanin of grape cultivars were also characterized by the uses of high performance liquid chromatography (HPLC) (9,10,13,14). However, no detail has been conducted on ‘Reliance’ grape yet.

My report is mainly a summary of the research we have done at OARDC, Wooster, Ohio in 1988. It is also an outlook of what we will do in next few years to improve color development of ‘Reliance’ grape and try to understand its physiology and biochemistry.
Materials and Methods

'Reliance' grapevines were planted in 1985, trained to Geneva Double Curtain system and single cordon system. Different chelated fertilizers of magnesium, copper, and calcium were sprayed three times during the course of the year. Ethephon (100 ppm) was also applied at veraison (color break) once as an aqueous foliar spray. Complete randomized block design was used in the study. Each treatment was applied to each individual vine. There were seven replications for each of two training systems in total. All of the clusters on the vines were visually graded with scores from 1-5 (1 represents totally green; 2 = 25% red; 3 = 50% red; 4 = 75% red; and 5 = 100% red). All the other cultural management techniques were identical to the ones in commercial vineyards.

Results and Discussion

Table 1 shows effects of chelated magnesium, copper and calcium on a growth regulator (ethephon) on color development of 'Reliance'.

Table 1. Effects of chelate sprays and ethephon on color development of 'Reliance' in 1988.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit Color Gradings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.09b</td>
</tr>
<tr>
<td>Ca-chelate</td>
<td>2.96b</td>
</tr>
<tr>
<td>Mg-chelate</td>
<td>3.99a</td>
</tr>
<tr>
<td>Cu-chelate</td>
<td>3.04b</td>
</tr>
<tr>
<td>Ethephon</td>
<td>4.06a</td>
</tr>
</tbody>
</table>

\[z\text{Means separations by Duncans multiple range test at 0.05 level.}\]

Based on the results in Table 1, Mg-chelate and ethephon increased color grading very significantly. However, Cu-chelate and Ca-chelate did not have any positive effect on the coloration of 'Reliance' grapes. There was one trial done with ethephon on 'Concord' grape. Ethephon applied on a very hot day caused severe berry drop (unpublished data). We did not see any berry drop with our ethephon treatment, even though it was 95°F when ethephon was applied. But, it is still too early to make any recommendations to growers based on the preliminary study.

My future research is going to concentrate on identification of anthocyanin in 'Reliance' grape and also key enzymes for its biosynthesis with field, greenhouse and in vitro studies. Cultural management such as vine pruning, cane girdling, ethephon, ABA, and nutrient manipulation will be examined for their effects on color development of 'Reliance' grape.
References


Our contribution to the discussion of pest problems of grapes in Ohio is restricted to two species: the grape root borer and the grape erineum mite, beginning with the latter: the grape erineum mite, which is of relatively minor importance.

For a number of years this mite has been present in ever increasing numbers on vinifera vines in the extreme northeast of the state. The erineum mite is one of the smallest animals to harm grape vines and the damage symptoms resulting from the infestation by a large number of these mites can be quite intimidating. From a distance the leaves have the appearance of being infested with grape phylloxera galls, but upon closer examination the blisters are easily distinguishable from the phylloxera galls, especially when looking at the lower leaf surfaces. The leaf has a white velvety appearance, especially in the early stages of infestation. If the mite population on the vines is particularly heavy, the infested leaves can be distorted, giving a shrunken appearance to the foliage. The internodes can also be very short.

Because of the parts of the vines where the mites are normally located: underneath the bud scales or inside the leaf blisters, chemical control is very difficult and protection lasts only for a short period. However, early applications of miticides can give very good control. The reason for this can be understood when examining the life history of the pest. Adults overwinter underneath the bud scales. Very soon after bud-break they begin to disperse and attack the developing leaves. At this stage of development of the vines spraying miticides will have the best chance of reaching all surfaces adequately to achieve near 100% kill. Once this period is missed for control measures, the foliage will develop and become so dense that adequate coverage cannot be achieved. In addition, the longer the delay the smaller the proportion of all mites present on the vine that will be out of hiding and, therefore, exposed to the pesticide.

Because only very young leaves are susceptible to mite damage (usually the youngest two leaves) the effectiveness and persistence of miticides can be checked fairly easily. Regular inspection of these new leaves for the presence of blisters will alert growers to the presence of live mites. Although spraying miticides during the growing season for erineum mite control is not very efficient, infestations can be temporarily halted.

In a field evaluation of several pesticides, no significant difference in amount of control was found between the compounds tested. Kelthane, Vendex, Sevin XLR and Thiodan all kept new leaves unharmed for a while. Two weeks after application, however, new leaves showed signs of infestation again. The actual relationship between infestation level and yield has not been established yet. It is possible that in light to moderately infested vineyards yield are not significantly affected.
The second pest to be discussed: the grape root borer, is of increasing importance.

In brief, its life cycle is as follows. Female moths lay their eggs on grape leaves or weeds underneath the vines. Soon after hatching, the young caterpillars drop to the ground and tunnel through the soil until they reach a suitable root. They enter the root and continue to feed on it for about 22 months. Mature larvae leave the root and move close to the soil surface where they pupate. Adult moths emerge from the pupal cases, mate and repeat the cycle.

At present, the grape root borer is found only in the southern half of Ohio. However, it is possible that it may be extending its range. Therefore, we plan to monitor its activity for the next few years. The insect has already been trapped in several counties in Michigan. Last season several traps were placed in Williams, Fulton and Lucas counties in NW Ohio to find out whether the insect was present in that part of the state. No male moths were caught during the three and a half months that the traps were placed (June to mid-September). Of course, this doesn’t prove they aren’t there, but at least if the insect is present, it is present in only small numbers. Similar traps placed in several vineyards in southern Ohio where the grape root borer has been found before, showed its continued presence there. This past season its first occurrence was two weeks later than in the previous two seasons, while catches were consistently lower than in the last 2 years. Because of the insect’s life cycle takes two years to complete its difficult to determine whether the reduced catches were the result of the smaller number of eggs deposited in 1986, adverse weather conditions during their development or other reasons.

At present the only registered insecticide for control of the grape root borer is Lorsban. Its application is strictly regulated in that it only may be applied once in a season and no later than 35 days before harvesting. Its application is also difficult because neither fruit nor foliage may come in contact with the insecticide. The proper application is, therefore, difficult and more time consuming than applying other pesticides. At present, we are trying to find out if adequate control can be achieved with doses smaller than recommended and possibly by split applications of small doses.

