OSU Wine and Grape Research and Extension Newsletter

April 2009 http://wine.oregonstate.edu

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Oregon needs to be aware and proactive with grapevine leafroll virus

Patty Skinkis, PhD, Viticulture Extension Specialist

During fall 2008, OSU Extension drew the industry's attention to the possibility of movement of mealybugs, an important vector of the grapevine leafroll virus, into and around Oregon. There was heightened concern following those notices, effectively increasing industry awareness of the pest-virus complex. However, there is still need for the industry to understand the pest and virus more clearly to be able to prevent infection or spread. These pests and viruses exist in many grape production areas of the world including, the US, Pacific Northwest and Oregon. Our goal is to help you as a grower, winemaker or vineyard/winery business owner become aware of the potential hazards and to identify or prevent a problem from occurring.

Last month, an OSU Viticulture Extension workshop was held in Corvallis to educate and inform the Oregon industry about the devastation that can result from grapevine leafroll virus (GLRaV) and the insects that transmit the virus from infected plants to uninfected plants. Guest speakers from California explained the factors that lead to rampant spread of the virus. They also discussed the spread of insects that transmit the virus from an infected vine to an uninfected vine. Although the leafroll virus likely has been in California for some time, it wasn't until recently that the spread has been of major concern. In the past seven years, leafroll has become a major concern and mealybugs may be the main culprit. For California, it was only a matter of years before the pest complex became widespread, devastating vineyards across the state growing regions. In a Napa area study, a vineyard experienced spread at a rate of 10 percent per year (Golino et al. 2008). This virus and insect pest complex is also causing problems in other regions. Washington verified the first leafroll vineyards around 2005 in Concord and Niagara vineyards (Soule et al. 2006), and mealybugs have been found. Idaho also has both the virus and mealybug vectors in vineyards (Bob Martin, personal communication). Oregon is not immune to the virus or insect. It is estimated that more than 7% of vineyards across the state already have some form on the virus based on surveys conducted in 2000 (Martin et al. 2005). The Willamette Valley has predominantly GLRaV-2 while southern and eastern Oregon regions have mainly GLRaV-3. These are likely a result of infected plant material being propagated and used as nursery stock or field grafting. Few vineyards have observed mealybugs; however, areas of southern and eastern Oregon have verified populations. Vineyards with both insect vectors and the virus are in trouble—the virus will spread and may result in spread to neighbors or other regions through movement of harvested fruit that harbors the insect. Many vineyards in Oregon do not know the status of their vines or insect population which warrants scouting by vineyard crews.

Understanding Viruses

The best guarantee any grower has against vine viruses is to purchase certified clean stock. However, certified plant materials may not in fact be free of all strains of leafroll virus, depending on when the plants in question were purchased. However, the methods for identifying viruses have become more precise. There are currently ten different strains of the leafroll virus, and not all of which are equal in their impacts on the vine. Like any other biological system, viruses experience change and modification through mutation over time. Different strains of the virus may play an important factor in the increased spread experienced in California.

Can a little virus can be good for wine quality? It has been said that a little virus can be good for wine quality. This statement is incorrect and does not take into consideration the problems vineyards face today! There are over 50 viruses that can plague grapevines and combinations of different viruses can cause significant problems in the vineyard including decreased ripening, declining vine health, reduced yields and death. These factors combined reduce vineyard productivity, longevity and fruit and wine quality, significantly reducing your bottom line.

Signs and Symptoms of Virus. The best line of defense for any vineyard is to plant to certified virus-free plant materials to avoid problems with virus infestation. If you have an

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already producing vineyard, make sure you and your vineyard crew is aware of the signs and symptoms to document any problems.

The virus's most distinct symptom is reddening of leaves (in red varieties) with veins remaining green and edges of the leaves roll downward (Figure 1). Leaves roll downward in white cultivars, but leaves do not turn red; they may become chlorotic (yellow). In some cases, there is great variability in the discoloration of leaves and it is not easily distinguished from nutrient deficiency, water stress or mechanical/mammalian damage. Other symptoms include decreased vine vigor, declining yields and unripe fruit. Fruit has low soluble solids, low pH and high titratable acidity. Recently, a study conducted with Pinot noir indicates reduced anthocyanins, total phenolics and tannins (Lee and Martin 2009).

Figure 1. A leaf from a GLRaV-3 virus infected vine.