This past season, in cooperation with 3 other states, a project to investigate a new control methods was started. This method is based on the principle that male moths can be prevented from finding females. Female moths normally produce a pheromone: a substance which attracts males; i.e., makes it possible for the males to find females. This pheromone can be made in the laboratory and is in fact at the moment produced in fairly large quantities. If a sufficiently large number of dispensers containing this pheromone would be placed in a vineyard the air would contain so much attractant that any males present would have no idea where its source was. Males would be flying around aimlessly and mating taking place only as a consequence of an accidental meeting between the two sexes. Very few females would, therefore, be able to lay fertile eggs. Result: reduced infestation.
In early June of 1988 such pheromone dispensers were placed in two different vineyards in southern Ohio at the rate of 100 per acre. Nearby, but adequately separated, vineyards of equal size did not have any dispensers and, therefore, were controls. Three traps were placed in each of these vineyards to monitor catches of male moths. In addition, in mid-July traps were also placed among wild grapes near the vineyards with the pheromone dispensers. No male moths were caught in any of the traps placed inside the treated vineyards, while in the control vineyards males were caught regularly. On several occasions the traps among the wild grapes also contained moths which indicated that grape root borers were present in or near the treated vineyards. Early in September all vineyards were inspected for empty pupal cases at the base of 100 vines per vineyard. In all locations the presence of empty pupal cases proved that the vineyards were infested. It is still too early to tell whether this male confusion technique will actually be effective in controlling further grape root borer infestations. The eggs that were deposited in the vineyards this past season won't complete their development until the 1990 growing season. The number of empty pupal cases found in the vineyards at the end of that season will give us an indication.
The grape phylloxera, *Daktulosphaira vitifoliae* (Fitch), is a small, aphid-like insect which occurs as both a root and foliar form. Economic damage caused by the root form has been well documented, however, economic impact of the foliar form has not been well studied. 'Seyval' is a variety of wine grape grown throughout Ohio. It is a member of a group of grapes known as French-American hybrids; favored hosts of foliar phylloxera. Studies were conducted in 1988 to determine: 1) if infestations by foliar phylloxera reduce yield of 'Seyval' grapes, and if so, 2) if time of phylloxera attack is of consequence to yield.

Investigations were conducted in a three-year-old 'Seyval' vineyard at the Grape Research Branch of The Ohio State University at Kingsville, Ohio. Individual shoots on the grapevine were artificially infested at various growth stages with phylloxera infested leaves from greenhouse colonies. Treatments consisted of shoots infested at 1) 2- to 4-inch shoot length (24 May); 2) 8- to 10-inch shoot length (9 June); 3) bloom (20 June); 4) 7 days post-bloom (27 June); 5) 14 days post-bloom (5 July); and 6) an untreated check. Treatments were arranged in a randomized complete block with 20 replications per treatment. Each shoot was cluster-thinned prior to bloom to one cluster per shoot. Grapes from experimental shoots were harvested on 14 September. Measurements were recorded in cluster weight, number of berries per cluster, mean berry weight, percent soluble solids, total titratable acidity, and pH.

No significant differences in mean berry weight, percent soluble solids, total titratable acidity, or pH were detected among treatments. However, differences were significant among treatments for cluster weight and number of berries per cluster (Table 1).

The study demonstrates that infestation by foliar phylloxera can significantly decrease yield of 'Seyval' grape. Moreover, it suggests that infestations initiated at 7 days post-bloom and 14 days post-bloom have more of an impact on yield than infestations initiated earlier in the year. This information aids in making management decisions, especially on when to implement control measures. In turn, this reduces number of necessary pesticide applications. Reducing frequency of pesticide applications has two advantages: 1) production costs are reduced and 2) the amount of pesticides entering the environment are reduced.
Table 1. Effect of foliar grape phylloxera infestations of selected growth stages on yield of 'Seyval' grape, Kingsville, Ohio 1988.

<table>
<thead>
<tr>
<th>Growth stage at infestation</th>
<th>Mean cluster wt. (g)</th>
<th>Mean berries/cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>2- to 4-inch</td>
<td>332.23bc</td>
<td>199.02b</td>
</tr>
<tr>
<td>8- to 10-inch</td>
<td>312.50abc</td>
<td>184.70ab</td>
</tr>
<tr>
<td>bloom</td>
<td>277.16abc</td>
<td>176.60ab</td>
</tr>
<tr>
<td>7 days post-bloom</td>
<td>254.40a</td>
<td>154.95a</td>
</tr>
<tr>
<td>14 days post-bloom</td>
<td>268.65ab</td>
<td>155.05a</td>
</tr>
<tr>
<td>check (uninfested)</td>
<td>341.69c</td>
<td>201.80b</td>
</tr>
</tbody>
</table>

Means in column followed by the same letter are not significantly different (P=0.05 DMRT).
MATURITY ASSESSMENT FOR IMPROVING WINE QUALITY

James F. Gallander and Judy F. Stetson
Department of Horticulture
The Ohio State University/OARDC
Wooster, OH

The first prerequisite in making a high quality wine is the selection of the correct grape variety. Throughout the many famous wine regions of the world, a single variety is often the critical factor in producing exceptional wines. For this reason, the evaluation of grape varieties for wines has been emphasized in the enology program at OSU/OARDC. The results from these studies have indicated that several varieties are desirable for making wines in Ohio. These include: Vidal blanc, Seyval, and Chancellor.

Although wine quality is greatly influenced by the variety, considerable attention should also be given to fruit condition. It is very rare that unsound fruit yield high quality wines. This is only true for Botrytis infected grapes from a few wine areas in certain years. When the temperature and relative humidity conditions are favorable, wines from Botrytis cinerea infection grapes are extremely high quality. However, more often than not, Botrytis infection is a serious spoilage problem of grapes in most wine regions. This rot produces an enzyme called laccase which is a powerful browning enzyme. To inhibit this enzyme in wines, winemakers often use high levels of sulfur dioxide. Another enzyme that is secreted by Botrytis is a pectinase. This enzyme makes filtration very difficult by increasing the level of a polysaccharide, glucan. In addition to the problems of high sulfur dioxide and poor filterability, fruit damage by Botrytis infection causes the invasion of other spoilage organisms. In many instances, this secondary spoilage leads to off-odors and undesirable tastes in wines, especially from the growth of acetic acid bacteria. Studies concerning the effect of Botrytis rot on wine quality have shown the importance of using sound fruit for wines. Wagener (4) reported that grapes containing 10% Botrytis rot should be processed within 1 hour after harvesting. For grapes held over 1 hour, he recommended that the percentage of rot must not exceed 5% to obtain the highest wine quality. Results from Loinger et al. (1) also indicated that wine quality decreased with higher levels of Botrytis rot. At a range between 5 to 10% rot, wine quality was significantly reduced as judged by a taste panel. Other fruit spoilage organisms, such as powdery mildew, also have a significant effect on wine quality. A study by Ough and Berg (2) showed that wines made from powdery mildew grapes were lower in quality.

In addition to the degree of spoilage, fruit condition may also refer to harvesting temperature and holding time between harvest and vinification. Most winemakers agree that low fruit temperatures are necessary for making high quality wines. This is especially important for vinifying white wines which are considered more delicate in aroma and taste than red wines. For this reason, some wineries require that their grapes be harvested at night or early in the morning. In a direct study, Wagener (3) reported that harvesting temperature had a significant negative effect on wine quality for a short holding time, 1 hour. Grapes held over 1 hour at 80°F yielded wines with
lower quality. At a holding time of 18 hours, grapes at harvesting temperatures of 62°F and 80°F produced wines which were judged as poor quality.

After selecting the correct grape variety with good fruit condition, the next important factor to consider in making high quality wines is harvesting the fruit at peak maturity. In cool regions, such as Ohio, the usual criterion for picking grapes is measuring the sugar content (°Brix) of the grapes. Although the general concept that the best wines are made from the highest °Brix grapes, studies in Ohio have found that this is not necessarily true. On several occasions, when good quality wines are expected from high °Brix grapes, wine quality has only been acceptable. For our studies in Ohio, several varieties were used to determine the effect of fruit maturity (°Brix) on table wine quality. These varieties included: Catawba, Delaware, Vidal blanc, and Niagara. Grapes from each variety were harvested at three maturity levels (°Brix) from commercial vineyards in northern Ohio. After the grapes were harvested at early, mid, and late stages of maturity, they were transported to the Research Center in Wooster, Ohio for vinification. The fruit were destemmed, crushed, treated with sulfur dioxide, and pressed. From the °Brix readings, those juices below 21° Brix were ameliorated with sucrose to bring °Brix content to 21°. After amelioration, the juices were inoculated with Montrachet #522 and fermented at 18°C. When the wines reached dryness, they were racked and treated with an additional amount of sulfur dioxide. Then, during a 6-month period, the wines were cold stabilized, bottled, and analyzed for composition and quality.

The results of the sensory evaluations indicated that most varietal wines were preferred from grapes at the mid-maturity stage. Wines from Vidal blanc, Catawba, and Niagara were rated best in overall quality at °Brix readings of 19.0°, 19.9°, and 15.0°, respectively. Delaware was the only variety which produced wines of better quality at the late stage of maturity, 23.7° Brix.

In conclusion, variety selection, sound fruit, and cool fruit temperatures are significant factors in producing high quality wines. Another important factor in making the best quality wines in harvesting the fruit at the correct stage of maturity, °Brix. Only the highest quality fruit should be used in vinifying wines.

Literature Cited


SOIL MANAGEMENT: COMPACTION, FRAGIPANS AND RELATED PROBLEMS

Martin Kaps
Southwest Missouri State University
Mountain Grove, MO

A well-known grape production manual describes the ideal vineyard soil as having a minimum rooting depth of 30 to 40 inches with well drained subsoil. The site should also be on a gentle slope without frost pockets or adjacent wooded acres on the low side of the slope. In addition, locations near large bodies of water have the benefit of temperature moderation. It would be well to follow this advice when selecting a vineyard site, but often we have a more limited choice on land we presently own.

My talk to you today is on soil management and the problems that compaction and soil fragipans can cause to grapevine growth. My perspective is the Missouri Ozark Region which is located in the southern half of the state and extends into neighboring states. This area is 'blessed' with shallow topsoil underlain by impermeable fragipans and hardpans. I would like to describe these soil conditions and their effect on plant growth.

Soil Physical Characteristics

First, I would like to describe two important soil physical characteristics and they are texture and structure. Texture is simply the relative proportions of sand, silt, and clay in the soil. These soil separates, as they are called, vary greatly in size from very coarse sand (1-2 mm diameter) to clay (below 0.002 mm diameter). Certain proportions will determine what the soil class is, such as a silty clay or sandy loam. Soil classes can be identified from a textural triangle illustration knowing the percentage of each separate. The reason texture is important is because it determines important soil properties like water holding capacity, permeability, rigidity, ease of tillage, natural fertility, and productivity.

The next important soil physical characteristic is structure. This is how the soil separates are aggregated into compound particles. The importance of structure is that it modifies soil air and moisture content, nutrient availability, micro-organism action, and root growth. Two measurements can give us an idea of how much aggregation is present; they are pore space and bulk density. Pore space will depend on the degree of soil aggregation and it will determine water and oxygen supply to the plant and water percolation through the soil. Normal topsoil is about 50% pore space. A greater portion is micropore space which holds water and less is macropore space which holds air. Bulk density is the weight per unit volume of oven dry soil. This divided by particle density (weight of soil solids divided by volume of solids) times 100 equals percent pore space. Percent pore space and bulk density are inversely related. As percent pore space decreases from topsoil to subsoil horizons, the bulk density increases which is a normal progression. The reason that bulk density increases with soil depth is that a greater percentage of fine texture soil separates (silt and clay) occurs.
Subsoil Defects

When a subsoil horizon has a lot more clay than horizons above, it is called claypan. Since clay soil separates are very small, their bulk density is much higher which results in reduced pore space. Water storage and percolation, and root growth are restricted in this soils. A hardpan is a subsurface horizon that has a hardened or cemented layer of any texture. Its effects on plant growth are similar to a claypan. Fragipan is another subsoil defect where silt or very fine sand forms a very hard layer when dry, but it can rupture under pressure which causes cracks or openings in the layer. Traffic pan is man-made through compaction of the soil surface.

Soil Compaction Development and Symptoms

Soil compaction develops from the pressure of equipment on the soil surface. This pressure crushes soil aggregates. Bulk density increases and pore space is reduced. The strength of the soil increases which requires larger equipment to work, resulting in more compaction. Surface soil symptoms of compaction are reduced water infiltration, standing water and drainage problems, and more surface erosion. Internal soil symptoms are increased soil water content and reduced air content, slower exchange of $O_2$ and $CO_2$, and slower movement of water and nutrients. Plant symptoms are off-color leaves, shallow restricted roots, and wilting due to moisture stress.