If you have symptomatic vines, samples can be submitted to a plant virus testing lab to verify. Contact the testing lab for the appropriate sample tissue and timing for sample collection for specific viruses. Samples for GLRaV should consist of leaf samples (leaf blade and petiole) collected in late summer or early fall.

Understanding the Insect Vectors and Spread

There are multiple insects that can transmit leafroll viruses, and the insect vector depends on what strains of GLRaV it is. Most of the ten species are transmitted by mealybugs and scale insects. GLRaV-2, however, is in a family that generally is spread by aphids, yet there has been no aphid transfer to vines observed. Recent observations of GLRaV spread throughout California vineyards suggest that other insects may be vectoring the virus or root grafting is allowing spread of the virus. Kent Daane, entomologist at UC Berkeley is investigating the possibility of spread by phylloxera.

Mealybugs themselves are not a major pest to the grapevine. They may exist at low levels and are more of a threat in virus transmission more than their pest status. The damage they do to a vine is aesthetic at low levels. At high populations, mealybugs will cause secondary ant infestation and sooty mold growth due to their sugary bodily secretion, thereby decreasing fruit quality. You can search for mealybugs at the axils of leaves along the stem and inside of clusters. They like to remain hidden on the vine and will migrate into crevices of bark and burrow into the top layers of the soil. They can be identified by their waxy, whitish appearance (Figure 2).

Figure 2. Mealybug infestation of a grape cluster. Photo courtesy of Bob Martin, USDA-ARS

Winery waste from vineyards that have mealybug infestations can be a source of spreading insects through unmanaged pomace. Rhonda Smith, Sonoma County Viticulture Advisor with UC-Extension, conducted research in 2003-2004 on pomace-compost management and incidence of mealybug survival. The research showed that vine mealybug was able to survive pressing and was found alive in pomace. Furthermore, they were able to survive in pomace piles. Only adequate composting of the piles was able to kill any mealybugs due to the high temperatures created during decomposition. This required that the piles be completely covered by a heavy poly liner (>3 mm thickness), making sure to have the entire pile encapsulated by burying the edges of the plastic. With this process, they were able to achieve 100°F inside the piles and effectively reduced the mealybug survival. However, the problem with simply transferring thing practice to Oregon is the difference in temperatures at the end our harvest season for most of the state. California experiences warmer temperatures during and following harvest in comparison, and their daily temperatures were near 90°F during the study period. The best recommendation for any vineyard to prevent the spread of mealybugs from infested vineyards is to do the following:

1. Communicate: Check with vineyards that you purchase from to determine if they have noted mealybug infestations in their vineyards or in the general vicinity or region. Such regions that have already identified mealybug populations

include southern Oregon (Rogue Valley), eastern Oregon and Washington (Walla Walla Valley), Washington, Idaho and California.

2. Quality Control: When you receive fruit on the crush pad, check all the fruit for potential signs of mealybug infestations (Figure 2). Be especially careful and thorough in checking fruit that originates from regions known to have mealybug infestations. Also, if you have mealybugs in vineyards, you can move the insects on humans, equipment and harvesting bins. Plan management accordingly so as not to be moving people/equipment/bins from infested to uninfested sites.
3. Proper Disposal of Pomace: If you notice mealybug in your crush pad observations, dispose of pomace and any other grape biproducts adequately. Do not simply spread the pomace/debris into your vineyards or that of others. Set up a composting area off-site or at least 100 yards away from the vineyard. Cover the pomace/debris with heavy poly and allow for it to compost into next season. If you haul pomace away to a waste management facility that may be composting it, make them aware of any potential mealybug infestations and ask about their composting procedures.
4. Do not purchase grape pomace from other vineyards/ wineries unless you plan to compost it adequately. If you purchase pomace from a waste management company, be sure to ask about their composting practices and ensure that any harmful insect pests would have been destroyed.

For more information on leafroll, other viruses, mealybugs and other vectors, you can access the presentations from the OSU Vineyard Workshop featuring viruses and vectors at http://wine.oregonsate.edu/outreach. If you find any signs or symptoms of either the virus or the vectors in your vineyard, please contact your local county Extension horticulturist for more information. Later this year, OSU Viticulture Extension will release a guide to leafroll and mealybug monitoring for the Oregon winegrape industry. Stay tuned for more information!

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Those "other diseases"

Jay Pscheidt, PhD, Extension Plant Pathologist

We seem to be well aware of powdery mildew management in the vineyard; we know a little about Botrytis bunch rot; and crown gall is a major problem for some areas. But then there are the little known diseases called Phomopsis cane and leaf spot and Eutypa dieback.

Eutypa Dieback. Canker problems such as Eutypa dieback are a real concern in many viticulture areas around the world--but not here. We have observed this disease in Oregon and it does have the potential to become a problem. I have campaigned against it since I got here 21 years ago. With Oregon's industry being so young, the disease had not yet become a problem. Back then, it was the right time to start fighting the disease, especially when the industry had a mass movement from cordon-spur pruning to cane pruning. The Eutypa fungus has a 5-year life cycle and many hosts which allow it to sneak into vineyards slowly. The real threat: once it gets going it is trouble to manage!

Look for the classic symptoms of Euytpa this spring before flowering. A description and photos of symptoms can be found online (http://plant-disease.ippc.orst.edu/disease.cfm?RecordID=519). Identify and flag symptomatic vines for removal during the drier part of the season. Together, we can keep this disease from being a problem in Oregon. And just in case you missed the symptoms, get rid of all those big gnarly pieces of cordon or trunk you pruned out last winter. That is where this fungus is likely to overwinter. Remove them from the vineyard and burn or send them to the landfill.

Phomopsis. Some of you may spray routinely in the spring for Phomopsis cane and leaf spot, but I am never sure why. It can be a big problem in France (excoriose), the Great Lakes growing areas in North America, and on Thompson seedless in California but not in Oregon. I have rarely seen the typical cane symptoms in Oregon vineyards (see symptoms online at http://ipmnet.org/plant-disease/disease.cfm?RecordID=515). I have only seen the fruit rot symptoms of Phomopsis once, and that was in a nursery growing vines for propagation. I recommended early season fungicides for those vineyards that have verified infestations, but it is a waste of time and money for most Oregon vineyards.

Now, given that statement, I am open to your testimonials otherwise. Show me a nasty Phomopsis situation, and I'll eat my proverbial hat. But then remember, I still have an offer out there for a dinner for two if you can show me downy mildew on an Oregon grown grapevine. No one has collected since I made the offer 15 or more years ago. It is always the grape erinum mite that people think is downy mildew. The offer still stands, and it would be worth the money to catch its early introduction in our area. Note: Boston Ivy doesn't count, but that was another story a few years ago!

Disease Resources for Vineyards

OSU Extension Online Guide to Plant Disease Control
http://ipmnet.org/plant-disease/

Oregon Winegrape Pest Management Guide 2009
http://wine.oregonstate.edu/publications

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How to Reduce the Risk of Pesticide Resistance in Oregon http://extension.oregonstate.edu/catalog/details.php?search=em+8968

Quality control programs in the winery

James Osborne, PhD, Extension Enology Specialist

For the winemaker, there is a huge amount of resources and information available to help predict, identify, and rectify problems that may occur during the winemaking process. For example, the modern winemaker has a wide array of methods that can be utilized to identify and quantify wine spoilage microorganisms. These methods may be a simple as the sensory evaluation of a wine or as complex as PCR based analysis that relies on the latest molecular biology techniques. However, without a systematic approach to applying this information in the winery, preventing problems during winemaking can become a haphazard affair. The hazard analysis and critical control points system (HACCP) is an example of such a systematic approach that has been widely applied in the food industry HACCP programs identify potential problems, critical points where monitoring is needed, corrective actions that can be taken, verification of actions taken, and documentation of the process. HACCP type quality control programs are now becoming more widely used in the wine industry and can become an integral part of how you approach, analyze, control, and prevent problems during winemaking.

The first step in developing a quality control program for a winery is constructing a flow diagram that identifies the key steps of winemaking from the vineyard to the bottle. This will be different for different wine styles (for example red versus white versus sparkling) and can be customized for any sized operation. An example of a quality control program for the control of sulfides is shown in Figure 1 (attached). This flowchart was developed in conjunction with Barney Watson (Chemeketa Community College) and was highlighted at the recent Oregon Wine Industry Symposium. As can be seen in the figure, key points during the winemaking process have been identified where monitoring or analysis is required. These are called the critical control points. For example, for sulfide issues a key critical control point is the incoming fruit. At each critical control point key parameters or critical limits are then determined and analysis to be performed is identified. For example, fruit quality parameters such as yeast available nitrogen (YAN), presence of visible rot, presence of spray residue, and pH and TA, could all effect the production of sulfides during winemaking. These parameters would be monitored/analyzed and compared to a previously established critical limit. For example, for fruit YAN the critical limit may be > 140 mg/L YAN. If analysis indicated a problem then established corrective measures will be implemented. In the case of low YAN a corrective measure would be the addition of yeast nutrients early in the fermentation. Critical limits for all monitoring and analysis performed should be established and a corrective action to be taken identified well in advance. That way your response to a problem can be quick and effective.