Management of Soil Problems

In Missouri soil modification was used to overcome the detrimental effects of a fragipan horizon. This involved modifying the soil by digging through the fragipan layer, mixing lime and sawdust with the soil, and returning it to the trench. This treatment required the use of a backhoe to dig through the fragipan which was an expensive operation. The modified soil was compared to an unmodified soil. Grapevines were grown in these treated areas for several years to determine how well they established. Measurements of cane and root growth are shown in Tables 1 and 2. It can be seen that both cane and root weights increased in the modified soil compared to unmodified soil. When drip irrigation was used, a further increase in cane and root weights occurred. From these results, it is apparent that drip irrigation is important for good establishment of grapevines in Missouri. Soil modification improves establishment over the unmodified soil conditions. Due to the expense of soil modification, it is not recommended at this time.

Other methods to manage soil problems include deep tillage using a caterpillar drawn slip plow or chisel. This technique has been used successfully to increase rooting depth and water percolation in Western U.S. vineyards. Proper liming and fertilization increases plant growth (top and root) and makes the plant more drought resistant. Good recommendations are available through the "Ohio Agronomy Guide" and "Fertilizing Fruit Crops" bulletins. Fertilizer recommendations are most accurate when based on soil and plant tissue analysis. These are standard tools of the successful grape grower. Split applications of fertilizer can be important on shallow soils or application of fertilizer through the irrigation system. Drip irrigation can help on shallow soils where water holding capacity is less. It appears to be required
in Missouri on shallow soils, particularly for establishment. Application of water by overhead sprinkler needs to be done according to soil permeability or its ability to absorb water. Excessive water application will cause surface runoff and erosion. Erosion from excessive rainfall can be reduced by sod row middles and orienting vineyard rows along the contour of slopes. These practices will encourage more water to enter the soil.

Summary

There are ways to manage soil problems, but the most important one to start with is AVOIDANCE. If you are going to establish a planting, then use the available 'tools' to select a good site. These are USDA Soil Survey Reports and Ohio Department of Natural Resources Program Reports.

If you have soil problems in your present vineyard, determine if they are 'natural' (claypan, hardpan, fragipan) or 'man-made' (compacted traffic pan). Your Soil Conservation Service can help you determine this. Once you know the cause of your soil problems, take steps to minimize their negative effects. Management techniques for 'natural' soil defects include: ridging to increase rooting depth and improve drainage around the vine, drip irrigation to supply moisture evenly to the vine, split application of nitrogen fertilizer or application through the irrigation system to provide a more even nutrient supply, and use of sod row middles to reduce soil erosion. Deep tillage between vineyard rows may have application where severe problems exist. Consult Soil Conservation Service and State Horticultural personnel before attempting this, since deep tillage can also reduce rooting and vine growth. Management techniques for 'man-made' soil defects include: those mentioned previously plus avoidance of unnecessary heavy equipment travel through the vineyard, particularly when soil is water saturated.

Table 1. Effect of soil profile modification and drip irrigation on root dry weight (g) of 'Vidal blanc' and 'Chancellor' grapevines growing in Missouri in 1985.

<table>
<thead>
<tr>
<th>Cultivar and Treatment</th>
<th>Root weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Vidal blanc'</td>
<td></td>
</tr>
<tr>
<td>CN - control soil, no irrigation</td>
<td>259</td>
</tr>
<tr>
<td>MN - modified soil, no irrigation</td>
<td>372</td>
</tr>
<tr>
<td>CI - control soil, irrigated</td>
<td>597</td>
</tr>
<tr>
<td>MI - modified soil, irrigated</td>
<td>821</td>
</tr>
<tr>
<td>'Chancellor'</td>
<td></td>
</tr>
<tr>
<td>CN - control soil, no irrigation</td>
<td>178</td>
</tr>
<tr>
<td>MN - modified soil, no irrigation</td>
<td>446</td>
</tr>
<tr>
<td>CI - control soil, irrigated</td>
<td>507</td>
</tr>
<tr>
<td>MI - modified soil, irrigated</td>
<td>515</td>
</tr>
</tbody>
</table>

*Weights were taken on one vine per treatment*
Table 2. Effect of soil profile modification and drip irrigation on pruning weight (g) on 'Vidal blanc' and 'Chancellor' grapevines growing in Missouri in 1985.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pruning weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Plot</strong></td>
<td></td>
</tr>
<tr>
<td>CN - control soil, no irrigation</td>
<td>218c²</td>
</tr>
<tr>
<td>MN - modified soil, no irrigation</td>
<td>508b</td>
</tr>
<tr>
<td>CI - control soil, irrigated</td>
<td>613ab</td>
</tr>
<tr>
<td>MI - modified soil, irrigated</td>
<td>731a</td>
</tr>
<tr>
<td><strong>Sub-plot</strong></td>
<td></td>
</tr>
<tr>
<td>'Vidal blanc'</td>
<td>513a</td>
</tr>
<tr>
<td>'Chancellor'</td>
<td>522a</td>
</tr>
</tbody>
</table>

²Mean separation within columns by LSD, 5% level.
THE USE OF ASCORBIC ACID (VITAMIN C) AS AN ANTIOXIDANT IN OHIO WINES

Mike K. Horvath and James F. Gallander
Department of Horticulture
The Ohio State University/OARDC
Wooster, OH

Introduction

Sulfur dioxide has been used in winemaking for over 1200 years, and has much to offer to both the home and commercial winemaker. It serves as an antioxidant and antimicrobial agent. However, due to possible health implications, the B.A.T.F. has recommended that the levels of sulfur dioxide be lowered in wine, pending anticipated regulatory changes. Therefore, it has become imperative for the wine industry to look for new ways of reducing the amounts of sulfur dioxide needed in winemaking.

Ascorbic acid, better known as Vitamin C, has been used in the food industry for centuries. In today's food and beverage industries, it serves as an antioxidant, a nutrient, a clarifying agent, and a color stabilizer (1,4). It occurs naturally in grapes in low concentrations, but is mostly destroyed during fermentation. It has been used in wine in the past, but with mixed reviews. Previous research has indicated that ascorbic acid can significantly improve the aroma, color, and clarity of wine (1,2), but if added at the wrong time, in the wrong concentrations, or without sufficient sulfur dioxide present, it can have a detrimental effect (1,2,3,4).

Several experiments were conducted at OARDC/OSU in Wooster, Ohio, to determine what benefits, if any, ascorbic acid can offer the winemaker, in an attempt to reduce the amounts of sulfur dioxide required in winemaking.