An important step in any quality control program is the documentation of what actions have been taken. This ensures that corrective actions have in fact occurred and just as importantly, that the corrective actions are not repeated by accident. This information also provides technical data for each fruit lot passing through the winery and can be useful when making decisions about future vintages. For example, documentation of parameters such as pH, YAN, and sugars of grapes from a certain vineyard in a certain year may help guide decisions a winemaker will make when using grapes from the same vineyard in future years.

Verification is the final step that is required for a successful quality control program in the winery. This involves verification of the accuracy of the analysis performed, the effectiveness of actions taken, as well as the impact of actions taken. Verification is particularly important when the quality program is first adopted and acts as a feedback mechanism for the whole system. For example, verification may indicate that a particular treatment was not effective and needs modification or that more detailed analysis is required.

Quality control programs can be developed for the overall winemaking process, from harvest decisions through to bottling, and can also be specific and more detailed for clearly identified problems. For example, you may develop a quality control chart for the control of *Brettanomyces*, or you could develop one for the addition of enological tannins during red winemaking. Many of the steps described previously, such as critical limits, type and frequency of analysis, and corrective actions to be taken, would be decided by each individual winery. This allows wineries to tailor make quality control programs suited to their specific needs and develop plans for preventing and controlling the various problems that can occur during winemaking.

OSU's Viticulture & Enology degree programs increase science knowledge for a career in the winegrape industry

Oregon State University first launched its Bachelor of Science (BS) degree program with an option in Viticulture and Enology in fall of 2003, making it one of only three BS programs in viticulture and enology in the US outside of California. The programs at Washington State University and Cornell University also began around the same time or shortly thereafter. The program was developed by OSU to address a changing tide in the world of production horticulture and food science. With increasing acreage and development of wineries both in the state, region, nation and world, there has been an increased demand for well-trained graduates with adequate science background. Secondly, OSU could offer the same viticulture and enology focus as other well-known institutes such as UC-Davis with added contribution of faculty with expertise in cool climate viticulture and Pinot noir production.

Just as the demand of quality wine production requires balance, the students in the Viticulture and Enology Program at OSU require a balance of knowledge areas and experience. Courses are not limited only to viticulture and enology, but other areas of science to support a knowledge foundation critical for a career in the winegrape industry. Courses include the following subject areas: biology, chemistry, biochemistry, mathematics, horticultural

sciences/production, plant physiology, plant nutrition, soil sciences, entomology, food sciences/production and microbiology. A full curriculum listing can be found online at http://wine.oregonstate.edu/undergraduate_programs. Before graduation, students complete an internship work experience to use their academic knowledge and gain hands-on experience in the methods and procedures used in the industry. Numerous opportunities are available for hands on experience within the programs in arranged viticulture/enology field trips by the OSU Vitis club, student networking and working with research programs in viticulture/enology at OSU.

As the viticulture course instructor, Dr. Patty Skinkis is impressed at student's interest in science and dedication to playing a role in the progression of the winegrape industry in- and outside- of Oregon through the use their knowledge gained in the BS program. She had a number of students volunteer their time in the lab, assisting in data collection to observe the vine, gain experience in the vineyard and further understand vine physiology growth and development. They have also taken advantage of industry workshops developed and delivered by my program to interact with industry and understand the important issues in industry. The interaction of the students has been most beneficial to their educational development, and provides them with a sense of importance and belonging within industry.

In a similar manner, Dr. James Osborne (enology course instructor) notes that students have a real passion for learning in such an applied field. "In class the students are making wine and measuring key wine quality parameters every step of the way. It makes it easy to link the fundamental science they learn in the classroom to real life applications in the winery". Of course it doesn't hurt that sensory evaluation is a large part of the class as well.