Procedure

In 1987, a study was designed to determine what effects different combinations of ascorbic acid and sulfur dioxide would have on the quality of white wine, in an attempt to lower the amount of sulfur dioxide required. The Vidal blanc grapes were harvested clean and rot-free, with a pH of 3.22, T.A. of 0.90%, and 21.6°Brix. Immediately after pressing, the juice received the following treatments: 0, 200, 400, and 800 ppm ascorbic acid in conjunction with 0, 40 and 80 ppm sulfur dioxide. The juice was inoculated with California Champagne yeast and fermented to dryness. The wines were racked, adjusted to 25 ppm free SO₂, and cold-stabilized at 35°F. After cold-stabilization, the wines were analyzed from pH, free and total SO₂, total acidity, acetaldehyde, ascorbic acid, volatile acidity, browning, and were judged for sensory qualities by a panel of nine experienced winemakers and tasters.

Results

Results of the analyses revealed that there were no significant statistical differences in pH (3.01-3.06), free and total SO₂ (FSO₂ adjusted to 25 ppm, TSO₂ ranged from 30-80 ppm), or acetaldehyde levels (15.5-40.3). All
acetaldehyde levels were in the acceptable range. Ascorbic acid levels after fermentation ranged from 1.0 to 73.9 ppm, a 90% decrease from original additions. Volatile acidity decreased significantly with each increase of sulfur dioxide, at all levels of ascorbic acid. Ascorbic acid decreased the amount of browning in the wines with no added sulfur dioxide, but only at the 200 ppm level. Additions greater than 200 ppm increased browning. At higher levels of sulfur dioxide, all additions of ascorbic acid led to an increase in browning. Other results of the chemical analysis are listed in Table 1.

Table 1. Chemical analysis of 1987 Vidal blanc wines.

<table>
<thead>
<tr>
<th>Treatment #</th>
<th>Ascorbic acid ppm</th>
<th>SO₂ added ppm</th>
<th>VA %</th>
<th>TA %</th>
<th>Browning abs @ 420 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.085</td>
<td>0.86</td>
<td>0.111</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>0</td>
<td>0.057</td>
<td>0.82</td>
<td>0.091</td>
</tr>
<tr>
<td>3</td>
<td>400</td>
<td>0</td>
<td>0.068</td>
<td>0.95</td>
<td>0.111</td>
</tr>
<tr>
<td>4</td>
<td>800</td>
<td>0</td>
<td>0.068</td>
<td>0.90</td>
<td>0.119</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>40</td>
<td>0.057</td>
<td>0.82</td>
<td>0.091</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>40</td>
<td>0.045</td>
<td>0.87</td>
<td>0.089</td>
</tr>
<tr>
<td>7</td>
<td>400</td>
<td>40</td>
<td>0.057</td>
<td>0.93</td>
<td>0.094</td>
</tr>
<tr>
<td>8</td>
<td>800</td>
<td>40</td>
<td>0.046</td>
<td>0.96</td>
<td>0.092</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>80</td>
<td>0.034</td>
<td>0.86</td>
<td>0.069</td>
</tr>
<tr>
<td>10</td>
<td>200</td>
<td>80</td>
<td>0.040</td>
<td>0.89</td>
<td>0.077</td>
</tr>
<tr>
<td>11</td>
<td>400</td>
<td>80</td>
<td>0.051</td>
<td>0.91</td>
<td>0.078</td>
</tr>
<tr>
<td>12</td>
<td>800</td>
<td>80</td>
<td>0.043</td>
<td>0.94</td>
<td>0.080</td>
</tr>
</tbody>
</table>

The sensory qualities were evaluated by a panel of nine judges, and asked to rate aroma, taste, and overall wine quality. In each category, they were asked to rate the wine from 1 to 7, 1 being extremely poor and 7 being extremely good. The results of the sensory analysis are shown in Figure 1.
Fig. 1. Effect of ascorbic acid on sensory analysis of 1987 Vidal blanc wines.
Conclusions

Based on the results of the 1987 Vidal blanc study, along with several studies conducted in 1988 (not reported here), it appears that ascorbic acid may not be the solution in reducing or eliminating sulfur dioxide from the winemaking process. Its effectiveness as an antioxidant in wine is dependent on several variables, but primarily on the amount of sulfur dioxide present. In Ohio white wine, it has shown some benefits in preventing oxidation at certain levels, but at higher levels can increase browning, due in part to auto-oxidation. These factors would make its use in commercial wineries difficult. Based on these studies, ascorbic acid cannot be recommended for use as an antioxidant in wine.

Literature Cited


RAPID MICROBIOLOGICAL METHODS FOR A SMALL WINERY

Jack M. Lucia
The Taylor Wine Company
Hammondsport, NY

Introduction

Rapid methods are microbiological techniques where the test time spans a few minutes to hours in order to estimate the number of viable organisms in a sample. Rapid methods can be divided into two groups as either direct or indirect methods.

Direct methods detect individual cells or microcolonies.

Indirect methods measure some aspect of cell growth.

Desired Features of a Rapid Method for a Winery

Operation Needs

a) Low operating costs
b) Simple to perform
c) Readily available stable reagents and supplies
d) Capable of simultaneous measurements

Microbiological Needs

a) Data can be equated to traditional plating methods
b) Capable of detecting low numbers of organisms
c) Can differentiate between live and dead cells
d) Non-destructive testing

Direct Methods

Direct Microscopic Methods:

Wolford-McDonald stain for detecting large numbers of yeast. This method calls for the 1:1 mixing of a wine sample with the Wolford-McDonald stain. The mixed sample is transferred to a Petroff-Hauser counting chamber and looked at under medium magnification. Live yeast cells remain clear and dead or damaged cells take up the stain. The main limitation is that it requires at least a cell population of 100,000 cells per ml or more. This technique is useful for counting yeast cells that have been added to sparkling wine cuvee or yeast that have been added to grape must.

Fluorescent stains are used for detecting low numbers of yeast. These techniques are extremely sensitive and rapid.

Fluorescein diacetate Stain: The yeast are trapped on the surface of a membrane filter and then stained with fluorescein diacetate. Viable cells fluoresce when examined under a UV light due to the presence of intracellular
fluorescein. Non-viable cells can be counter stained with rhodamine B.

**Acridine Orange Stain:** Viable and non-viable cells are stained with acridine orange and can be counted directly using an epifluorescence microscope. Total test time is about 25 minutes. This technique has been automated using TV-imaging analysis.

**Microcolony Method:**

Instead of incubating a membrane filter for 3-5 days as specified in the membrane filter technique, the membrane is incubated for about 24 hours. The microcolonies are stained and viewed either under a light microscope or an incident-light fluorescence microscope.

**Indirect Methods**

These methods rely on the detection of metabolic activity, metabolites or cell constituents. Such methods require a certain cell population to trigger detection.