Students in the program believe that OSU has one of the best programs in the nation because of the new faculty and their efforts in teaching courses in innovative ways. They value the link to industry through OSU specialists in enology and viticulture, Dr. James Osborne and Dr. Patty Skinkis. Currently, Dr. Skinkis teaches several viticulture courses live online to both industry and students, providing information to and allowing interaction of two very different student groups. One BS degree student from this past winter term stated that "The link with industry members helped me realize what we were learning was of real importance and increased my interest in viticulture." Future avenues of teaching are being explored within the Viticulture and Enology Program at OSU to bring the vineyard and winery experience into the classroom and a focus of science into the vineyard and winery.

If you are interested in learning more about the program or know of people interested in joining OSU for a BS program, please contact Kelly Donegan, horticulture student advisor, at donegank@hort.oregonstate.edu or Dan Smith, food science student advisor, at dan.smith@oregonstate.edu. They can provide you with details on course curriculum, credit transfers and degree requirements. To be in contact with other students currently in the program, please contact OSU Vitis Club (osuvitis@lists.oregonstate.edu) to be linked with students for discussing the program, internships, opportunities and careers. If you are an industry member interested in taking courses online, visit http://wine.oregonstate.edu for more information.

Appointment of Southern Oregon Viticulture Extension Educator Is Renewed

The fixed-term appointment of Oregon State University Extension Viticulture educator, Dr. Marcus Buchanan has been renewed for another year, until June 2010, based on a decision by Bill Boggess, interim dean of the College of Agricultural Sciences at OSU.

"It is clear that, in his role as an area Extension educator with a focus on viticulture, Dr. Marcus Buchanan is a respected and valued resource person for the wine industry in southern Oregon. Although his appointment was scheduled to end later this year, there is considerable support for extending his appointment," Boggess said.

Members of the Policy Board of the OSU-based Oregon Wine Research Institute supported Boggess' proposal to allocate funds for the appointment renewal from wine industry-related funds in the budget of the Oregon Agricultural Experiment Station.

"Doing so will not only extend Buchanan's appointment, but also will afford a new director of the Oregon Wine Research Institute an opportunity to develop and implement a broadly based staffing plan that considers this southern Oregon position as part of the Institute's statewide role," Boggess said. A search for the director of the Institute is now underway with participation from the industry and OSU.

Buchanan works closely with grape growers and winemakers in the rapidly expanding southern Oregon wine industry. His educational work is a source of research-based information that addresses general production questions and problems, and his focus has been on irrigation management and nutrition. He has developed workshops, newsletters, and one-on-one grower contact for vineyard

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development, pest management, and economics to meet the needs of the Southern region.

Grape Researcher to Join Oregon State University Horticulture Faculty

Dr. Laurent Deluc will begin work in the Horticulture Department at OSU in late June as an assistant professor with responsibility for developing a research program on the metabolimics of grape. His work will compliment that of the current viticulture and enology research programs by focusing on the molecular mechanisms that are involved in vine physiology and berry ripening. He will join other team members, Drs. Patty Skinkis and James Osborne, as part of the recently established Oregon Wine Research Institute at OSU.

Deluc has a BS degree in plant physiology and a docotorate in plant molecular biology from the University of Bordeaux. He also studied biology for his masters degree at the Forestry University of Nancy. He currently is working as a post-doctoral research associate in Dr. Grant Cramer's lab at the University of Nevada, Reno.

In his role as OSU's new winegrape researcher, Deluc brings expertise in two areas important to Oregon's industry. The first involves his expertise in using molecular tools to identify genes responsible for the biosynthesis of compounds in the grape. His second area of expertise involves using these molecular tools to understand how grape plants respond to environmental stresses such as drought and cold.

To help identify research needs and to communicate results, Deluc will work closely with the Oregon wine industry, with Drs. Skinkis and Osborne in the Oregon Wine Research Institute and researchers from other departments at OSU and USDA-ARS. As part of his position, Deluc also will teach one 400/500 level graduate course each year in his area of molecular plant biology, and train graduate students in his lab.

Upcoming OSU Extension Events:

Sustainable Vineyard Management Workshop Series 2009

Three in-field workshops will be offered during the season to showcase viticulture research in sustainable production and demonstrate vineyard equipment that may be used in sustainable production. The three events will be held in spring, summer and early fall and will feature topics in sustainable viticulture research (insect/pest management, vine physiology and cultural management) and showcase vineyard equipment that can be used in demonstrations in the vineyard according to the season. Register today!