**Radiometric methods:**

C¹⁴ labelled CO₂ is generated from C¹⁴ labelled glucose which is detected and quantified by scintillation counting. This method is sensitive down to 10-100 yeast per ml in about 15 hours.

**ATP method:**

A bioluminescence assay using a luciferin-luciferase enzyme system from fireflies measures the amount of ATP present by generating light. This assay is highly specific and sensitive and can detect extremely low levels of microorganisms. Detection of 1 to 100 cells per ml is possible in 15 minutes.

**Electronic methods:**

Metabolic end products that result from microbial growth accumulate in the medium and alter the electrical impedance and increase the conductance or capacitance of the growth medium. Detection times are possible in 12-20 hours. Electronic methods are well suited to automation and computer adaptation.

**Operation Considerations**

Direct methods are fast, sensitive and moderately specific. ATP analysis is fast and sensitive, but only moderately specific. Electronic methods are not as fast as direct or ATP methods, are not very sensitive but are adaptable to automation. Direct methods can detect 1 organism in about 30 minutes, ATP assay can detect about 100 cells in 8 hours and electronic methods can detect about 1 million cells in 24 hours.
Traditional Methods

More time is necessary to obtain results using traditional methods, but the results are often more reliable than other methods.

Membrane Filter Technique: This procedure calls for passing a known volume of wine through a membrane filter whose pore size is smaller than the bacteria or yeast cell. The membrane is then rinsed with sterile water and transferred to a Petri dish containing nutrient medium. The dish is incubated for 2-3 days to allow colonies to form. This is a very reliable method and is the standard method used in testing potable water, refreshment beverages and waste water. The detection level of this method can be easily increased by passing a larger volume of water through the filter. There are many versions of this method available in kit form that should make this method attractive to the small winery.

Swab Kits: These are self-contained kits that can be used to swab surfaces for yeast or bacteria that may be on areas such as fill spouts, hoses, corks, etc. Swab kits are a convenient way to determine the presence of yeast or bacteria.
Most of us are familiar with the typical cane and leaf spot symptoms associated with Phomopsis cane and leaf spot. Although at times these symptoms are alarming, lesions on the rachis and the fruit rot phase of this disease are of much more economic concern to New York growers. Rachis infection, resulting in rachis breakage, and fruit rot at harvest caused up to 40% crop loss in some western New York Concord vineyards in 1986. Due to grower concern regarding this disease, the New York Wine and Grape Foundation funded a research project for two years. The following report is based on the research conducted by Dr. Jay Pscheidt while he was a post-doc on this project at Geneva in 1986 and 1987.

During the past five or six years we have noticed an increase in Phomopsis cane and leaf spot in Concord vineyards in western New York. Much of the increase seemed to be associated with hedged vineyards and one of Dr. Pscheidt’s assignments was to document whether or not this was a valid observation. Furthermore, if this was the situation, he was to determine why hedged vineyards had more disease. Dr. Pscheidt was also interested in determining when fruit infection took place and how it could be controlled.

Disease Incidence in Hedged Vineyards

Vineyard surveys conducted in 1986 and 1987 showed a significantly higher incidence of disease in top-wire cordon, hedged vineyards than in Umbrella Kniffin (UK)-trained, hand-pruned vineyards. Furthermore, when hedged vines were retrained to UK and pruned by hand, the incidence of disease was reduced significantly in the first year.

Once we had determined that hedged vineyards had significantly more disease, studies were conducted to determine the reason. Dr. Pscheidt measured various environmental parameters in the canopy of UK trained vines and in hedged vines. He found no significant difference in temperature, duration of leaf wetness, or relative humidity within the two canopies measured continuously between bud break and bloom. Since this is the time of most Phomopsis activity, environmental conditions could not account for the differences in disease development between the two canopies.

Inoculum production within the two canopies was studied to determine its influence. Canes were collected from various vineyards prior to bud break. Each node was cut to a length of about 1 inch and then cut in half lengthwise. The half with the bud was retained, soaked in water for a short time, placed on wet paper towel, and incubated in a plastic crisper at room temperature for 1 week. The samples were allowed to dry and the number of pycnidia of Phomopsis viticola were counted on each half-node. There was no significant difference between the number of pycnidia per half-node segment collected from UK vineyards and hedged vineyards.
However, although the number of pycnidia per node was the same, the number of retained nodes in hedged vineyards was much greater than that in UK vineyards, hence the total amount of inoculum was greater in hedged vineyards. In an effort to simulate increased numbers of retained nodes found in hedged vineyards, bundles of one-year-old canes were tied above the trellis of UK-trained vines prior to bud break in 1987. As bundle weights increased (and therefore node number) in half pound increments from 0.5-2.0 lbs, the amount of disease on leaves, internodes, and summer laterals increased (Fig. 1). The amount of Phomopsis fruit rot on vines under 2 lb bundles (ca 250 extra nodes) was 5% versus 0.5% (p=0.05) on the check vines. Surprisingly, there was also a significant increase in the amount of black rot under the 2 lb bundles.

During the 1988 season the bundle experiment was repeated. The 1987 prunings were saved and placed over UK vines as one treatment and 1988 prunings were placed over other vines as an additional treatment. The bundles were suspended above the vines prior to bud break on April 4, 1988. In spite of the dry growing season, several days of wet weather in mid-May provided conditions for infection. The check vines had only 6% internode infection and 3.5% rachis surface area infection, whereas the vines under the 1987 bundles and the 1988 bundles had 25.5% and 19% internode infection, and 21.8% and 15.4% rachis surface area infection, respectively. Not only did the bundles from 1987 continued to provide inoculum. Apparently, the amount of inoculum in hedged vines can be additive from year to year.

Previous studies by Dr. Pscheidt had indicated that only one-year-old wood provided inoculum. He was not able to find sporulating pycnidia in live wood older than 1 year of age. Perhaps pycnidia do not survive in the exfoliating bark of older wood. In contrast, one-year-old infected wood that dies in the first year retains its pycnidia-laden bark and apparently continues to provide inoculum in subsequent years.

Prior to bud break in 1987, plastic tents were erected over a row of hedged Concord vines and a row of UK-trained vines at Cornell's Vineyard Laboratory at Fredonia, NY. The plastic tents were designed to keep the vines dry and hence prevent natural infection by the causal fungus. Within these tents, Dr. Pscheidt inoculated shoots and clusters at different stages of development with a spore suspension of Phomopsis viticola. Although Dr. Pscheidt found no difference in susceptibility of leaves, clusters or internodes of hedged versus UK-trained vines, the UK-trained vines developed larger lesions on the internodes. Apparently, the shoots on UK-trained vines, which have fewer and hence more vigorous shoots than hedged vines, grew larger in girth than the hedged vines, thereby exhibiting larger lesions.