Spring Workshop – May 7, 2009

Come observe new vineyard equipment in use and learn a few innovations in the vineyard along the way with OSU and USDA-ARS viticulture researchers. There will be educational modules, equipment demonstrations and plenty of time to interact with researchers and others in industry. Our guest, Glenn McGourty, UC-Mendocino County Viticulture advisor will also be available to provide information on cover crops and pest control. For more information, visit http://wine.oregonstate.edu/node/202. Registration is $20.

Umpqua Grape Day – June 4, 2009

The annual grape day for the Umpqua grape growing region will be held in Roseburg. The day begins with seminars from OSU researchers and invited speakers and leads into field visits. This year, the field visits will feature vineyard machinery and management discussions. Contact Steve Renquist at steve.renquist@oregonstate.edu or visit http://wine.oregonstate.edu for more information.

New Extension Publications:

2009 Pest Management Guide for Wine Grapes in Oregon EM 8413-E
Authors: Patricia A. Skinkis, Jay W. Pscheidt, Vaughn Walton, and Nancy Allen
Revised, March 2009, 46 pages, available only online http://extension.oregonstate.edu/catalog/pdf/em/em8413-e.pdf

2009 PNW Insect Management Handbook
Revised, March 2009, 704 pages, $50.00 or online
http://pnwpest.org/pnw/insects

2009 PNW Plant Disease Management Handbook
Revised, March 2009, 670 pages, $50.00 or online
http://plant-disease.ippc.orst.edu/

2009 PNW Weed Management Handbook
Revised, March 2009, 556 pages, $50.00 or online
http://pnwpest.org/pnw/weeds

SULFIDES QUALITY CONTROL FLOW CHART

			MONITORING/ ANALYSIS	CRITICAL LIMITS	CORRECTIVE ACTION	VERIFICATION/ DOCUMENTATION
Grapes	**Maturity** **Fruit Condition**		Brix,TA,pH,YAN Rot, mold Spray residue	> 140 mg N/L YAN Visible rot, off odors Visible residue	Sorting	Monitor YAN during ripening Visual, sensory evaluation Vineyard spray records
Crush Destem Maceration	**Whites**	**Pressing Clarify**	SO_2 Suspended solids Temperature Microbial and sensory evaluation	25-35 mg/l 0.5-1.5% 5-10°C, 40-50°F Presence undesirable microorganisms Presence off odors	Add SO_2 Settling, racking 5-10°C, 40-50°F Chill Adjust SO_2	Monitor SO_2 levels Monitor suspended solids Monitor temperature Microscopic observation Plating, PCR
		Racking	Brix,TA,pH,YAN	140-250mg N/l YAN	Add nutrients early in fermentation	
	Reds	**Cold Soak**	SO_2 Temperature Microbial and sensory evaluation	50-75 mg/L ≤10°C, 50°F Presence undesirable microorganisms Presence off odors	Add SO_2 Chill Adjust SO_2	Monitor SO_2 levels Monitor temperature Microscopic observation Plating, PCR
			Brix,TA,pH,YAN	140-250mg N/l YAN	Add nutrients early in fermentation	
Alcoholic Fermentation			Yeast inoculation	Strain selection Inoculum level Yeast preparation Temperature shock	120-240 mg/l Rehydrate, temperature Monitor temperature	Low sulfides production
			Oxygen availability Indigenous yeast	6-8 mg/l Undesirable yeasts Presence off odors	Moderate aeration Adjust SO_2	Monitor oxygen content Microscopic observation Plating, PCR
			Lactic acid bacteria Brix/temperature Sensory evaluation	Undesirable bacteria Slow/stuck Sulfide off odors	Lysozme Reinoculate,nutrients Copper addition	Monitor fermentation rates Copper bench test, sulfides profile
Post Fermentation & Aging			SO_2 Lees management Sulfides, sensory	<20 mg/l Excessive depth Loss fruitiness Hydrogen sulfide Mercaptans Polysulfides	Adjust SO_2 (postML) Settling, racking Rack, aerate, +copper No aeration, +copper Ascorbate, + copper	Monitor SO_2 levels Monitor redox potential Copper bench test, sulfides profile
Bottling			Recheck sulfides Sensory evaluation		Appropriate corrective measures pre-bottling	Monitor sulfides, sensory after bottling