**Phomopsis Fruit Rot**

To determine the time of infection for the fruit rot phase of this disease, Dr. Pscheidt inoculated shoots and clusters of Concord vines at various stages of development under the tents at Fredonia during 1987. At harvest, the amount of fruit rot was evaluated. The noninoculated check vines had 0.4% fruit rot (Table 1). Vines inoculated at 5 inches of shoot growth and vines inoculated at veraison (9% sugar) had 0.5% and 1.0% fruit rot,
respectively. However, vines inoculated at 90% bloom had 30.1% fruit rot at harvest.

Similar inoculation studies were repeated at Geneva on Concord vines not protected by tents. Noninoculated check vines, vines inoculated at veraison (9% sugar), and vines inoculated at 13% sugar had 3.3%, 4.1% and 2.5% fruit rot, respectively, at harvest. Vines inoculated at 90% bloom and those with green, pea-sized fruit at inoculation had 16.3% and 14.0% fruit rot, respectively, at harvest. These results were similar to those obtained under the tents at Fredonia.

A study of fruit susceptibility was conducted by inoculating detached Concord berries of differing ages. Berries were placed in contact with a spore suspension of Phomopsis viticola for 24 hours in the laboratory. Berries became less susceptible to infection and colonization as they progressed from green pea-size to ripe stages of growth. In general, infection and symptom development occurred faster on berries incubated with the pedicel (cap stem) in contact with inoculum than on those with the stylar end in contact with inoculum. All of the green (4% sugar) and veraison (9% sugar) berries inoculated through the pedicel developed symptoms 50-55 days after inoculation, while only 10% of the ripe (13% sugar) berries rotted. Only 60% of the green and veraison berries inoculated through the stylar end developed symptoms 50-55 days after inoculation, while none of the ripe berries rotted in this time period. Wounding of the fruit was not a prerequisite for infection.

Under field conditions, infection of berries occurs during and shortly after bloom. The fungus remains inactive or latent until the fruit ripens at which time the fungus resumes activity and rots the berry. These latent infections of fruit and rachises can be detected using a paraquat dip technique. In future this technique may be useful to estimate potential crop loss and to help growers decide if the crop should be harvested early to avoid losses due to fruit rot.

It is interesting to note that historically, Phomopsis fruit rot has been associated with unseasonable amounts of rainfall at bloom. Severe losses due to Phomopsis fruit rot occurred during 1972, 1984, and 1986 when over 5 inches of rain fell in the 2-week period starting 1 week before 90% bloom through 1 week after 90% bloom. The results of Dr. Pscheidt’s studies to explain this observation.

Fungicide Trials

Fungicide trials conducted on Delaware vines in 1987 showed that two applications of mancozeb (Dithane M45 at 4 lb/acre), applied 1 week prior to bloom and again at 90% bloom, significantly reduced fruit rot and rachis lesions at harvest. In previous studies,captan applied weekly beginning 4 weeks prior to harvest did not control Phomopsis fruit rot.

We understand the importance of fungicide protection during early spring and throughout the bloom period to control all phases of this disease, but is there an interaction between training system and fungicide applications? A
fungicide trial was conducted in a Concord vineyard at Fredonia during 1988 to study this interaction. The vineyard was trained to the UK system for approximately 25 years. In 1985, 2/3 of the vineyard was converted to a top-wire cordon system. Since then, half of the cordon trained vines have been pruned and the other half have been hedged with no hand followup. The fungicide trial was superimposed over the three training/pruning systems. Half of all the vines were sprayed with an intensive program of Dithane M45 at 4 lb/acre, whereas, the other half was sprayed only with Karathane to control powdery mildew. Dithane M45 was applied at 1 inch and 5 inches of shoot growth, 1 week prior to bloom, at 90% bloom, and 2 weeks after bloom.

Sprayed, hedged vines developed about the same amount of disease (both internode infection and rachis surface area infection) as nonsprayed UK-trained vines (Table 2). Furthermore, sprayed UK-trained vines had significantly less rachis infection than did sprayed hedged vines. It appears that growers who elect to hedge their vineyards to reduce the costs of hand pruning should reinvest some of those savings into a more intensified spray program.

In summary, Phomopsis cane and leaf spot can cause significant economic losses to commercial Concord production; hedged vineyards have a high risk of disease development due to an increased inoculum potential; and fruit infection occurs during and shortly after bloom. All phases of this disease can be controlled through an intense sanitation program (removal of dead wood from the trellis) and maintenance of fungicide protection from the time clusters are first visible through the period of fruit shatter.
Figure 1. Relationship between amount of retained nodes (weight of case bundles) and incidence of Phomopsis cane and leaf spot.
Table 1. Development of fruit rot and rachis lesions following inoculation of Concord clusters at different stages of growth in 1987 using spores of Phomopsis viticola.

<table>
<thead>
<tr>
<th>Growth Stage</th>
<th>Berries with Phomopsis Fruit Rot (%)&lt;sup&gt;w&lt;/sup&gt;</th>
<th>Clusters with Rachis Infection (%)&lt;sup&gt;x&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fredonia&lt;sup&gt;y&lt;/sup&gt;</td>
<td>Geneva</td>
</tr>
<tr>
<td>Noninoculated control</td>
<td>0.4b</td>
<td>3.3c</td>
</tr>
<tr>
<td>5 inches shoot growth</td>
<td>0.5b</td>
<td>--</td>
</tr>
<tr>
<td>90% bloom</td>
<td>30.1a</td>
<td>16.3a</td>
</tr>
<tr>
<td>Pea-sized</td>
<td>--</td>
<td>14.0b</td>
</tr>
<tr>
<td>Veraison (9% sugar)</td>
<td>1.0b</td>
<td>4.1c</td>
</tr>
<tr>
<td>Ripe (13% sugar)</td>
<td>--</td>
<td>2.5c</td>
</tr>
</tbody>
</table>

<sup>w</sup>Treatment means followed by the same letter(s) are not significantly different using Fisher's protected LSD procedure at the 5% level.

<sup>x</sup>True population means, no statistical analysis necessary.

<sup>y</sup>A 6 x 30.5 m sheet of heavy duty (6 mil), clear polyethylene film was placed over PVC pipe arches to cover vines from bud break to harvest.

<sup>z</sup>Not inoculated.

Table 2. Effect of training/pruning system on Phomopsis cane and leaf spot of Concord at Fredonia, NY, during 1988.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Spray Treatment</th>
<th>% nodes infected</th>
<th>% rachises infected</th>
<th>% rachis area infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umbrella Kniffin</td>
<td>Sprayed</td>
<td>2.6a&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3.0a</td>
<td>0.8a</td>
</tr>
<tr>
<td>Top Wire Cordon</td>
<td>Sprayed</td>
<td>2.6a</td>
<td>5.5ab</td>
<td>1.6ab</td>
</tr>
<tr>
<td>Hedged</td>
<td>Sprayed</td>
<td>4.3ab</td>
<td>15.5b</td>
<td>4.4bc</td>
</tr>
<tr>
<td>Umbrella Kniffin</td>
<td>Nonsprayed</td>
<td>8.8bc</td>
<td>16.0b</td>
<td>4.6bc</td>
</tr>
<tr>
<td>Top Wire Cordon</td>
<td>Nonsprayed</td>
<td>12.3cd</td>
<td>28.0c</td>
<td>7.0c</td>
</tr>
<tr>
<td>Hedged</td>
<td>Nonsprayed</td>
<td>16.2d</td>
<td>43.5d</td>
<td>13.9d</td>
</tr>
</tbody>
</table>

<sup>2</sup>Treatment means followed by the same letters are not significantly different at the 5% level.
Much detailed attention has been given at this and other short courses concerning all the enological manipulations necessary to produce a sound, quality wine. Likewise, most of the viticultural aspects for good grape production have been presented and discussed. One important topic that has received periodic attention is vineyard nutrition. It is well known, for example, that deficiencies of nitrogen and potassium, as well as other nutrients can result in significant decreases in fruit yield and quality. Through the process of plant (petiole) analysis, ways have been developed for identifying and correcting these nutritional imbalances before they can cause serious effects. This program has been available as a service to Ohio growers since 1964. However, judging by the number of Ohio grape producers and winemakers that take advantage of these facilities, as a means of improving grape production and quality, much of this information has not been translated into grower practices. Therefore, the goal of this discussion is to re-examine the role of petiole analysis as a means of improving and maintaining vineyard nutrition.

From the inception of the Ohio Plant Analysis Laboratory 25 years ago, it was envisioned that through an annual program, growers would utilize the information to eliminate or at least greatly reduce nutritional stresses in their vineyards. The sequence of events to take maximum advantage of such a program requires teamwork between the laboratory and the grower require at least the following 3 steps:

1. Initially a grower would make a normal application of fertilizer to his vineyard in early spring.

2. By mid-summer he would monitor vineyard conditions through petiole analysis. Kits are available at all county cooperative extension offices.

3. Armed with this information and other facts available to him, he would plan adjustments in his program for the following season.

Steps 1 through 3 would be repeated on an annual basis. By such a procedure the grower would have the opportunity to review information from all previous years, build on the results, and make each year an opportunity to continually refine his nutritional program.

To enable growers to put such practices into effect the following form has been designed. Please feel free to use it, copy it, or develop your own. Additional copies can also be obtained from this laboratory upon request.
VINEYARD NUTRITION PROGRAM - GROWER EVALUATION FORM

Year _______ Field # _____ Cultivar (Variety) ________________________________

Date Petioles were taken ___/___/______ Acres in Vineyard ____________

Condition of Wood at Pruning Time _______________________________________

Condition of Foliage and Clusters at Bloom ________________________________

Weather Conditions at Bloom _____________________________________________

Date of Bloom ___/___/______ Earlier _____ or later _____ than Normal?

Fertilizer Applied (Date) __________________ Kind(s) ______________________

Condition of Foliage at Sampling Time: Vigor: High ____ Med ____ Low ____

Foliage Color: Good ____ Fair ____ Poor ____

Yield/Acre ________________ Fruit Maturity: °Brix ____ Acid ____ pH ____

Results (Current Year): % Range (D-L-S-H-E)*

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>%</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

----- PPM -----

Mn _________ Fe _________ B _________ Cu _________ Zn _________

Results (Previous Year) % Range (D-L-S-H-E)*

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>%</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

----- PPM -----

Mn _________ Fe _________ B _________ Cu _________ Zn _________

*FOR FOLIAR ANALYSIS STANDARDS SEE ATTACHED SHEET

Check nutrients with greatest deviations from desired range:

N _______; P _______; K _______; Ca _______; Mg _______; Mn _______; Fe _______; B _______; Cu _______; Zn _______

Comments ________________________________________________________________

__________________________________________

53
What conditions, especially those previously listed, could have been related to these deviations?

General Considerations for Next Year’s Fertilizer Program:

A. Nitrogen (fertilizer or nutrient) needs to be applied: 1) Every year ___; 2) Every other year ____; 3) Only when indicated by petiole analysis (or soil test) ___; 4) At a higher ___ lower ___ rate.

B. Phosphorus (fertilizer or nutrient) needs to be applied: 1) every year ___; 2) Every other year ____; 3) Only when indicated by petiole analysis (or soil test) ___; 4) At a higher ___ lower ___ rate.

C. Potassium (fertilizer or nutrient) needs to be applied: 1) Every year ___; 2) Every other year ____; 3) Only when indicated by petiole analysis (or soil test) ___; 4) At a higher ___ lower ___ rate.

Specific Decisions for Next Year’s Fertilizer Program:

The following kind(s) and amount(s) of fertilizer(s) should be applied next year:

- Nitrogen (kind) __________ (Amount) _______ 1bs/Acre
- Phosphorus (kind) __________ (Amount) _______ 1bs/Acre
- Potassium (kind) __________ (Amount) _______ 1bs/Acre
- Other (kind) __________ (Amount) _______ 1bs/Acre
Basic Considerations for Long Range Fertilizer Planning:

1. How do the results from these petiole analyses and my proposed fertilizer decisions relate to previous fertilizer practices?

2. Have I taken annual petiole analysis samples enough years to determine any nutritional trends in my vineyard?

3. Do I see year-to-year changes in nutrient levels based upon the fertilizers I have applied?

4. Has this program improved the levels of various nutrients associated with good yield and quality; i.e., is the nutritional balance among the nutrients in my petiole samples improving?

5. How have I observed crop load (size), weather conditions, or cultural practices to affect my fertility levels and in turn my yield and/or quality?

6. Is my current fertilizer program having the positive effect on my vineyard that I desire?

7. What appears to be the greatest problem in my vineyard that might be related to fertilizers or nutrition? Is it yield, vine vigor, quality, late maturity, poor maturity, fruit color, other?

8. What cultural practices, not fertilizer related, appear to have the biggest effect on my vineyard nutrition?

9. Other?
This page intentionally blank.
This page intentionally blank.
This page intentionally blank.